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Hydrocarbon Generation Potential of the Zagros Basin, Pabdeh Formation Using Rock-Eval Pyrolysis Technique

Mehdi poorjahangiri
Saeedeh Senemari

Summary

One of the most important petroleum source rocks in the Zagros basin is the Pabdeh Formation that has been evaluated by geochemical techniques. The aim of this study was to assess the quality of organic matter, check thermal evolution and highlight Pabdeh Formation potential as a source rock of Mansouri oilfield located in Zagros Basin. Based on HI versus Tmax and HI versus OI diagrams were used in classifying the organic matter in the formation indicating the presence of Type II kerogen. Most samples of the Pabdeh formation have Tmax values more than 435ºC indicate that the shale of formation is thermally mature with respect to petroleum generation. Hydrogen Index (HI) values range from 150 to 500 mgHC/g TOC and S1 + S2 yields values ranging from 0.53 to 26.06mgHC/g rock, suggesting that the shale have oil generating potential. The TOC of shale samples of the studied Pazanan Well no. 4 ranges from 0.96 to 4.63 %, an indication of a very good source rock of terrestrially derived organic matter. So, investigation of the variation S1 + S2 and TOC parameters indicated that Pabdeh Formation (in the well) is assessed a good source rock. Also with T max examination reveals that Pazanan is mature enough to generate hydrocarbon and has entered oil generation window.

Theory / Method / Workflow

Source rock evaluation studies entail assessing the hydrocarbon generating potential of sediments by looking at the sediment's capacity for hydrocarbon generation, type of organic matter (kerogen) present and what hydrocarbons might be expected after generation, and the sediment's thermal maturity and how it has influenced generation [1]. The commonly used analytical methods for these studies during hydrocarbon exploration are the total organic carbon (TOC) content analysis, Rock-Eval pyrolysis, and vitrinite reflectance analysis. Some of the possible drawbacks in using these analytical techniques can be overcome by integrating the results of various analyses, and keeping in mind the possible errors that might arise from each method.

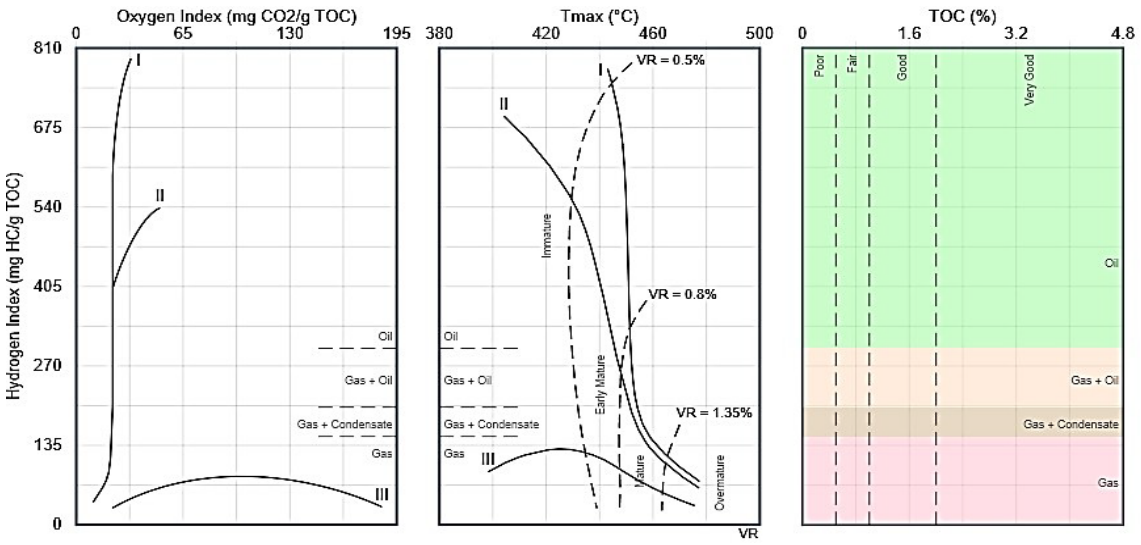
Results, Observations, Conclusions

Total Organic Carbon (TOC) Contents and Rock-Eval: Analyses The pulverised rock samples submitted to GH Geochemical Laboratory, University of Liverpool, were analysed for TOC contents, HI, the oxygen index (OI) and Tmax (temperature of maximum kerogen pyrolysate yield), using Rock-Eval II instrument. The oven was initially kept isothermally at 300℃ for 3 mins during which time the free hydrocarbons are volatilized and the S1 peak is measured by the Flame Ionization Detector (FID). Pyrolysis of organic matter was later performed at 300 – 600℃ with a temperature rise of 25℃/min. This is the phase of volatilization of the higher carbon number hydrocarbons compounds (>C40) as well as the cracking of non-volatile organic matter. The

hydrocarbons released from this thermal cracking are measured as the S2 peak (by FID). The temperature at which S2 reaches its maximum depends on the nature and thermal maturity of the kerogen and this is measured as Tmax. The CO2 produced from kerogen cracking is trapped in the 300 - 390℃ range. The trap is heated, and CO2 is released and detected on a Thermal Conductivity Detector (TCD) during the cooling of the Pyrolysis oven (S3 peak). The HI was determined as the yield of reduced products of pyrolysis (S2) relative to the TOC (mg HC/g TOC) and OI is the yield of the oxygen and bound organic carbon (S3).

