Application of Geophysics for the Detection of Derangement of Phosphate Layers in the Oulad Abdoun Basin in Morocco

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Doi: 10.19044/esj.2018.v14n30p7 URL:http://dx.doi.org/10.19044/esj.2018.v14n30p7

Abstract

The phosphate series of the basin of Oulad Abdoun begins in Maastrichtian with phosphate deposits relatively very marly. It ends at the Lutetian by a calcareous slab. Derangement is any disruption of the usual succession of the phosphate series and that which disrupts the evolution of the kinematic chain, leading to a decrease in production and profitability. In this case, we have a partially disturbed series and the disturbance consists of all the elements of the series (limestone, flint, marls and phosphate). The present work has been carried out in two ways: The present work has been carried out in two ways: The first one, purely geological, consists of the identification of the different layers of the Ouled Abdoun basin in the El Halassa site and their continuity to the outcrop. At the end of these observations, the basin shows derangement of two kinds: a disturbance on the scale of the whole series known as major disturbance, and a second which affects only part of the series. Thus, it is a minor or local disturbance. The second one, geophysics, is the application of three geophysical methods: electric tomography, magnetism, and refraction seismic. The correlation of these applications should result in

delineating the mineralized zone and tracking all elements that in one way or another affect this mineralization. These elements are referred to as "derangement". The combination of the results of these two methods (vertical electrical survey and tomography) used allowed us to identify and map the disturbed places in the chosen area of El Halassa. The study will be extended to other sites and the results can be compared and correlated to understand the extent and origin of these disturbances.

Keywords: Phosphate series, Ouled Abdoun, dérangement, VES

Introduction

In the sedimentary basin of the Ouled Abdoun (Morocco), the phosphate series is formed by a regular intercalation of phosphate levels and marl-limestone levels over about 50m. Locally, this regularity is perturbed by the frequent presence of structures commonly called "derangement". However, these are unstratified sterile masses, which disrupt and weigh down the working of the phosphate layers. In fact, the phosphate series is not systematic. In the deposits in regards to its operation and in several parts of the Ouled Abdoun basin and the area situated to the south-east of the city of khouiribga, the phosphate banks are not always regular. They are frequently disturbed by large bodies sterile non-stratified materials that interrupt phosphate layers and make them locally deformed. Thus, this derangement is the origin of two types of problems:

- Firstly, since they are often hard and compacted, the operating chain will be automatically disrupted and, consequently, the price of extraction of phosphates will become high and heavy. During a drilling operation or "blasting" along the operating trenches, in the presence of a rheologically harder fault, the mesh of the holes that will be filled with explosives must be tighter. Also, during the extraction of the phosphates, the derangement is not always destructible even after blasting. As a result, it causes a real problem for the usual displacement of draglines.

- Secondly, since these bodies are sterile and always masked by a quaternary cover, they do not allow a precise calculation of the reserves and are, therefore, a good feasibility study for each deposit.

Presentation of the Study Area

The phosphate plateau consists of a set of nested platforms dissected by erosion, each corresponding to the most resistant limestone levels of the sedimentary series. It extends from the Cretaceous to the Eocene (Belfkira, 1980). The altitude of these plateaus varies between 450 m in the region of Settat and 850 m near Khouribga. They terminate at the north and south by a relief in "Cuesta" with mounds in front of the line of ribs. On the shales and

pale quartzites of the Paleozoic which flush out to the north and southwest of the plateau, we would successively meet the Infra-Cenomanian, the Cenomanian, the Turonian, the Senonian, the Maestrichtian, and the Eocene. These terrains, overall, are capped by a mass of detrital limestone (Belfkira, 1980).

