THE APPLICATION OF GIS-BASED WEIGHTS OF EVIDENCE ANALYSIS TO AEROMAGNETIC DATA FOR HYDROCARBONS EXPLORATION IN THE TRIASSIC PROVINCE, CENTRAL SOUTH ALGERIA

K. Allek[1], A. Bouguern[1], D. Boubaya[2] and M. Hamoudi[3]

[1]*Laboratoire de physique de la Terre, University of Boumerdès, Avenue de l'indépendance, Algeria*
[2]*Faculté des sciences exactes et des sciences de la nature et de la vie, University of Tebessa, Algeria*
[3]*Laboratoire de Géophysique, FSTGAT - USTHB, B.P. 32, El Alia, 16111, Algiers, Algeria*

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The experience with the applicability of shallow-sourced magnetic anomalies to locate hydrocarbon fields has shown both successful results and limitations of the method. Numerous oil and gas fields demonstrate a close correlation between short wavelength magnetic anomalies and deeper hydrocarbon production. These anomalies appear to be related to authigenic ferromagnetic minerals induced by vertical seepage from a hydrocarbon reservoir. On the other hand, many micromagnetic anomalies are shown to be 'false' anomalies and unrelated to any deeper hydrocarbons. The definite way of discerning between them remains a challenge. The present study has been carried out to implement an innovative means which expected to ensure a good efficiency in the separation of anomalies caused by hydrocarbon seepage from false anomalies due to other causes. The application of GIS-based weights of evidence analysis to the identified short wavelength, small amplitude aeromagnetic anomalies within the Algerian central Triassic province has allowed to determine which anomalies are "significant". This involves consideration of their magnitude, width, half-width, and their spatial correlation with known oil and gas fields.

In a previous study, a spatial association analysis were carried out by the authors of this work between the amplitude of analytic signal of sedimentary residual magnetic anomalies and hydrocarbon fields and results have been quite successful in forming an opinion about the characteristics of identified micromagnetic anomalies believed to be related to hydrocarbon microseepages. Although the processing approach used here is almost the same as that employed in the previous study, our main purpose from the present work is a continual refinement of spatial analysis results with the aim of improving consistency and effectiveness. So, instead of the analytic signal of magnetic anomalies, we used reduction to the magnetic pole to prevent any discomfiture with anomalies that exhibit two highs over the edges of relatively large magnetic body. In addition to the amplitude and the width of anomalies, we also took into consideration in the present analysis another significant parameter, namely the half-width of anomalies, in order to assess the depths from which the sedimentary residual magnetic anomalies are generated and to provide a more refined spatial association results.

The study area, occupy the central part of a vast geologic unit known as Triassic province, one of the most petroliferous basins located in central south Algeria. It contains the giant Hassi R'mel gas field and numerous oil and gas deposits (Fig. 1). The datasets used were derived from a nationwide low-altitude airborne magnetic coverage of Algeria acquired with wide line spacing. To provide accurate information about the near surface geology, the survey was flown at relatively low altitude (150 m), using a high resolution (0.02 nT) magnetometer; and the measurements were taken every

150 feet (~ 46 m) along the flight path. Several data processing procedures: such as tie-line leveling, IGRF calculation and removal, lag effect correction and microlevelling, were carefully achieved to get the most out of the detection of subtle anomalies. The application of a relevant Butterworth band-pass filter to profile data reduced to the pole has permitted to reveal a significant number (224) of intra-sedimentary shallow-sourced magnetic anomalies distributed over the entire region. However, we notice a substantial concentration of anomalies in the central and eastern zone of the study (Fig. 1).

The identified residual magnetic anomalies occur with amplitude in the range of 1.5 - 8.8 nT, while their widths and half-widths vary from 1030 to 12850 meters, and from 580 to 8160 m respectively. A part of these anomalies would be in relationship with hydrocarbon microseepages. In order to recognize the characteristic parameters of the seep-induced anomalies, they were categorized as high, intermediate, and low-class with respect to their amplitude, width, and half-width. Then, we quantify the spatial associations between each class of anomalies and known hydrocarbon fields within the study region by mean of GIS-based weights of evidence modeling technique (Tab. 1). We note that when we use together all of the 224 picked anomalies, the result show positive but not particularly high value of the contrast *'C' (1.17)*. This is due to the fact that a number of anomalies among the picked ones are unrelated to gas and oil fields, therefore when the anomalies are treated as a whole, the effect of the seep-induced ones is simply diluted. On the other hand, when the anomalies are addressed by class, we can notice strong spatial association regarding certain classes of anomalies and weak association with others (Tab. 1).

