ANNALS OF THE FACULTY OF ENGINEERING HUNEDOARA
2006, Tome IV, Fascicole 3, (ISSN 1584 – 2673)
FACULTY OF ENGINEERING HUNEDOARA,
5, REVOLUTIEI, 331128, HUNEDOARA

ENHANCEMENT EDGES OF SIDI CHENNANE PHOSPHATE DEPOSIT "DISTURBANCES" USING NON-PARAMETRIC REGRESSION ANALYSIS OF RESISTIVITY DATA

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Abstract
Several methods are currently used to optimize edges and contours of geophysical data maps. This work introduce the non-parametric regression filtering method. This method has been used much success in the analysis of stationary geophysical data. The advantage of the non-parametric regression is easy to use and can provide results. A resistivity map was expected to allow the electrical resistivity signal to be imaged in 2D in moroccan resistivity survey in the mining domain. Anomalous zones of phosphate deposit "disturbances" correspond to resistivity anomalies. The key idea of this paper is the application of the non-parametric regression filtering method to optimize such anomalous zones of phosphate deposit "disturbances". Filtering technique as non-parametric regression is an efficient tool in the interpretation of geophysical potential field data particulary suitable in denoising, filtering and analyzing resistivity data singularities. The non-parametric regression filtering approache applied to modeling surface phosphate "disturbances" was found useful.
Key words:
resistivity , phosphate, non-parametric, regression, filtering, Morocco.

1. INTRODUCTION

Resistivity is an excellent parameter and marker for distinguishing between different types and degree of alteration of rocks. Resistivity surveys have long been successfully used by geophysicists and engineering geologists and the procedures are well established. The study area is the Oulad Abdoun phosphate basin (figure 1) which contain the Sidi Chennane deposit. The Sidi Chennane deposit is sedimentary and contains several distinct phosphate-bearing layers. These layers are found in contact with alternating layers of calcareous and argillaceous hardpan. However, the new deposit contains many inclusions or lenses of extremely tough hardpan locally known as "*derangements*" *or* "disturbances" (figure 2), found throughout the phosphate-bearing sequence. The hardpan pockets are normally detected only at the time of drilling. Direct exploration methods such as well logging or surface geology are not particularly effective They interfere with field operations and introduce a severe bias in the estimates of phosphate reserves (figure 1) [1]