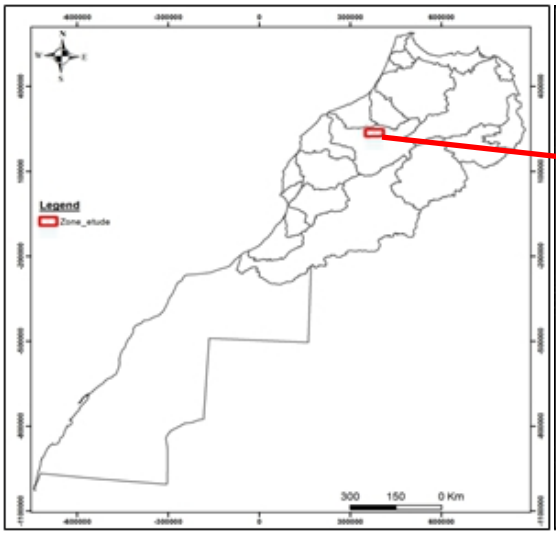

Figure 1. Location of the study area at the scale of Morocco

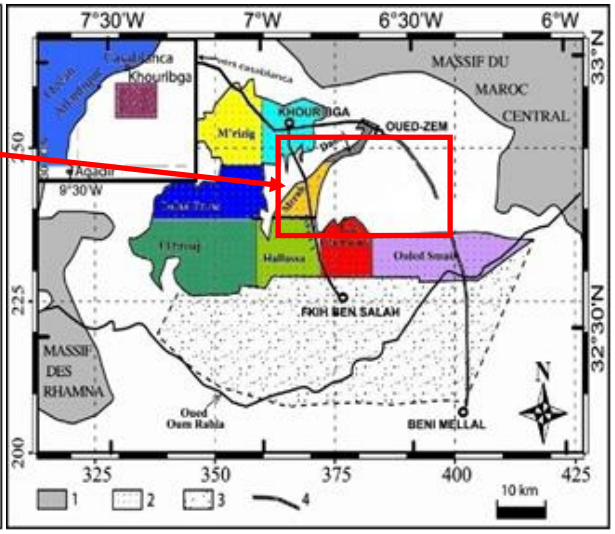

Figure 2. Location of the study area at the Ouled Abdoune deposit

Description of the Phosphate Series

The phosphate series of the Ouled Abdoune deposit starts from the Maastrichtian, which is formed by an alternation of limestones, phosphate marls, and sandy phosphates. Then comes the Paleocene made up of movable phosphates and phosphate limestones that ends with coprolitic limestone with flint nodules. A powerful Eocene formation overcomes the Paleocene which is formed by alternating levels of soft phosphates, marl-phosphate limestones, and flint. The phosphate series ends with a limestone bar containing shells called the upper Eocene "thersity slab" characterized by its resistance to erosion (Boujo, 1976; Choubert & Salvan, 1949).

