TOC PREDICTION FROM WELL LOGS USING Δ LOGR METHOD AND NEURAL NETWORK TECHNIQUE IN THE NORTHERN DEZFUL EMBAYMENT, ZAGROS,IRAN

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ABSTRACT

In order to evaluate some of the source rocks in Dezful Embayment such as Pabdeh and Gurpi formations 14 wells distributed in different oil fields of the northern Dezful Embayment were selected and TOC % calculated by Δ log R method and neural network. Results were compared with measured data (by Rock Eval). The results coming from neural network have more correlation with measured data than Δ log R results. We calculated TOC % based on combination of resistivity, sonic logs and level of organic metamorphism (LOM).

ISO TOC contour map in this area were constructed, and also made zonation with respect to vertical TOC variation in Pabdeh and Gurpi formations based on geochemical criteria.

The study shows:

1- Pabdeh formation has one or two rich zones (very good) of organic matter and

   Gurpi formation has no rich zone(except Lali and Palangan oil fields).

2- Average organic matter amount (TOC)% in Pabdeh formation is about 1-2% and in Gurpi formation is 0.5-1.5%.

3- Neural network results have more correlation with measured data than Δ logR results, it is suitable for all type rocks that have organic matter.

INTRODUCTION

Total organic carbon (TOC) is one of the important parameters that must be estimated for source rock evaluation. Source rocks are usually shales, marls and limestones which contain considerable amounts of organic matter. Amount of TOC determined by Rock eval, this instrument measures (TOC %) in cutting or core has been obtained from samples retrieved at intervals down a well. Sample spacing is usually 18 m, and it can be difficult to obtain an appropriate average value from this data. So number of researchers tried to make a correlation between well log responses and organic carbon richness of rocks because well logs provide continues measurement of vertical sections with a resolution of about 0.15 m. Schmoker (1979), Schmoker and Hester (1983 and 1989) used both gamma ray and density logs for calculation of the wt% TOC. Passey et al. (1990) presented a technique that's called Δ log R .

Δ log R technique:

This technique uses overlaying of porosity logs (sonic, density and neutron) and resistivity log for calculating of TOC % .When a rock is barren (free of fluid and organic matter), its density is high but if a rock contains considerable amount of organic matter, it has high resistivity values. Δ log R technique is based on curve separation between baselined fine grained non -source rock and the actual source rock interval.

In case of resistivity/sonic

$\Delta \log Rt = \log_{10}(R/R_{base\ line}) + .02*(\Delta t - \Delta t_{baseline})$ ……(1)

Where :

Δ.logR: is the curve separation measured in log. (Resistivity cycles)

R: is the measured resistivity values obtained from resistivity tool

Δt : is the measured sonic values from well log

$R_{baseline}$: is the resistivity corresponding to the measured $\Delta t_{baseline}$

TOC % is depend on level of organic matter maturity that's called LOM so

$TOC\% = \log R * 10^{(2.297 - 0.1688 LOM)}$ .....(2)

Level of Organic Metamorphism (LOM) can be obtained from a variety of sample analysis (e.g. vitrinite reflectance, thermal alteration index and Tmax method described by Hoode et al. (1975). Noteworthy it is an important parameter, that must be estimated exactly because minor error will lead to major error in TOC%, for example only 1 degree inaccurate decrease in LOM will result in a TOC increase remarkably the real value.

LOM 8-9 corresponds to early maturity of kerogen and LOM 12-13 corresponds to ending maturity of kerogen

NEURAL NETWOORK TECHNIQUE:

Neural networks are a well developed computational intelligence technology with many possible applications in the oil and gas industry. An artificial neural network is a system based on the operation of biological neural networks, in other words, is an emulation of biological neural system. A neural network consists of large number of units joined together in a pattern of connections. Units in a net are usually segregated into three classes: input units, which Receive information to be processed, output units where the results of the processing are found, and units in between called hidden units. Those hidden units compute their activation values in the same way, and send them along to their neighbors. Eventually the signal at the input units propagates all the way through the net to determine the activation values at all the output units.

Huang and Willimson(1996) applied neural network modeling for source rock characterization.

STUDIED AREA:

The Dezful Embayment is the most important hydrocarbon provinces in Iran, its located in south of Iran with 50000 sq km, produces from the Asmari limestone of Early Miocene and from the Cenomanian Sarvak limestone, and contains some 400 billion barrels of oil-in-place, or 7% of the oil global reserves .Three source rocks are associated with these reservoirs, the Kazhdumi Fm of Albian, Gurpi F.m of Upper Cretaceous and the Middle Eocene Pabdeh Fm.

RESULTS AND DISCUSSIONS

Fourteen wells located at the northern part of the Dezful Embayment were considered in this study. A well log analysis based on resistivity and sonic logs is carried out. We estimated LOM from vitrinite reflectance or Easy Ro method that can be calculated by oil generation modeling software. We used P.B.M in this study for obtaining of maturation trend versus depth diagram, and then estimated LOM. Resistivity values are corrected as result of temperature effect, in according to Schlumberger formula (1989). In According to Schlumberger (1989) the measured resistivity (Rt) at a temperature (t) is related to the standard resistiv ity at 75^{o}F (24^{o}C) is given by Arps formula as follows:

$$Rt=R75*82/(T+7) \quad (3)$$

Where :

Rt= measured resistivity.

