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APPLICATION OF DISCRIMINANT SCORE / Δ LOG R METHOD FOR PREDICTION OF ORGANIC RICHNESS AT NEGELAH WELL, COASTAL MEDITERRANEAN ZONE, WESTERN DESERT EGYPT

BY

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تطبيق معامل التمييز / الفرق اللوغارتمي للمقاومة لتحديد المحتوى العضوى في بئر النجيلة - ساحل البحر الأبيض المتوسط - الصحراء الغربية - مصر

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استخدمت التسجيلات الجيوفيزيائية للآبار ممثلة بالقياسات الصوتية - المقاومة الكهربائية ودرجات الحرارة وذلك في إطار تكاملي لتحديد مستوى المحتوى العضوى لسماكات الطين المنتشرة في كل من عصرى الآلبيان / الآتبيان في بئر النجيلة الواقع على الساحل الشمالي الغربي للصحراء الغربية - مصر. وقد استخدمت أولاً معادلات تحديد معامل التمييز (D) وكذا قيم الفرق اللوغارتمي للمقاومة (Δ logR) وذلك لتحديد مدى التطابق والاختلاف بينهما كطريقتين مستحدثين في عدم وجود نتائج تحليل معملية للعينات البئرية. وقد أعطت هذه الدراسة توافق في النتائج تتمثل في أن جميع قيم معامل التمييز (D) تقع في النطاق السالب مما يعنى عدم تمتع نوعيات الصخور الطينية بمواصفات صخور الأم من حيث المحتوى العضوى وقد أُيدت هذه النتائج كلية بما تم الحصول عليه باستخدام طريقة الفرق اللوغارتمي للمقاومة الكهربائية. وبناءً على ذلك فإنه يمكن استخدام هاتين الطريقتين بشكل تكاملي لاعطاء أفضل النتائج في حالة غياب العينات البئرية.

Key Words : Organic richness, Resistivity, Sonic Western Desert.

ABSTRACT

Both sonic, resistivity and temperature information are used in an integrated manner in order to identify the organic richness of the shally intervals allover the Albian - Aptian rock sequence in Negelah well located at the north western coastal zone of Egypt. The sonic / resistivity cross plot are first used for calculation of the discriminant value (D). The Δ logR method is used in order to determine the TOC with the help of the temperature information. The results obtained from both methods gave confirmed results. The step comprising the conversion of the Δ logR values to TOC is not carried out because their values lie in the negative range.

INTRODUCTION

In the last three decades the different well log tools are extensively used for determination of organic richness in rock formations. Each tool has its specific response to the presence and abundance of organic matter. Both shale and carbonate rocks can contain organic matter. If organic matter exists in a subsurface layer, a three component system (matrix, organic matter and fluids) prevails. A relation between the total gamma ray intensity and organic richness has been proposed by Schmoker and Hester [1]. They show that the gamma ray method significantly underestimate the organic matter content. So, special sorts of calibration should be considered during application of this tool for such a purpose. supernaw et al. [2] and Fertle and Kotes [3] have used the gamma ray spectral logging tools for identifying and qualifying the organic richness. Herron [4] and Herron et al. [5] have studied the uses of pulsed Neutron spectral logs for organic richness identification Accirding to Passey et al. [6] the advantages of this tool include the sensitivity to low amounts of organic carbon and that no calibration with core data is required, although correction for the inorganic content must be made. Solid organic matter is less dense than the country rocks so density logs are effective for such purposes. Schmoker [7] is one of the pioneers that used the density logs for estimating organic matter content. Schmoker and Hester [1] applied the density tool in an area where four component (rock matrix, organic matter, fluid and pyrite) prevail. They concluded that the using of density tool is more correct when compared to the gamma ray logs. Meyer and Nederlof [8] gave a direct relation between the volume percentage of organic matter and the density of both shale and source rocks. This relation is given by the following equation.

$$\text{Vol}\ \% = \frac{\rho\,\text{shale} - \rho\,\text{source rock}}{\rho\,\text{shale} - \rho\,\text{organic matter}}$$

They also concluded that sonic logs can be used to determine source rocks qualitatively where a relatiive decrease in sonic transit time and an increase in resistivity indicate an organic rich layer in shale rocks. Sonic logs are sensitive to water / organic matter, mineral composition and to clay / carbonate. Resistivity tool is being considered as an effective tool in source rock identification. It is known that source rocks are generally laminated and thus are electrically anisotropic which inturn increases the resistivity values. When the source rock is enough mature, then resistivity increases dramatically.