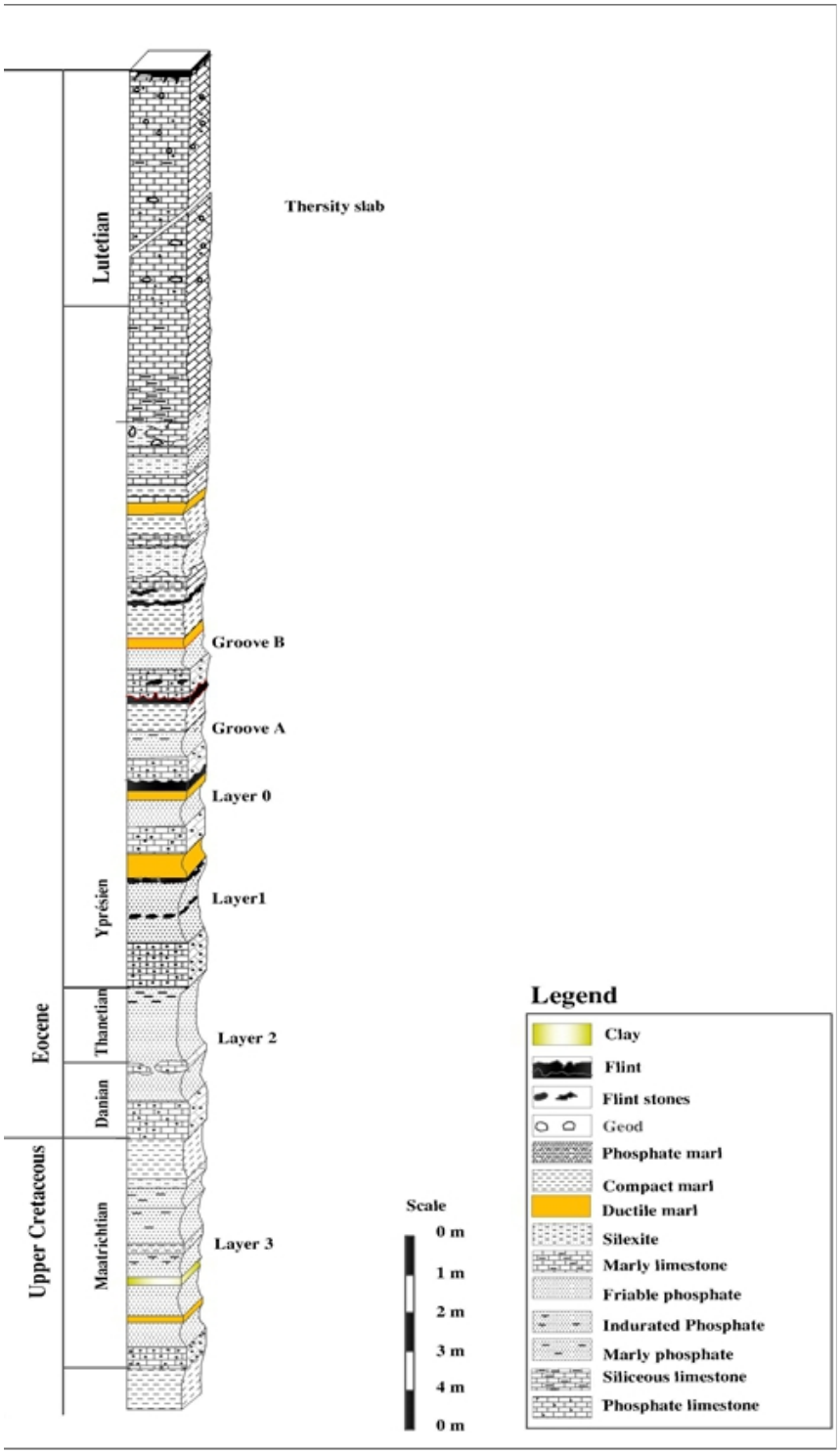

Figure 3. Average lithostratigraphic section of the Oulad Abdoune phosphate deposit (Belfkira, 1980)

Recognition Program

The general recognition program includes:

- Geological sounding at different scales
- Inventory of different drilling and carrotted soundings
- Synthesis of previous geophysical results
- 3 Vertical electrical sounding
- 3 Magnetic field measuring line