Organic Matter (Kerogen) Type: The organic matter type is an important parameter in evaluating source rock potential and has important influence on the nature of the hydrocarbon products [11], [12] and [13]. Peters [14] proposed that, for mature source rock, HI for gas-prone organic matter is less than 150, gas-oilprone organic matter is ranged between 150 and 300, whereas the oil-prone organic matter is more than 300 HI. Thus, it is very important to determine the kerogen types of the source rocks as they have a first-order control on the hydrocarbon products after maturation. The results from this study showed that the HI values are greater than 300 (Table 2) for the majority of the samples. Thus, they are oil-prone. However, there are few exceptions. The Gault Clay sample has HI value of 66 mg/ g, meaning that it is an ideal potential gas generator. The Nothe Clay and one of the Oxford Clay samples have the HI values 185 mg/ g and 229 mg/ g respectively indicating that they are gas-oil-prone.

Figure 1



Source Rock Richness and Generation Potential: The organic matter richness of source rocks is determined usually using the total organic carbon content, which is the total amount of organic material (kerogen) present in the rock, expressed as a percentage by weight (TOC wt.%). By and large, the higher the TOC, the better the chance and potential for hydrocarbon generation. According to Peters, the TOC values between 0.5 and 1.0% indicate a fair source-rock generative potential, TOC values varying from 1.0 to 2.0% reflect a good generative potential, TOC values between 2.0 and 4.0% refer to a very good generative potential, and rocks with TOC greater than 4.0% are considered to have excellent generative potential. In line with this criterion, the TOC results of rock samples in this study show that Dehluran sample (Table 1) has a fair generative potential, the pazanan sample has moderate generative potential while the other samples have good to excellent generative potential. This is demonstrated in the plot of the Rock–Eval HI versus TOC (Figure 1). TOC results of Naft E sefid,Mansouri,Gachsaran shows Low to Fair generative potential, On the other hand Lab E Sefid has the lowest Organic Content and maturity.According to Hydrogen Index (Table 1) aside Dehluran with oil and gas generative potential others have only oil generation potential.

Table 1

Well Name	*Code Samp*	*Depth(m)*	*TOC%*	*Tmax*	*S1*	*S2*	*HI*	*PI*	*S1+S2*	*Oil Generation Potential*
Pazanan	PDD 1	2438	0.96	428	1.31	3.63	378	0.26	4.94	WEAK
	PDD 2	2505	4.63	428	3.63	22.43	484	0.14	26.06	GOOD
	PDD 3	2563	1.42	429	1.81	6.85	482	0.21	8.66	GOOD
	PDD 4	2609	0.28	429	0.4	0.84	300	0.32	1.24	WEAK
Gachsaran	PDD 10	1992	0.26	430	0.36	0.87	335	0.29	1.23	WEAK
	PDD 11	2047	0.99	432	0.87	3.92	396	0.18	4.79	WEAK
	PDD 12	2106	2.26	437	1.61	8.73	386	0.15	10.34	GOOD
Naft-sefid #34	PDD 15	2106	0.37	422	0.37	0.69	186	0.35	1.06	WEAK
	PDD 16	2135	0.23	425	0.22	0.36	157	0.23	0.58	WEAK
	PDD 17	2260	2.29	424	1.37	10.16	444	0.12	11.53	GOOD
	PDD 18	2350	0.44	426	0.24	0.29	66	0.45	0.53	WEAK
Dehluran	PDD 28	3022	1.58	431	11.11	2.98	189	0.79	14.09	GOOD
	PDD 29	3160	2.62	434	15.54	5.77	220	0.73	21.31	GOOD
	PDD 30	3408	6.47	422	24.06	23.78	368	0.5	47.84	GOOD
Lab-sefid #1	PDD 35	3020	0.54	430	0.49	0.46	85	0.52	0.95	WEAK
	PDD 36	3084	0.48	438	0.47	0.38	79	0.55	0.85	WEAK
	PDD 37	3206	0.48	434	0.41	0.28	58	0.59	0.69	WEAK
	PDD 38	3261	0.4	435	0.39	0.24	60	0.62	0.63	WEAK
	PDD 39	3340	0.38	400	0.52	0.17	45	0.75	0.69	WEAK
Mansuri #1	PDD 40	2715	4.76	418	2.7	20.9	422	0.12	23.6	GOOD
	PDD 41	2804	0.58	431	0.86	1.57	271	0.35	2.43	WEAK
	PDD 42	2889	0.31	424	0.48	0.38	123	0.56	0.86	WEAK

Novel/Additive Information

Results of TOC and Rock-Eval analyses of potential hydrocarbon source rocks in the Mansouri Oilfield of the Zagros Basin show that:

(i) Dehluran, Pazanan, Mansouri, and Naft e Sefid contain predominantly Type II kerogen and are both oil- and gas-prone, and the organic matter content intermediate from good to very good and so does the generative potential from moderate to excellent

(ii) Lab E Sefid contains mainly Type III kerogen and is gas prone, but the organic carbon content is generally only poor to fair so generative potential is lean; and.

The studied outcrop samples have right kerogen types and the potential to generate hydrocarbons at a suitable temperature in depth. The variation in the kerogen types may be attributed to the relative stratigraphic positions of the outcrops within the basin. The results of this study also unlocked the petroleum generation potential of the least studied organic-rich rocks in the basin - the Pazanan, Gachsaran, Naft E Sefid, Dehluran revealed that they have potential for hydrocarbon generation except for the Lab E Sefid with poor to fair or lean generative potential. Hence, it is recommended that these wells should be considered for hydrocarbon exploration in the study area.

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