Dallenbach et al. [9] developed a method using the sonic-gamma ray logs to provide a parameter that relates linearly to organic richness. Autric and Dumesnel [10, 11] modified the methods described by [9] to give more accurate presentation. Passey et. al [6] gave a method called the Δ logR which is a sort of separation between resistivity record represented on a logarithmic scale and any of the sonic, density and neutron log scale represented by normal scale. In their study they proposed a three component system (matrix, fluid and organic matter). Abdel Fattah [12] derived an equation based on the density log analysis using a three component system.

METHODS

The techniques described by [8] and [6] are used to estimate the organic reichness in a well located at the coastal Mediterranean zone of the western desert of Egypt (NW of Qattara depression) Fig. (1).

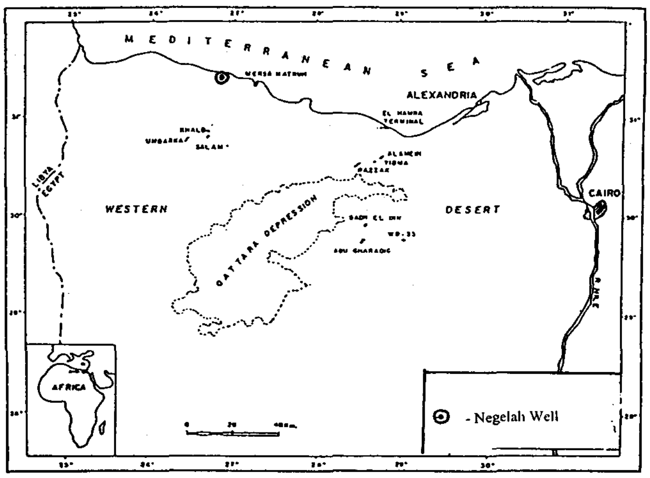

Fig. (1) - Location map of the study well.

THE DISCRIMINANT SCORE TECHNIQUE [8]

In this technique a special statistical method based on the scheme described by [13] is used. This technique is based on using both sonic / resistivity and density / resistivity cross plots to derive equations for source and non-source rock identification. Source and non-source rocks are classified as class (1) and (2), respectively. The results of their analysis provided two equations that can be used in most cases. The first equation is derived from the sonic / resistivity cross plot and takes the form:

$$\mathbf{D = -6.906 + 3.186\ Log\ \Delta t + 0.487\ LogR\ 75}$$

where :

D : is the discriminant score

Δt : is the interval transit time in microsecond per foot as obtained from sonic log.

$R_{75}°$: is the corrected temperature at (75°F or 24°C).

The $R_{75}°$ value can be obtained using Arp' s equation given by [14] which takes the form :

$$R_{75} = Rt\,(T + 7) / 82$$

where :

Rt : is the recorded well resistivity at the different depths and can be obtained from either Bottom Hole Temperature (BHT) and geothermal gradient from continuous temperature record.

T : is the recorded temperature at the desired depth.

The second equation which depends on density / resistivity cross plot takes reversed trend when compared with the sonic / resistivity cross plot. This equation takes the form :

$$D = 2.278 - 7.324 \, Log \, \rho + 0.387 \, Log \, R_{75}.$$

where :

ρ : is the density obtained from the density log.

The other terms are described before.

In both cases the calculated value of (D) is a function to the source / non - source rocks. If (D) equals positive value then we have source rock, if it is zero the case is undecided and if it is negative source rock is identified.