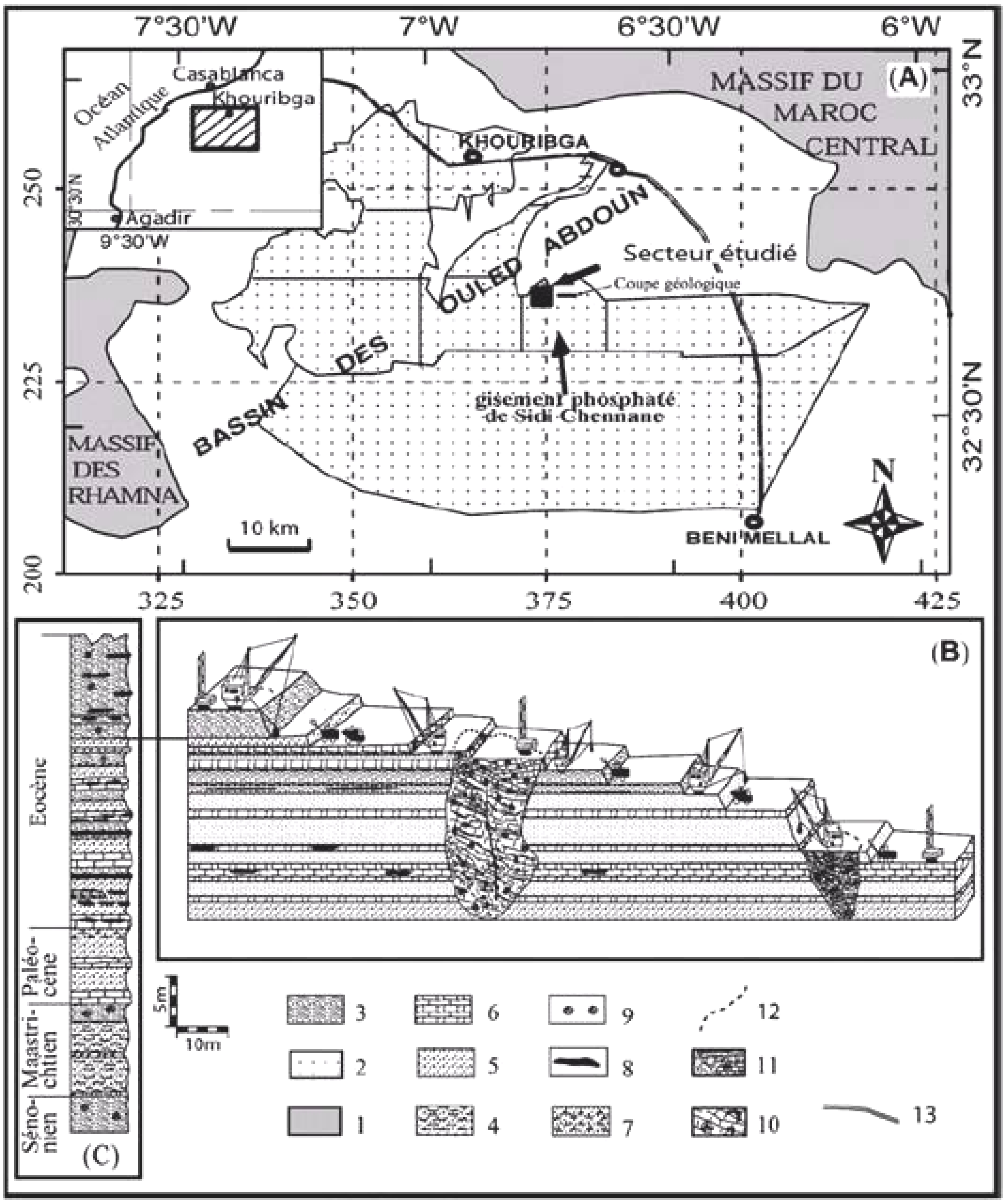


Figure.1. (A) Location of the studied area in the sedimentary basin of Ouled Abdoun.
(B) Section showing the disruption of the exploitation caused by disturbances.
(C) Stratigraphical log of the phosphatic series of Sidi Chennane: (1) Hercynian massif; (2) phosphatic areas; (3) marls; (4) phosphatic; marls; (5) phosphatic layer; (6) limestones; (7) phosphatic limestone; (8) discontinuous silex bed; (9) silex nodule; (10) *dérangement* formed exclusively of silicified limestone; (11) *dérangement* constituted of a blend of limestone blocks, marls and clays; (12) *dérangement* limit; (13) roads.

The study area was selected for its representativity and the resistivity profiles were designed to contain both disturbed and enriched areas. The sections were also calibrated by using vertical electrical soundings. High values of apparent resistivity were encountered due to the presence of near-vertical faulting between areas of contrasting resistivity, and fault zones which may contain more or less highly conducting fault gouge. The gouge may contain gravel pockets or alluvial material in a clay matrix [2] [3]. Such anomalous sections are also classified as *disturbances.* Apparent resistivity values in these profiles locally exceeded 200 Ωm .

Figure 2. Example of "disturbances" in the phosphatic series

The apparent resistivity map (figure 3) which one obtains from such a survey is actually a map of discrete potentials on the free surface, and any major singularity in the apparent resistivities due to the presence of a perturbation will be due to the crossing from a "normal" into a "perturbed" area or vice versa. In other words, the apparent resistivity map may be considered a map of scalar potential differences assumed to be harmonic everywhere except over the perturbed areas. Interpretation of resistivity anomalies is the process of extracting information on the position and composition of a target mineral body in the ground. In the present case the targets were essentially the inclusions called *perturbations.* The amplitude of an anomaly may be assumed to be proportional to the volume of a target body and to the resistivity contrast with the mother lode. If the body has the same resistivity as the mother lode no anomaly will be detected. Thus assumed in fact and in first approach that the resistivity anomalies would be representative of the local density contrast between the disturbances and the mother lode. Level disturbance of the anomalous zones is proportionnal to resistivity intensity (figure 4) [3].