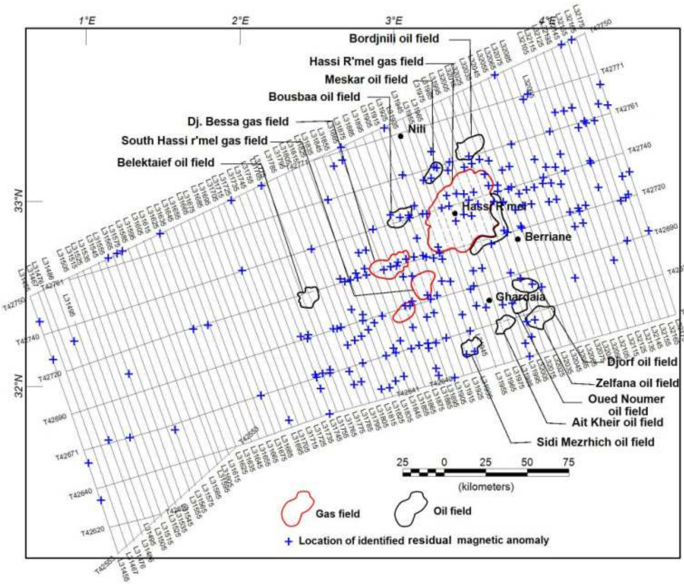

Figure 1 Location of hydrocarbon fields and the picked residual magnetic anomalies (blue crosses) superimposed on flight paths of the aeromagnetic survey of central Triassic province of Algeria

In order to gain sufficient confidence in the results and to give more emphasis on the category of anomalies that we expect to be induced by hydrocarbon microseepages, only the anomalies whose characteristic parameters simultaneously fall into the amplitude, width, and half-width classes characterized by high weights (C > 1.2) are retained. On the basis of this combination, a number of 53 anomalies are discerned which represent barely 24% of all identified residual anomalies. They demonstrate higher value of contrast C (1.73) and Studentized contrast C_S (5.42) than the previous classes of anomalies. Their amplitudes vary between 2.8 nT and 8.8 nT, while their widths and half-width range from 1700 m to 5170 m, and from 800 to 3100 meters respectively. The estimated depth vary within a wide interval, between 11 m and 1500 m. However, nearly 80% of anomalies are caused by sources lying within 1 km deep.

Table 1 Summary of spatial association (defined by weights of evidence analysis) between the hydrocarbon fields and the picked residual magnetic anomalies. The anomalies are classified according to their amplitude, width and half-width and categorized as high, intermediate, and low-level, such that each category contains the same number of anomalies. W+ and W- are the positive and negative weights of evidence respectively; σ denotes standard deviation; C is the difference between the weights known as contrast; C_S is the Studentized contrast C_s (a student t-test) which provides a useful measure of the significance of the contrast.

Parameters	**Class of anomalies**	**W+**	**σ(W+)**	**W-**	**σ(W-)**	**C**	**σ(C)**	**C_S**
	1.5 - 1.9	-0.2946	0.5776	0.0146	0.1188	-0.3092	0.5897	-0.5243
Amplitude (nT)	1.9 - 2.8	1.0678	0.2892	-0.1160	0.1251	1.1839	0.3151	3.7570
	2.8 - 8.8	1.6079	0.2243	-0.2594	0.1362	**1.8674**	0.2624	7.1162
	1040 - 4440	1.2359	0.2679	-0.1508	0.1281	**1.3867**	0.2969	4.6704
Width (m)	4440 - 5340	1.1749	0.2779	-0.1374	0.1281	**1.3123**	0.3060	4.2882
	5340 - 12860	0.6744	0.3540	-0.0569	0.1222	0.7313	0.3745	1.9526
	580 - 2580	1.1615	0.2779	-0.1346	0.1271	**1.2960**	0.3056	4.2410
Half-width (m)	2580 - 3100	1.1482	0.2779	-0.1318	0.1261	**1.2800**	0.3052	4.1943
	3100 - 8160	0.8195	0.3338	-0.0757	0.1251	0.8952	0.3565	2.5114
All picked 224 anomalies		1.0622	0.1700	-0.1144	0.0729	1.1766	0.1849	6.3618

Our approach has proved that it's possible to discern residual magnetic anomalies related to hydrocarbon seeps from those reflecting other sources. As established by the computed weights, the degree of spatial association rises with particular class of anomalies, indicating that areas where these later occur host more hydrocarbon sites than would be expected by chance.