Discussion of Results

A- ***Vertical Electrical sounding***

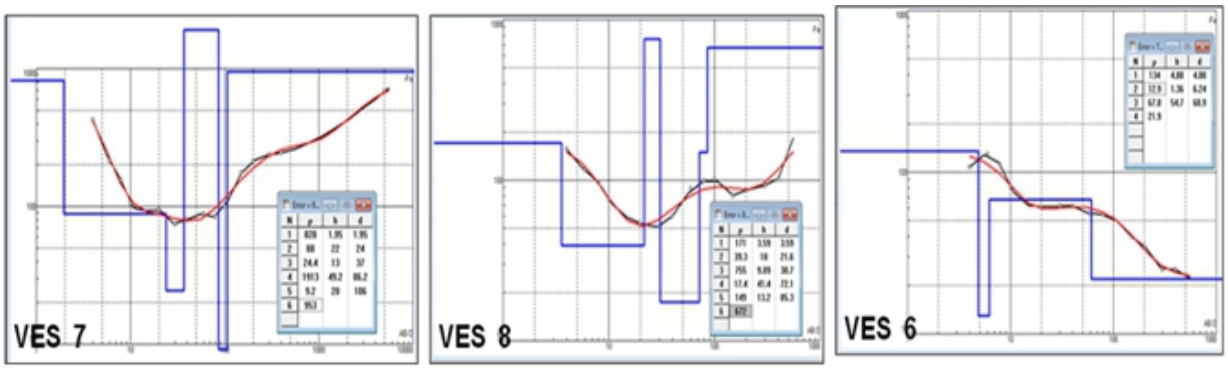

Figure 4. The vertical electric sounding curves

- The resistant upper formation affected by the first two boreholes corresponds to Lutecian limestone benches which overlie a marly level above the first exploitable phosphate level called “Sillon B”.
- The term “conductive” corresponds to an alternation of phosphate levels and marly or clayey levels which constitutes the phosphate series proper. Also, it is between the Maestrichtien and the Ypresien, with resistant Eocene limestone levels.
- The conductive level probably corresponds to the Senonian formations below the Eocene phosphate series containing marls and marly limestones.
- The last resistant formation can correspond to the deep Turonian formed by hard limestones, sometimes dolomitic, and is cracked. They are characterized by a high permeability. The Turonian is the most important aquifer in the region.
- The land area affected by Survey No. 6 is an unstratified mixture of blocks of limestone, clay, marl, and flint kidneys.

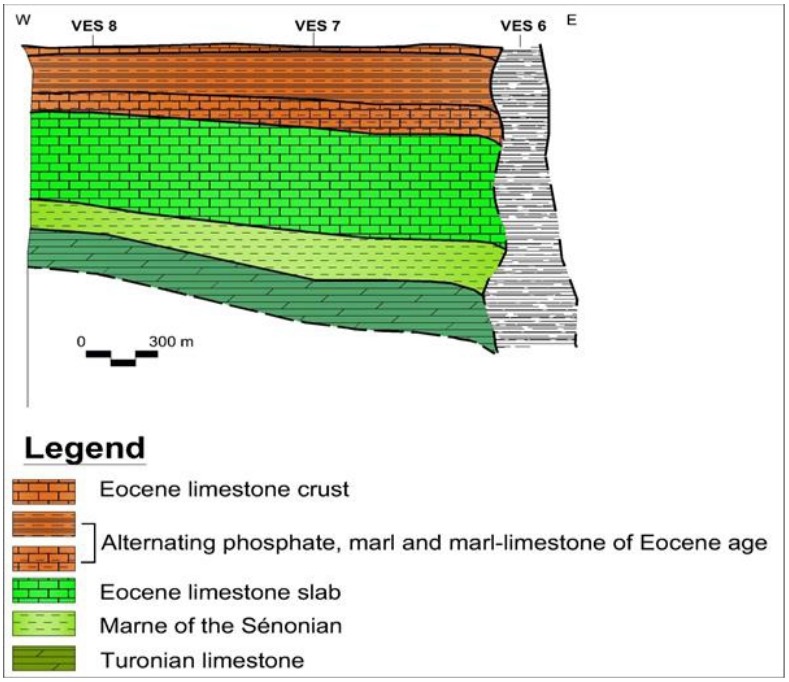

Figure 5.

B- Magnetism

According to this map, it is observed that the disturbance has a different magnetic field from that of the regular phosphate series. It has values greater than 62200 which are grouped and clear in very distinct places. This method allowed us to detect certain anomalies that resemble the derangement. Therefore, it can be said that each means a disturbed place since the anomalies measured at these points are similar to those detected in the previously defined and targeted perturbed zone (Well disturbed).

From the above, by making a comparison between the two methods (electric and magnetism), we can easily carter for the areas that have derangement with simple analysis of the results of the electric soundings and the establishment of a map of variation of the magnetic field.