THE Δ LogR TECHNIQUE :

This technique is proposed by [6]. They used sonic, density and neutron logs from one hand and the resistivity log from the other. A matching technique ia applied between sonic / resistivity, density / resistivity and neutron / resistivity to define the Δ LogR zones. In application one of the three logs is scaled such that its relative scaling is two divisions on the normal scale per two resistivity cycles. The two curves are overlie and baselined in a fine grained "non - source" rock. A baseline condition exists when the two curves overlie each other at significant depth range. With the baseline established, organic rich intervals can be identified by separation and non - parallesim of the two curves. This separation is designated as Δ logR. The Δ logR separation is linearly related to the TOC% and is a function of maturity level repressted by the Level of organic Metamorphism (LOM), [15]. Figure (2) shows the relation between LOM - Δ logR and the TOC.

The most important step in this technique is to locate the baselined interval that should be used for calculation allover the well. As this baseline is established calculation of the Δ logR can be proceeded to all shally interval using special equations for both sonic / resistivity, density / resistivity and Neutron / resistivity.

SONIC / RESISTIVITY :

$$\Delta \, logR_{son.} = log\,(R / R_{bas.}) + 0.02\,(\Delta t - \Delta t_{bas.})$$

Where :

R : is the obtained resistivity value at the shally interval from resistivity log.

$R_{bas.}$: is the resistivity value at the overlie interval

Δt : is the obtained interval transit time of the shally interval.

$\Delta t_{bas.}$: is the interval transit time at the overlie interval.

DENSITY / RESISTIVITY :

$$\Delta \, logR_{Den.} = log\,(R / R_{bas.}) - 2.5\,(\rho - \rho_{bas}).$$

Where :

ρ : is the bulk densiity as obtained from the density log.

$\rho_{bas.}$: is the density value at the overlie interval.

The other terms are defined before.

NEUTRON / RESISTIVITY :

$$\Delta \, logR_{neu.} = log\,(R/R_{bas.}) + 4\,(\varnothing - \varnothing_{bas}).$$

where :

$\varnothing$: is the obtained neutron porosity value at the study interval.

$\varnothing_{bas}$: is the neutron porosity at the overlie interval.

LEVEL OF ORGANIC METAMORPHISM :

many techniques are used for the LOM determination. The method given by [15] one of these techniques. It is based on the calculation of the effective heating time ($t_{eff.}$) as can be deduced from the $T_{max.}$ and the geothermal gradient.

Table (1) Summary of the results obtained from Negelah well

Formation	thick.	t	Rt	R75	teff	LOM	logR	D
	3	90	4	9.6	31.2	9.1	- ve	- ve
	1	81	9	21.7	28.8	8.5	0.06	- ve
Kharita	4	93	3	7.3	30.6	9.15	- ve	- ve
	1	85	3	7.3	28.8	8.5	- ve	- ve
Formation	3	80	2	4.9	31.2	9.4	- ve	- ve
	2	80	9	22.3	32.4	9.4	0	- ve
	1	90	4	10	28.8	9.3	- ve	- ve
	2	90	5	12.5	32.4	9.4	- ve	- ve
	8	85	5	12.6	31.5	9.5	- ve	- ve
	4	80	10	25.2	30.6	9.5	- ve	- ve
	3	88	5	12.7	31.2	9.5	- ve	- ve
	5	90	4	10.3	31.7	9.6	- ve	- ve
	2	95	2	5.2	32.4	9.6	- ve	- ve
	2	77	8	20.7	32.4	9.6	- ve	- ve
	10	90	2	5.3	31	9.6	- ve	- ve
	2	90	3	7.9	32.4	9.8	- ve	- ve
	2	90	2	5.3	32.4	9.8	- ve	- ve
	5	86	3	7.9	31.7	9.8	- ve	- ve
	3	86	3	8	31.2	9.8	- ve	- ve
	1	70	1.5	4	28.8	9.8	- ve	- ve
	4	86	3.5	9.4	30.6	9.8	- ve	- ve
	3	70	1.2	3.3	31.2	9.8	- ve	- ve
	3	90	5	13.6	31.2	9.8	- ve	- ve
	3	80	2	5.5	31.2	9.8	- ve	- ve
	2	100	1	2.8	32.4	9.8	- ve	- ve
	3	70	1	2.8	31.2	9.8	- ve	- ve
	4	92	1.5	2.8	30.6	9.8	- ve	- ve
	2	90	1	4.2	32.4	10	- ve	- ve
	9	100	3	9.2	85	10	- ve	- ve
	7	90	3	9.3	85	10.1	- ve	- ve
Alamein	23	95	2	6.2	71	10.1	- ve	- ve
	2	65	8	25.2	72	10.2	- ve	- ve
	23	65	8	25.2	72	10.3	- ve	- ve
	4	85	2	7.2	71.4	10.8	- ve	- ve
Alam -	3	90	2	7.2	71.6	10.8	- ve	- ve
El - Buib	8	80	3	10.9	71.5	10.9	- ve	- ve
	5	92	3	10.9	72	10.9	- ve	- ve
	30	80	2	7.4	69	11	- ve	- ve
	4	85	1.5	5.6	68	11	- ve	- ve