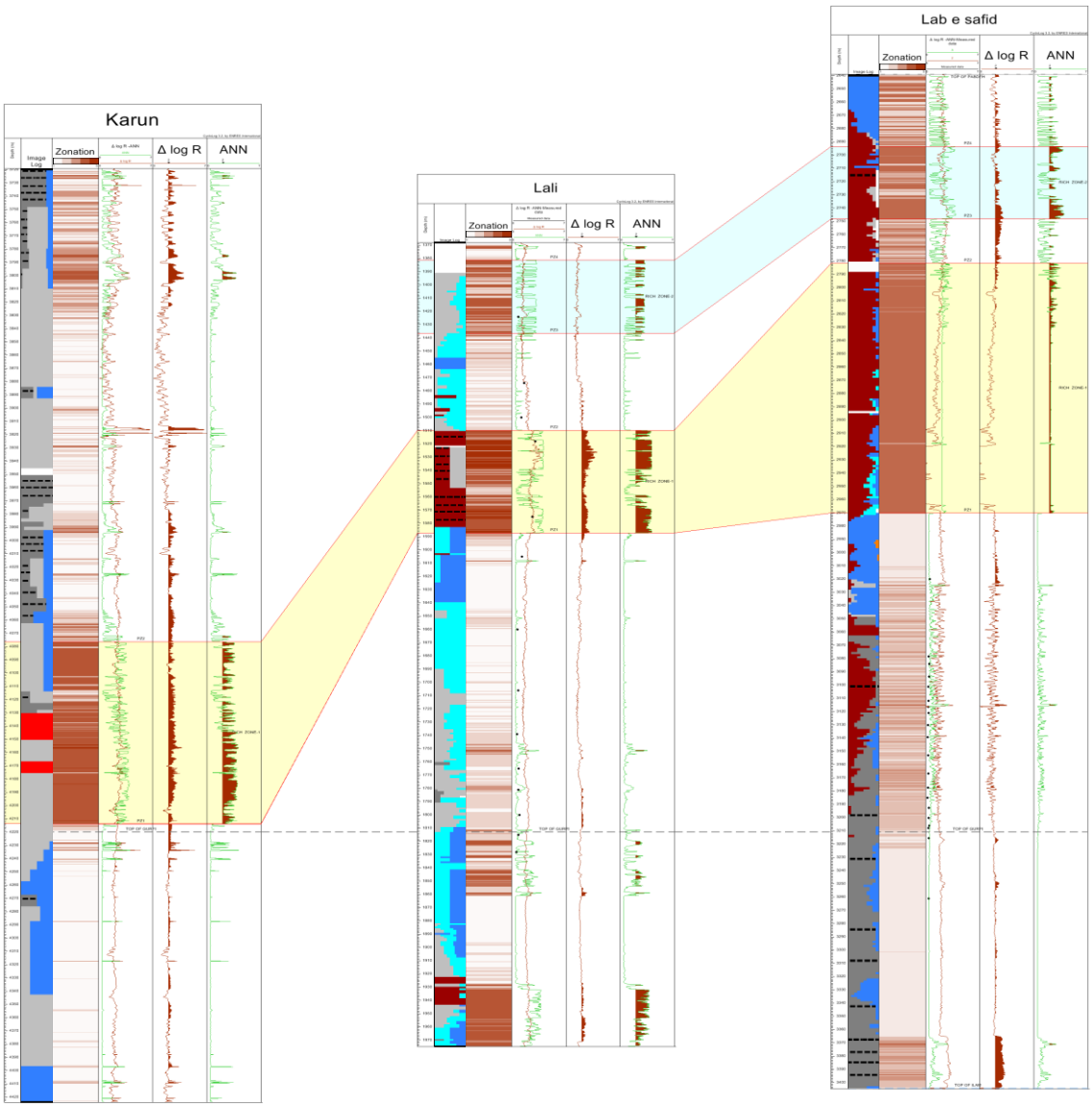
R75=Standard resistivity .

T= Temperature in ^{o}F .

The dominated lithology of Kazhdumi F.m is Shale, Pabdeh & Gurpi F.ms are composed of limestones ,marls and shales, Then we calculated TOC% in Gurpi and, Pabdeh F.ms based on Δ log R technique, we got 34 percent correlation between results and measured data. Since this technique is suitable for shale, results have good correlation with measured data in shale interval and no correlation in limestone and marl. We gathered measured data and selected 70 data of them (data selected from shale, limestone and marl). We made a table with 5 columns contain depth, resistivity, sonic, LOM and measured data , then used neural network toolbox from Matlab software and we entered resistivity, sonic and LOM (as input) and measured data(as target). After the training were simulated all wells. We got 70 percent correlation between neural network results and measured data. The results had good correlation to shale, limestone and marl. This method is suitable for all type rocks that have organic matter. Therefore we accepted neural network results and it became foundation for our study, but in order to illustrate more correlation neural network results than Δ log R technique results to measured data, results come from three method are combined and represented in FIG.1(both based on Δ log R technique and neural network approach associated to measured data). Source rocks zoned with respect to variation of calculated TOC % versus depth and based on geochemical criteria (Table1) which is separated by different color (FIG. 1).

