Azadegan Sandstone Reservoir Oils Comparison in North Persian Gulf Oil Fields, Iran

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Abstract

The Iranian part of the Zagros Range and Persian Gulf accounts for 10.9% and 16% of the world's proven oil and gas reserves.

Azadegan Sandstone reservoir (equivalent with Burgan, Middle Cretaceous) produces oil in different fields including Sorosh, Nowroz, Binaloud-B and Foroozan in the north Persian Gulf with API gravity ranging from 21.4 to 24.3.

Based on Rock Eval Pyrolysis, different formations above and beneath Azadegan Sandstone reservoir showed non indigenous hydrocarbon contamination in Binaloud-B oil field. Moreover, hydrocarbon shows such as high viscosity oil and bitumen confirmed during drilling of Tertiary to Jurassic formations in Binaloud structure. Results of Geochemical analyses in Azadegan oil of Binaloud-B demonstrate some dissimilarity with same reservoir in Abouzar and Sorosh oil fields and some relationship with Jurrasic reservoirs of Foroozan oil field. Pr/Ph ratio, DBT/Phen, C28 Sterane are most important parameters in which the Binaloud-B oil sample is completely different from the same reservoir's oil in Sorosh and Abouzar fields. For example Pr/Ph is equal to 0.76 in Binaloud-B which is close to 0.88 and 0.64 in Upper Jurassic Carbonate (Manifa) and Surmeh (Arab) reservoirs of Foroozan oil field, respectively. It is entirely different with 1.04 and 1.13 values of Sorosh and Abouzar oil samples.

Gas chromatogram comparison of the oils makes obvious bimodality of Binaloud-B Azadegan reservoir's oil. Charging the reservoir with two different source rock intervals could be inferred by GC. The bimodality could be seen in Azadegan reservoir of Sorosh field with a very minor extent. This disappears completely in Azadegan reservoir oil of Abouzar field.

Considering different biomarker parameters containing maturity and source dependent parameters, the Azadegan sandstone reservoir of Binaloud-B charged mainly by the same source rock as Foroozan's older reservoirs alongside a secondary source rock.

Introduction

The Persian Gulf Basin is the richest region of the World in terms of hydrocarbon resources. According to different estimates, the basin contains 55–68% of recoverable oil reserves and more than 40% of gas reserves. The biggest Gas Reservoir in the World (South Pars / North Dome) is also located in the Persian Gulf.The Iranian part of the Zagros Range and Persian Gulf accounts for 10.9% and 16% of the world's proven oil and gas reserves.

The main Hydrocarbon Trap in Zagros Range and Persian Gulf is Structural Trap which is mostly, Anticlinal Trap (or Fold Trap).The main reservoir rock in the Iranian part of Persian Gulf is carbonate rock but there is some clastic reservoir in both regions. There are four main petroleum reservoir target horizons in different ages in the Persian Gulf. The youngest is in Cenozoic, and then there are two major reservoir targets in Mesozoic while the oldest is in the Upper Paleozoic-lower Mesozoic horizon. The main source rock in the Persian Gulf is shale and marly shale which is situated in different horizons and ages. The youngest source rock is in Cenozoic- Mesozoic, and there are two important horizons as source rocks in Mesozoic, while the fourth one is in Paleozoic horizon (Fig. 1).

According to source rock study and ID modeling which previously has been done in the study area, at list the oil was generated from Upper Cretaceous to present time (NIOC).

Burgan Formation (lower-middle Albian), In the type area in the Burgan Field, is a sandstone unit that may reach a thickness of 351 m (1150 ft), of which intercalated shale may represent only 10% of the thickness. It consists of well-bedded, well-sorted, littoral sands deposited near a delta front on a gradually sinking shelf. The shale is estuarine and contains abundant plant remains (including amber), but foraminifera are absent (Alsharhan, 1994).

Azadegan Sandstone Reservoir consists of sandstone and shale of a terrestrial to marginal-marine environment. The formation has a gross reservoir thickness of 65-200 m (213-650 ft) and a net reservoir thickness of 30 m (98 ft).