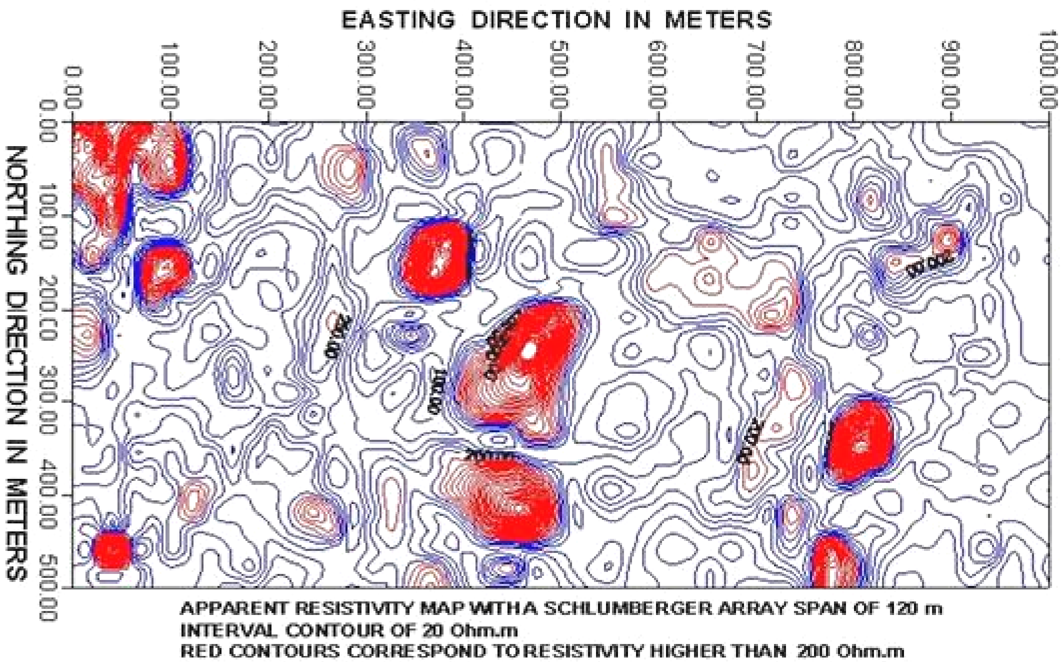


Figure 3 : A map of resistivity anomalies for AB=120 m .

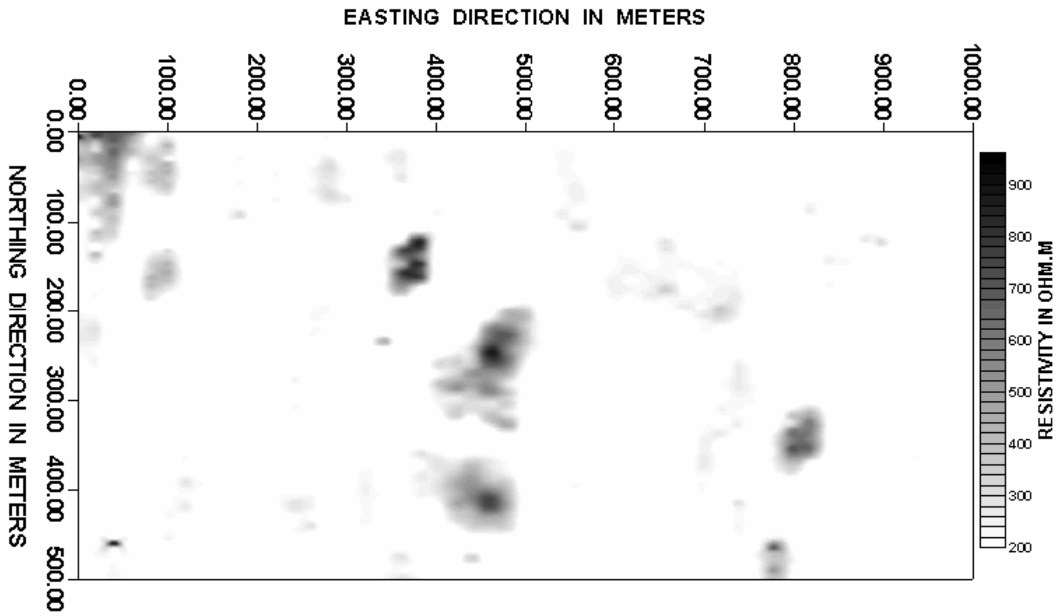


Figure 4 : A map of the disturbed phosphate zones corresponding to Fig.3

Data resistivity collected in the resistivity survey are often contaminated with noise and artifacts coming from various sources. The presence of noise in data resistivity distorts the characteristics of the geophysical signal resulting in poor quality of any subsequent processing. Consequently the first step in any processing of such geophysical data is the "cleaning up" of the noise in a way that preserves the signal sharp variations.