N. B. thick.: Thickness in meter, Rt and R75 are the read and corrected temperature at 75 °F, respectively, teff : effective heating time, LOM : Level of organic Metamorphism, Δ logR : Sonic / resistivity separation and D : Discriminant function .

Δ LOGR - LOM AND TOC RELATION :

The total organic carbon (TOC) is determined using an equation relating the three parameters logR - LOM beside the TOC. it takes the form :

$$TOC = \Delta \log R \times 10^{(2.297 - 0.2688\ LOM)}$$

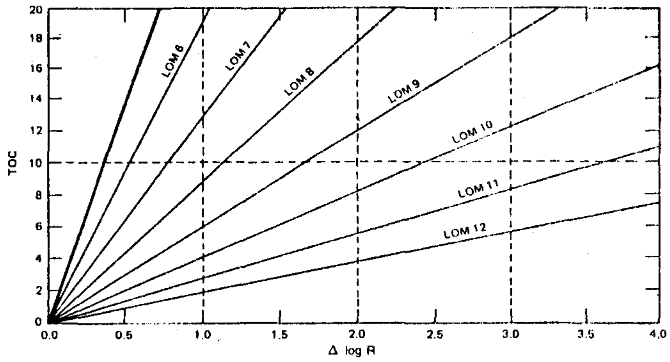

Fig. (2) – Δ logR - LOM and TOC relation (after Passey *et al.* [6])

APPLICATIONS AND DISCUSSION

The cross plot method described by [8] and the Δ logR technique described by [6] are used in this paper. Information collected from a well located at the north western coastal zone of Egypt are used for achieving this purpose. Although some other wells are available this well is the only one used for its suitable recording form to apply the Δ logR technique, All shally intervals distributed in a depth covering the ages from Albian to Aptian are considered. Beside the proper scale by which this well is represented its loaction has special importance because of its location with respect to some important oil fields in the western Desert. The hydrocarbon are accumulated mainly in faulted structures in most of these oil fiields. Analysis of information collected from some wells show some occurrences of source rocks at different depths allover the geologic time beginning from the Paleozic [16]. Negelah well which has sonic, resistivity and temperature records are suitable for applying one of the techniques described by [6]. It should be mentioned that not all shally intervals can be considered as source rock, so the application of the techniques may give negative results and the main task is to correlate or discriminate the results obtained from both techniques used. Concerning the sonic / resistivity cross plot the calculated (D) are found to be negative for all the study intervals. According to [8] these interval proved qualitatively as non-source rock intervals. The method given by [6] give more identified quantitive description of the source rocks based on the TOC%. To achieve that level of organic metamorphism (LOM) is determined using the T_{max} and $T_{eff.}$ given by [15]. Other methods such as vetrinite reflectance may be used for the same purpose. If the Δ logR values are negative, that means from the first view that no source rocks are available and in this case it is not necessary to calculate the LOM values. In this work two steps are followed : The first is to calculate the (D) values to disriminate between source and non-source rocks. The second one is the calculation of the Δ logR values. The baselined values of both resistivity and interval transit time are taken to be 6 ohm.m and 89 μs/ft., respectively. The results are represented by table (1). Although most of the LOM values lie in the beginning of maturation zone no source roock is identified where all Δ logR values are negative. It is observed that the (D) method and the (Δ logR) methods confiirms each other and can help in case of absence of other information in identifying the source rock intervals.