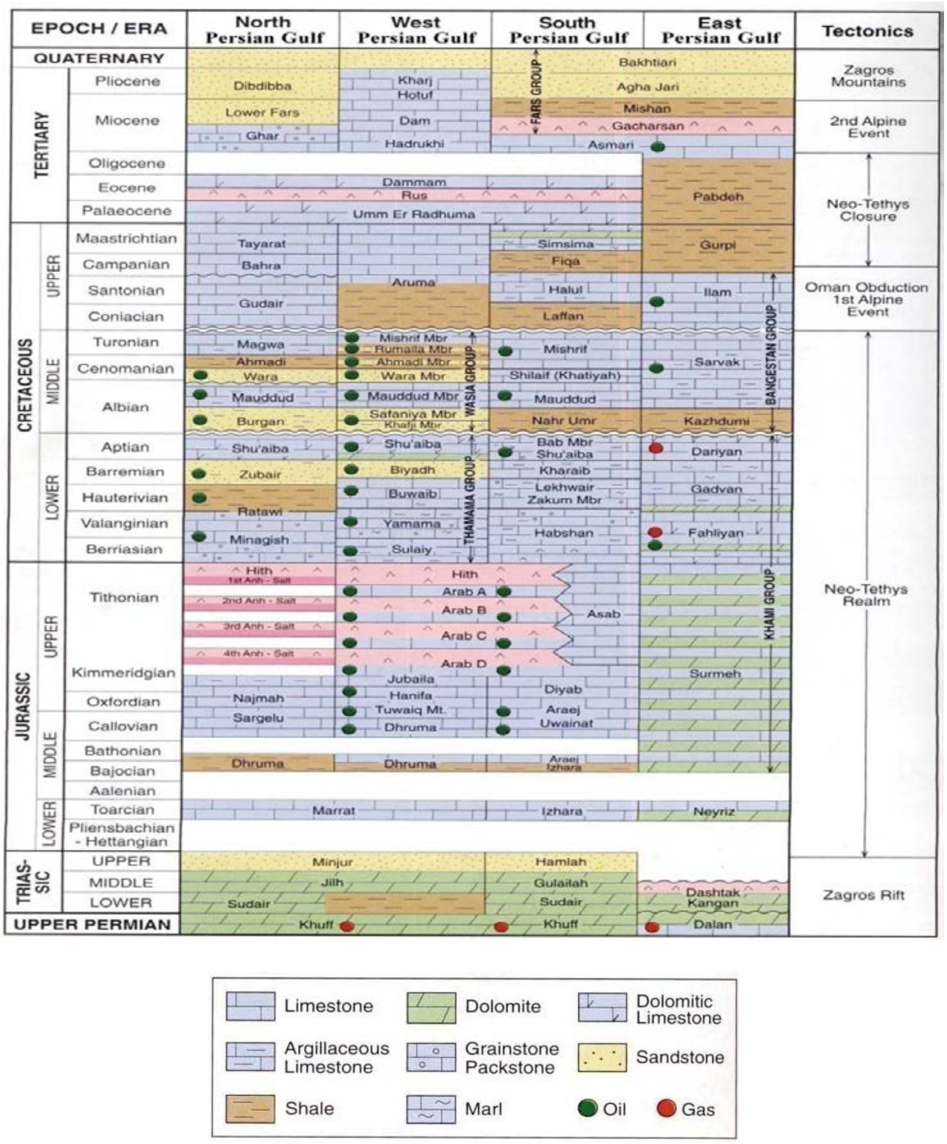

Figure 1: Simplified Stratigraphy, petroleum systems and tectonics of the offshore Persian Gulf. North Gulf corresponds to Kuwait and Southeast Iraq, East Gulf to Iran's offshore Gulf, West Gulf to Saudi Arabia and Bahrain, South Gulf to the United Arab Emirates and Qatar [Al-Husseini, M.I., 1998].

Experimental Details

Five crude oil samples from North Persian Gulf have been geochemically analysed. The studied samples are from Middle Cretaceous Azadegan Sandstone (Burgan) Formation, Upper Jurassic Surmeh (Arab) and Manifa formations. Samples were separated into aliphatic and aromatic hydrocarbons, and polar fraction (resins and asphaltenes) using liquid chromatography procedure. The saturated and aromatic hydrocarbons were analysed using gas chromatography (GC), and gas chromatography-mass spectrometry. The stable carbon isotope compositions of crude oils were determined and the values are expressed relative to PDB carbonate (0‰).