The non-parametric regression filtering method has become a powerful signal and image processing tool which has found applications in many scientific areas. This method is a widely used technique that is applicable to the filtering geophysical data.

The present paper deals with analyzing resistivity data map using the non-parametric regression filtering to denoise anomalous zones map of phosphate deposit disturbances. The results show a significant suppression of the noise and a very good recovery of the resistivity anomalies signal. So the non-parametric regression processing is thought to be a good method to geophysical anomaly filtering.

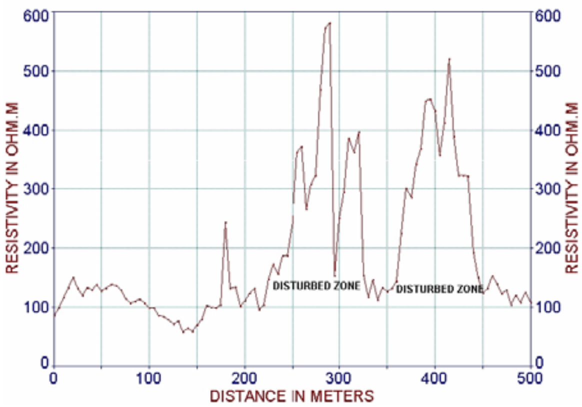
2. NON-PARAMETRIC ANALYSIS REGRESSION

The non-parametric regression smoothing filter was introduced for smoothing data. The non-parametric regression method can extract an underlying low frequency data pattern in extremely noisy data. This procedure is also useful for both upsampling and downsampling since the range and number of output points are specified. Uniform data are not required. Non-parametric analysis [4] provided better identification of dominant independent variables. Non-parametric analysis regression is one of the novel approaches to constructing a suitable model description from available information. It is developped to alleviate parametric regression problem that often leads erroneous results caused by the mismatch between assumed model structure and the real data. In non-parametric analysys regression we don't fix a priori a 'form' of the dependency of the dependency of the dependent variable on the independent variables. In fact one of the main results of non-parametric analysis regression is the form of the relationship. Non-parametric analysis regression is intended to build a model. The resistivity data base is a compilation of 51 traverses at a spacing of 20 m. There were 101 stations at 5 m distance for every traverse, which makes 5151 stations all together in the resistivity survey.

The non-parametric analysis regression method applied to our resistivity data consisted to consider that the apparent resistivity, for each 51 resistivity traverse, ρ is represented by a model in the following form : $\rho = f_0^{-1}\left[\sum_1^n f_p(x_p)\right]$ where x_p represent the northing coordinates of a gidded point of the resistivity map, and f_0^{-1} an inverse transformation. The individual transformation $f_1, f_2, \ldots\ldots, f_n$ are selected to maximize the correlation between the right and the left sides of the following expression subject to some contrains : $f_0(\rho) = f_1(x_1) + f_2(x_2) + \ldots. + f_n(x_n)$

In this case the symbol $f_p(x_p)$ does not necessarily mean a certain algebric expression. This procedure is a fitting, smoothing and filtering algorithm that performs a series of weighted least squares fits in a moving window across the data. The local regression estimation algorithm used is similar to the Loess non-parametric estimation procedure [5].

We calculated the output non-parametric analysis regression filtered signal using AutoSignal routine [6] for each resistivity traverse (figure 5). Then we deferred all the results to built a regular gridded map which represent in fact the non-parametric analysis regression filtering and denoising map of the phosphate deposit "disturbances" (figure 6).



