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Study of Predictability and Forecast Efficiency of Rock Eval Data for Accumulation Prediction*

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Abstract

Rock Eval (RE) analysis, comprising heating of small amount of pulverized rock (less than 100 mg) in inert environment, initially at 300^{o} C for 3 minutes, followed by programmed pyrolysis to 650^{o} C and further under oxic environment, up to 850^{o} C, provides data on free hydrocarbon content (S1), petroleum generative potential (S2), thermal maturity (Tmax) and organic richness (TOC) of the sample. Accumulation is indicated by free hydrocarbon content (S1) and calculated parameters: Production Index (PI=S1/S1+S2) and Oil Saturation Index (OSI=S1/TOC*100).

We have examined RE Data of 147 side wall/conventional core samples of sandstone/siltstone lithology from 22 exploratory wells of Cambay Basin, India, each corresponding to a tested interval that was identified based on geological and geophysical (G&G) data to determine effectiveness of geochemical data in terms of both the "Predictability: Percentage of oil bearing/dry horizons, predicted based on geochemical data out of total number of oil bearing/dry horizons found after testing" and "Forecast Efficiency: Percentage of oil bearing/dry horizons found after testing out of total number of geochemical predictions."

As hydrocarbons higher than C24 elute with S2 peak (Tarafa et al., 1983), in the present work, RE pyrolysis was carried out both on original and organic solvent extracted rock samples to obtain correct estimates of free oil. The difference between $S2_{original}$ (S2 for original sample) and $S2_{extracted}$ (S2 for solvent extracted rock sample) was added to $S1_{original}$ (S1 for original rock sample) to get $S1_{total}$ for total free oil content. PIoriginal ($S1_{original}/S1_{original}+S2_{original}$) and PI_{total} ($S1_{total}/S1_{total}+S2_{extracted}$) were also calculated. Four different sets of criteria of S1 and PI values: $S1_{original}>0.5$ and $PI_{original}>0.4$ (CR1); $S1_{total}>0.5$ and $PI_{total}>0.4$ (CR2); $S1_{original}>0.5$ and $PI_{original}>0.3$ (CR3); and $S1_{total}>0.5$ and $PI_{total}>0.3$ (CR4) were examined as indicators of presence of accumulated hydrocarbons vis-à-vis the actual testing results (Table 1).

Out of the 147 tested intervals, 47 are oil bearing and 100 are dry or water bearing or show oil traces (non-accumulation). For oil bearing intervals, the 'Predictability' and 'Forecast Efficiency' respectively are 49% and 79% for CR1; 71% and 81% for CR2; 66% and 78% for CR3; and 74% and 70% for CR4 (Table 2A and Figure 1A).

On the other hand, of the intervals identified as non-accumulation zones employing CR1, CR2, CR3, and CR4 respectively, 80%, 83%, 86%, and 83% were found to be dry or water bearing or show oil traces (Table 2B and Figure 1B).

Observations indicate that the geochemical predictions employing the CR4 ($S1_{total}$>0.5 and PI_{total}>0.3) yields the optimum results for oil bearing horizons. The criteria results in 74% 'Predictability' and 70% 'Forecast Efficiency' for oil accumulations and 83% of predicted non-accumulation intervals were found dry or water bearing or show oil traces on testing.

Out of the 147 studied intervals, 31 intervals have OSI data. Inclusion of OSI>100 mg HC/gm TOC along with CR4 criteria results in increased 'Predictability' to 89% and 'Forecast Efficiency' to 100% (Table 3 and Figure 2).

The study suggests that predictions of accumulation based on both the RE and G&G data can yield Forecast Efficiency up to 100%, when OSI data is included, or 70%, without considering the OSI, compared to only 32%, if the prospects had been ranked only by conventional G&G data. Rapid RE screening, preferably at drill locations, of intervals identified for testing through conventional G&G data can drastically reduce risk and costs.

Acknowledgment

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Reference Cited

Tarafa, M.E., J.M. Hunt, and I. Ericsson, 1983, Effect of hydrocarbon volatility and adsorption on source-rock pyrolysis: Journal of Geochemical Exploration, v. 18, p. 75-85.