Results and Discussion

The gravities of the crude oils are from 21.4 to 24.3 API°. These values indicate that the crude oils are without biodegradation and low mature.

Gas chromatography performed on saturate fraction of different oil samples show first indication of difference between Azadegan reservoir of Binaloud oil field and Azadegan reservoir of Sorosh and Abouzar fields. It is clear the similarity of Binaloud oil sample with Arab and Manifa reservoirs of Foroozan Oil filed. In Abouzar and Sorosh oil fields (Group 1), the Pr/nC17 and Ph/nC18 values are above 1 but in other samples (Group 2) the values are 0.25-0.43 and 0.47-0.57 respectively (Table 1). Phytane dominates over Pristane samples analysed in Group 2 and Pr/Ph values range from 0.64 to 0.88 (Table 1). In the other group Pr/Ph ratio is above 1. Pristane/n C17 vs. Phytane/n C18 ratios indicate that all of the oils originated from type II organic matter deposited under reducing conditions but there is two distinct groups.

Table 1: GC analysis data and ratios in studied oil samples

Field	Abouzar	Sorosh	Foroozan		Binaloud
Reservoir	Burgan B	Burgan B	Arab	Manifa	Burgan
CPI	1.01	1.05	0.99	1	1.01
Pr/n-C17	1.02	1.04	0.25	0.43	0.33
Ph/n-C18	1.06	1.13	0.47	0.5	0.57
TAR	0.36	0.31	0.18	0.23	0.22
Pr/Ph	1.13	1.04	0.64	0.88	0.76
n-C17/(n-C17+n-C27)	0.73	0.73	0.81	0.76	0.78
n-C18/(n-C18+n-C19)	0.49	0.5	0.52	0.53	0.52
C Isotope	-27.3	-27.5	-26.8	-27	-26.9

Moreover, regarding distribution of alkanes in Gas-Chromatography of oil samples indicate bimodality of Azadegan reservoir of Binaloud oil field (Fig. 2). Effect of two different source rocks can be seen based on GC of the Azadegan reservoir of Binaloud that will be further discussed based on biomarker analysis. In the studied area, North Persian Gulf, the candidate source rock both in Lower Cretaceous and Jurassic entered main phase of oil generation window. In the deepest part of the Northwest Persian Gulf, younger formation in Cretaceous begins oil generation also.

One explanation of similarity between Burgan oil sample in Binaloud Field and Arab and Manifa reservoir of Foroozan oil field is effect of Jurassic source rock on hydrocarbon filling in Binaloud' reservoir.