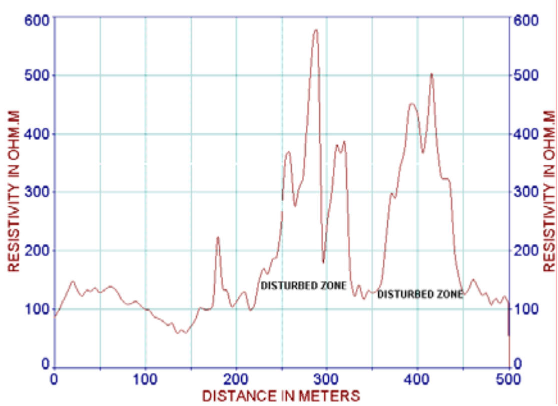


Figure 5 : Example of real resistivity traverse data of the survey and the corresponding output non-parametric analysis regression filtered signal

3. RESULTS & CONCLUSIONS

Figure 6 represents an indicator of the level of variation of the contrast of density between the disturbances and the normal phosphate-bearing rock. The non-parametric regression filtering output map correponding to surface modeling of resistivity anomalies is obtained by AutoSignal routine. This procedure enables us to define the surface phosphate disturbed zones.

The non-parametric regression filtering analysis surface of phosphate deposit disturbance zones as obtained by the above procedure in the study area provided a direct image for an interpretation of the resistivity survey. This method enable us to identify the anomalies area which turned out to be strongly correlated with the disturbances. The use of the non-parametric regression filtering method represent an effective filtering method which makes it possible to attenuate considerably the noise represented by the minor dispersed and random "disturbances". The overall effect is that of scanning and denoising the anomalous bodies. Comparatively to classical approaches used in filtering and denoising geophysical data maps, the advantage of the non-parametric regression filtering method is doesn't introduce significant distorsion to the shape of the original resistivity signal .

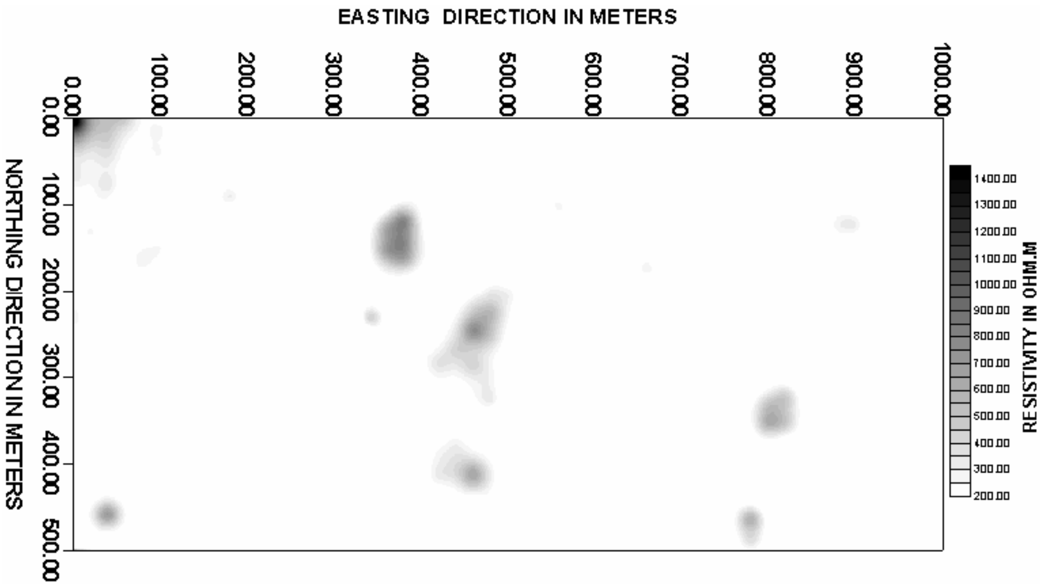


Figure 6 : Non-parametric regression filtering output of the phosphate deposit "disturbances" map given in Figure 4

The non-parametric regression filtering output of the apparent resistivity map which correspond to the non-parametric regression filtering output of the anomalous phoshate deposit map obtained from such a technical tool represent the crossing dominate area from a "normal" into a "perturbed" area or vice versa. Moreover the level of disturbance is very clearly shown. The proposed filtering and denoising method using non-parametric regression filtering tends to give a real estimation of the surface of the phosphate deposit "disturbances" zones with a significant suppression of the noise. The level disturbance resulting from such method is also more defined in all the disturbed zones.

We have described a singular procedure to analyze the anomalies of a specific problem in the phosphate mining industry. The results proved satisfying. Data processing procedures as the non-parametric regression filtering technique to denoise resistivity data map was found to be consistently useful and the corresponding map may be used as auxiliary tools for decision making under field conditions.

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