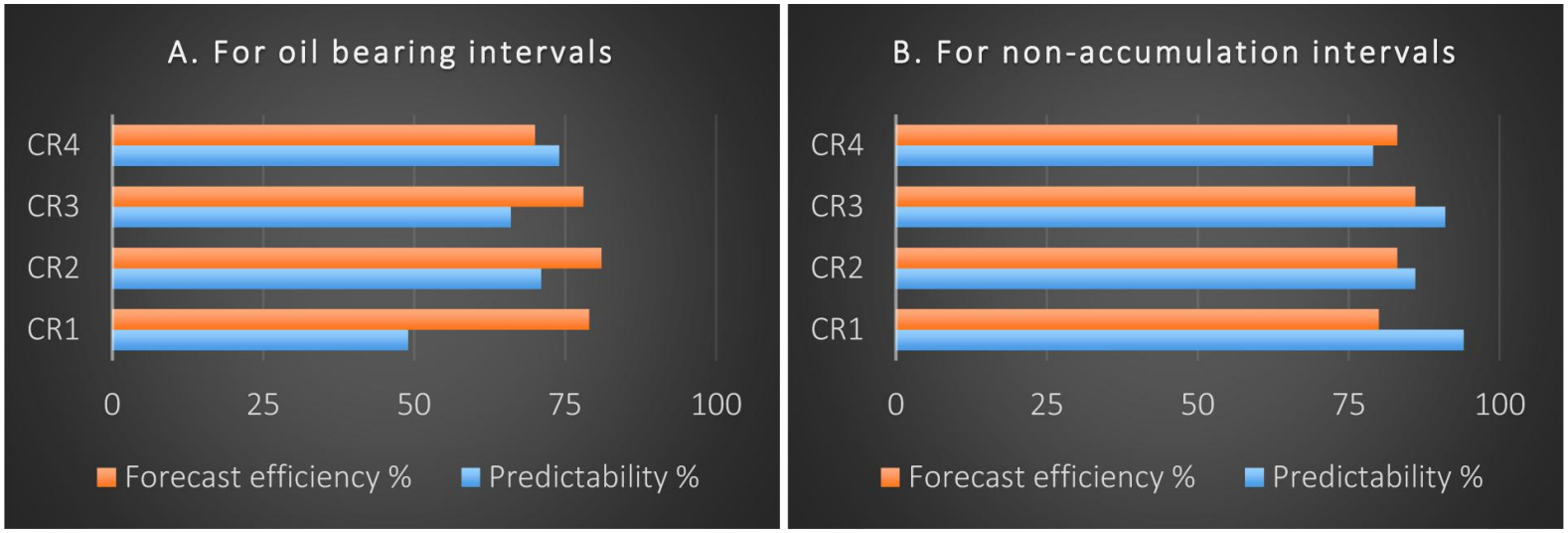

Figure 1. Predictability and Forecast Efficiency of geochemical data (A) for oil bearing intervals, and (B) for non-accumulation intervals.

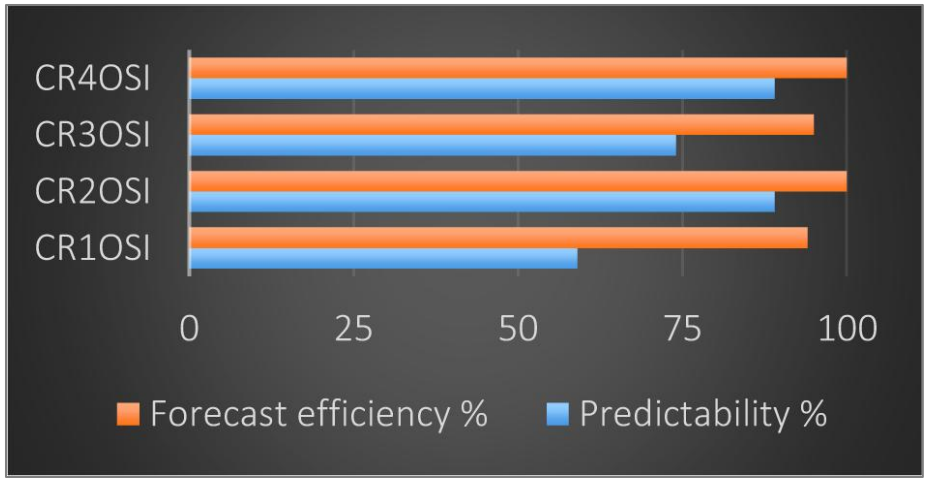

Figure 2. Predictability and Forecast Efficiency of geochemical data using different criteria's with OSI data.

Criteria	$S1_{original}$ (mg HC/gm rock)	$PI_{original}$	$S1_{total}$ (mg HC/gm rock)	PI_{total}
CR1	>0.5	>0.4	-	-
CR2	-	-	>0.5	>0.4
CR3	>0.5	>0.3	-	-
CR4	-	-	>0.5	>0.3

Table 1. Four criteria employed to identify hydrocarbon accumulation.

A) for oil bearing intervals			B) for non-accumulation intervals		
Criteria	Predictability %	Forecast efficiency %	Criteria	Predictability %	Forecast efficiency %
CR1	49	79	CR1	94	80
CR2	71	81	CR2	86	83
CR3	66	78	CR3	90	86
CR4	74	70	CR4	79	83

Table 2. Predictability and Forecast Efficiency of geochemical data.

Criteria with OSI	Predictability %	Forecast efficiency %
$CR1_{OSI}$	59	94
$CR2_{OSI}$	89	100
$CR3_{OSI}$	74	95
$CR4_{OSI}$	89	100

Table 3. Predictability and Forecast Efficiency of geochemical data using different criteria's with OSI data.

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