Thirty Nine shale intervals with a sum of of 198 m thickness are considered in this study.

CONCLUSION

Application of both cross-plot and Δ logR techniques at all shale intervals at Negelah well show good correlation between both of them. Correlation and integration between them proved all the study intervals to be barren from organic carbon and can not considered as source rock. Both techniques confirmed each other and can be used in an integrated manner in case absence of adequate information from core samples.

REFERENCES

[1] **Schmoker, J. and T. C. Hester.** 1983. Organic carbon in Bakken Formation, United State Portion of Williston Basin, AAPG Bull., v.67 : 2165 - 2174.

[2] **Supernaw, I. R., D. M. Arnold and A. J. Link.** 1978. Method for in - situ evaluation of the source rock potential of earth formation : United States Patent. 4 : 071 - 744.

[3] **Fertle, W. H. and H. H. Kotes.** 1980. Gamma - ray spectral evaluation techniques to identured shale reservoir and source rock characteristics, Journal of Petroleum Technology, 31 : 2053 - 2062.

[4] **Herron, S. L.** 1986. Derivation of a total organic carbon log for source rock evaluation : Transaction of 27 th SPWLA Annual logging Symposium, paper HH.

[5] **Herron, S. L., L. Letendre and M. Dufour.** 1988. Source rock evaluation using geochemical information from wireline logs and core (abs.), AAPG Bull., 72 : 1007.

[6] **Passey, Q. R., S. Creaney, J. B. Kulla, F. Moretti and J. D. Stroud.** 1990. A practical model for organic richness from porosity and resistivity logs, AAPG Bull., 74 : 1777 - 1794.

[7] **Schmoker, J. W.** 1979. Determination of organic content of Appalacian Devonian shale from formation density log. AAPG Bull. 63 : 1504 - 1537.

[8] **Meyer, B. L. and M. H. Nederlof.** 1984. Identification of source rocks wireling logs by Density/Resistivity and Sonic transit time / Resistivity cross plots, AAPG Bull., 68 : 121 - 129.

[9] **Dallenbach, J., J. Espitalie and F. Lebreton.** 1983. Source rock logging : Transaction of the 8th European SPWLA Symposium.

[10] **Autric, A. and p. Dumesnil.**1984. Les diagraphie de resistivite radioactivite temps de transit (Ts) evaluent le contenu en matiers organiques des roches a faible permeabilite. Societe pour 1, avancement de l'Interpretation des Diagraphies, 9th international formation evaluation : Transaction, paper 40.

[11] **Autric, A. and P. Dumesnil,** 1985. Resistivity, radioactivity and sonic transit time logs to evaluate the organic content of low permeabilti rocks. The log Analyst, 26 : 36 - 45.

[12] **Abdel Fattah, Th.** 1994. Source rock Evaluation of the Pre - Aptian section at Matruh Sub - Basin Northwestern Desert, Egypt, Delta Journal of Science, 17 : 117 - 1124.

[13] **Kendal, M. G.** 1961. A cource in multivariate analysis : London, Macmillan, 195P.

[14] **Schlumberger,** 1989. Log Interpretation Principle, Schlumberger Eduucational Services.

[15] **Hood, A. C., M. Gutjahr and R. I. Heacock.** 1975. Organic metamorphism and the generation of petroleum: AAPG Bull., 59 : 986 - 996.

[16] **Abdel Fattah, Th.** 1993. Temperature Effect on Hydrocarbon Effect on Hydrocarbon Generation at Some Paleozoic Formations NW - Desert - Egypt. A paper presented at the 1st Symposium - Geology of Sirt Basin - Tripolo - Lybia.