Table 1- Source rock classification based on TOC percentage.

Source rock quality	Amount of TOC(%)
Poor	0-0.5
Fair	0.5-1
Good	1-2
Very good	2-4
Excellent	>4



LEGEND

LITHOLOGY

ARGILLACEOUS LIMESTONE	BITUMEN SHALE	LIMESTONE	SANDSTONE
ANHYDRITE	BROWN SHALE	MARL	SHALE
ASPHALT	CHERT	RED MARL	NO SAMPLE

S.R GEOCHEMICAL EVALUATION: POOR | FAIR | GOOD | VERY GOOD | EXCELLENT

FIG.1-Cross section between Karun, Lali and Lab e safid

This figure is illustrate TOC% variation both vertically & horizontally, comparison between results, source rocks zonation based on geochemical criteria and rich zone

Then some cross sections were prepared in different directions to study TOC % variation in wells. Average organic matter amount (TOC%) in Gurpi F.m varies between 0.5 in Zeilioi and 1.5 % in Lali oil fields. Gurpi F.m has rich zone only Lali and Palangan oil fields. Average organic matter amount (TOC%) in Pabdeh F.m vary between 0.93 in Naft safid and 1.84 % in Qaleh nar oil fields(FIG.2). Pabdeh F.m has one or two rich zones (very good) that has formed commonly in shaly rocks. Thickness of rich zone varied between about 27 m in Kupal to 180 m in Lab-e-safid.

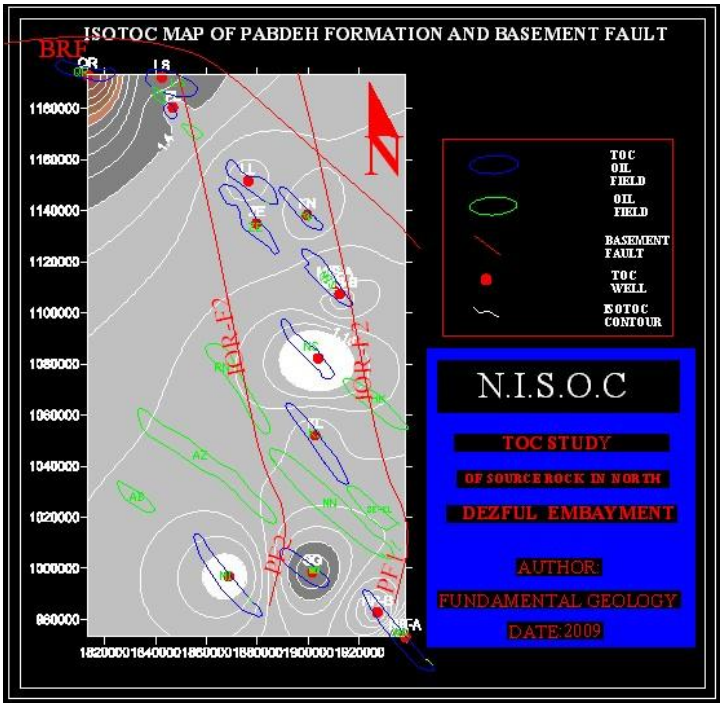


FIG.2- ISO TOC MAP OF PABDEH FORMATION

This figure is illustrate variation of Pabdeh average organic matter amount (TOC%) in the northern part of Dezful Embayment and basement faults effect on TOC%

The results suggest that Gurpi and Pabdeh F.ms TOC% in some wells are decreased considerably, further investigations indicated that geothermal gradient of these wells are higher than other wells, high geothermal gradient caused maturation of these formations and so, parts of their TOC has converted to oil. Its needed to say geothermal gradient rise near the basement faults and border of paleohighs(Heidarifard et al 2008).

ISO TOC map in northern part of Dezful Embayment indicate variation of TOC % is related to lithology, shales have maximum TOC%, then we have marls and limestones have minimum TOC.%

CONCLUSIONS:

1-Pabdeh formation has one or two rich zones (very good) of organic matter and Gurpi formation has no rich zone(except Lali and Palangan oil fields).

2-Average organic matter amount (TOC)% in the Pabdeh formation is about 1-2 % and in the Gurpi formation is 0.5-1.5% that is accordance with shale content in source rock.

3-Thickness of the rich zone varies between about 27 m in Kupal to 180 m in Lab-e-safid.

4-Neural network results have more correlation with measured data than Δ logR results because Δ logR equation suitable for only shaly rocks , use for carbontic rocks give unreliable results, but neural network can be used in both of them.

5- LOM values must be estimated exactly in Δ logR method otherwise results remarkably wrong, but in neural network method LOM values is less important, it is only enough to correct relative LOM values.

6-The wells located near the basement lineaments and paleo high borders show a TOC % lower than other wells for example RR-B than RR-A, because these wells have geothermal gradient higher than others, so that Pabdeh and Gurpi formations matured as result of TOC % decrease.

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