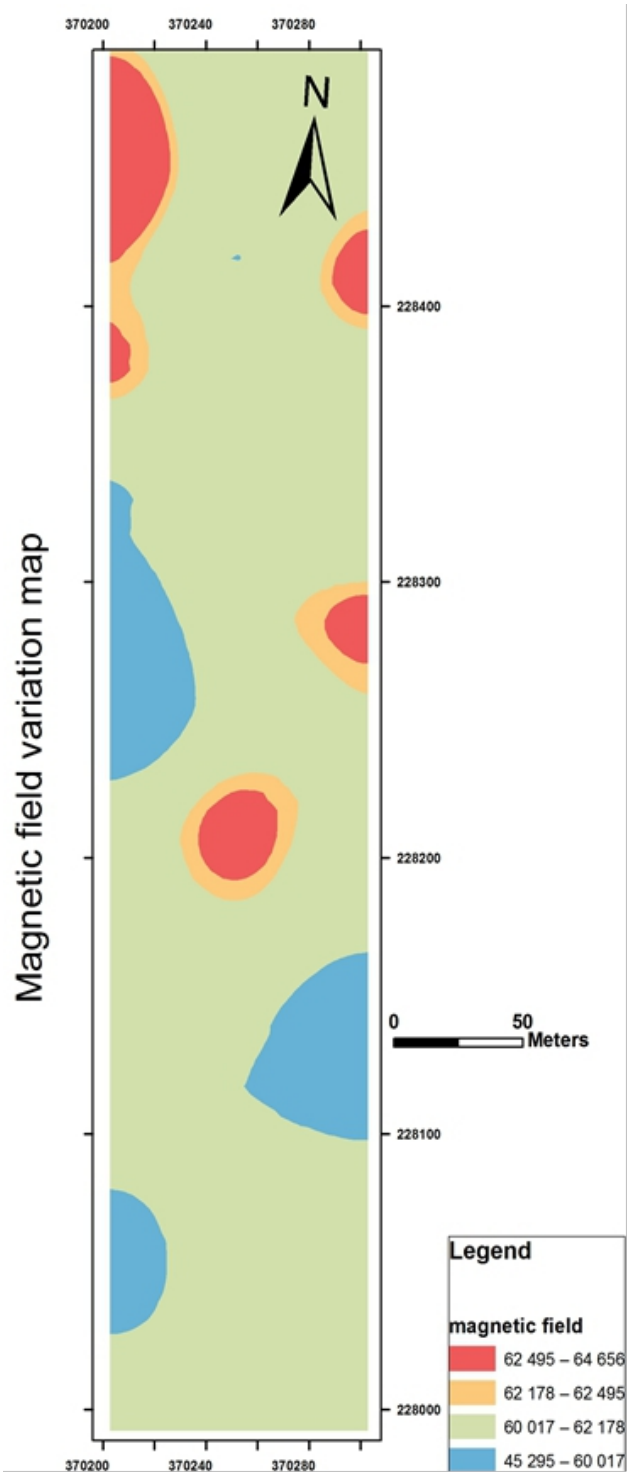
370200
370240
370280
N
228400
228300
228200
228100
228000
Magnetic field variation map
0
50
Meters
Legend
magnetic field
62 495 – 64 656
62 178 – 62 495
60 017 – 62 178
45 295 – 60 017

Figure 6.

Conclusion

Derangement is an important problem for the phosphate mining chain of the Ouled Abdoune deposit. Hence, there is the need for a detailed mapping of these disturbing bodies. Electrical geophysics and magnetism can answer to this problem by measuring the resistivity of subsoil levels. This includes their magnetic field such as disturbances while showing the discontinuities associated to disturbances in mineralized zones. With a very tight mesh for measurements, all or substantially all of these anomalies will be detected and will be represented in a location map, most especially the dimensions. Our study, even at the preliminary stage, accounts for the disturbance zones that are the source of problems in the production chain.

Once these faults have been identified and located at the scale of the deposit, the problem of increasing the operating phases from the financing point of view will be solved. Thus, this is irrespective of the displacement of large machines called "Dragline", or when optimizing the explosive or the change of the trench layout.

Subsequently, this study will be calibrated by the electrical tomography and the seismic refraction predicted. In addition, we will arrive at a 3D model containing information necessary for the feasibility study of deposit.

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