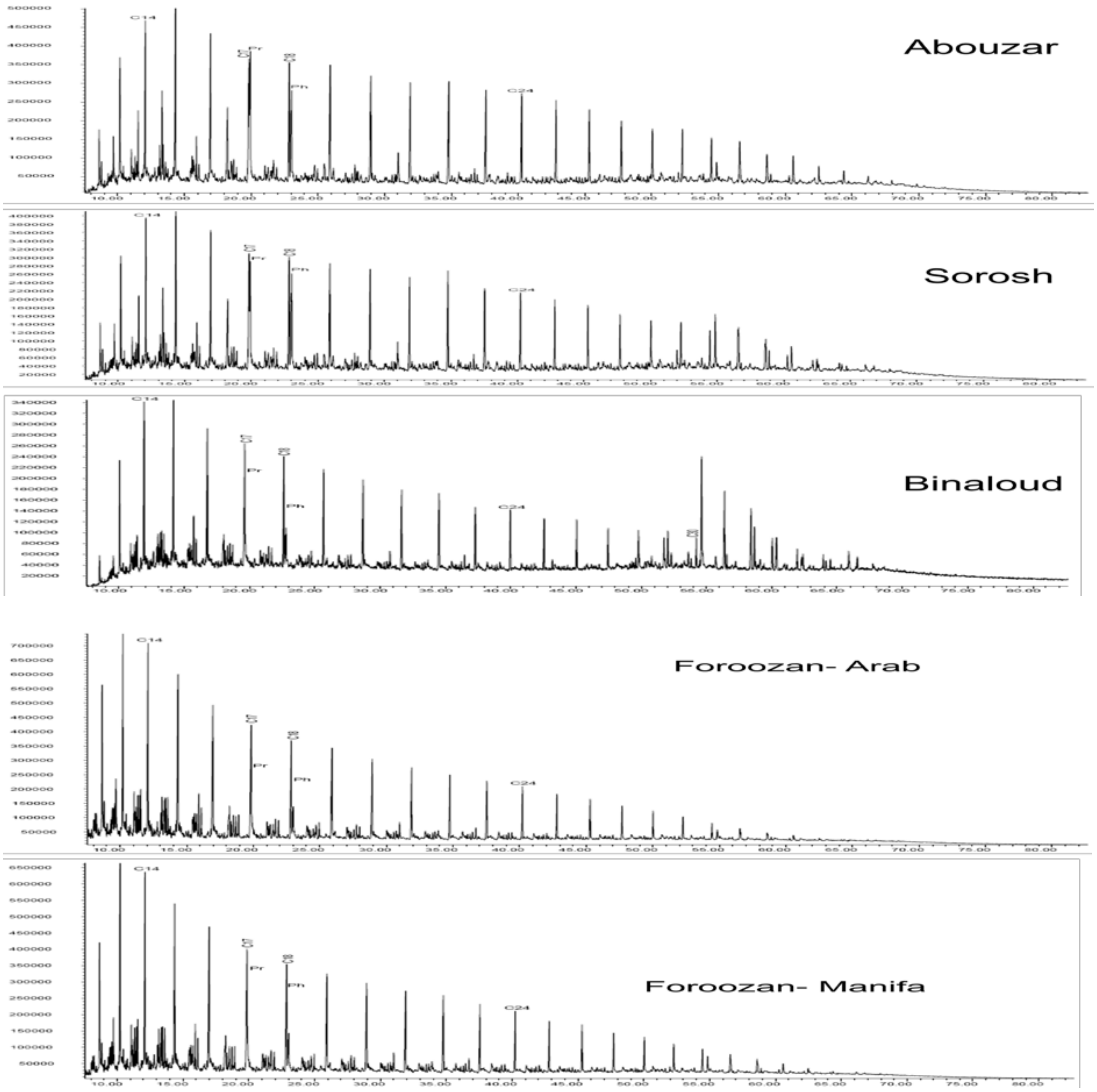

Figure 2: Gas-Chromatography of studied oil samples

The C29 steranes 20S/(20S+20R) and ββ/(ββ+αα) ratios, relative content of diasteranes and Ts/Ts+Tm ratio are maturity parameters that can been used to distinguish crude oil maturation (Duan et al., 2006). Huang et al., (1991) suggested that the value 0.25 of C29 Sterane 20S/(20S+20R) and ββ/(ββ+αα) was a limit between immaturity and lower maturity and a value 0.42 was taken as the boundary between lower maturity and maturity. Based on these parameters, the maturation of the studied crude oils is presented in Fig. 3 and Table 2. As C29 steranes 20S/(20S+20R) and ββ/(ββ+αα) ratios in the crude oils are from 0.46 to 0.48 and from 0.53 to 0.55 (Table 2), respectively, the studied crude oils are mature. The relative contents of diasterane in the crude oils from the two oil pools are very low and diasterane/regular sterane ratios range from 0.05 t0 0.18. The ratio of diasterane/regular sterane has been generally used as a maturation index. However, previous studies showed that carbonate-derived oils contain a relatively low amount of diasteranes due to absence of clay minerals to catalyse the sterane rearrangement (Peters and Moldowan, 1993). The amount of diasteranes in oils could decrease in highly reducing non-carbonate environments with increasing salinity. Therefore, the low diasterane/regular sterane ratios for the two oil pools indicate a lower maturity and saline-hypersaline condition. The Ts/Tm ratio is commonly used to infer oil maturation, but Ts/Tm ratios are also low in carbonate source rocks. The studied crude oils have Ts/Tm ratios

(0.19-0.59), reflecting different maturity from low to medium (Fig. 5 and Table 2). Main difference between Azadegan reservoir of Binaloud with other studied fields is environmental condition of source rock. As shown in Fig. 4, two Jurassic oil samples of Foroozan Field and Azadegan oil of Binaloud locate in Zone 1A (Marine Carbonate), but other samples indicate Zone III (Marine Shale).

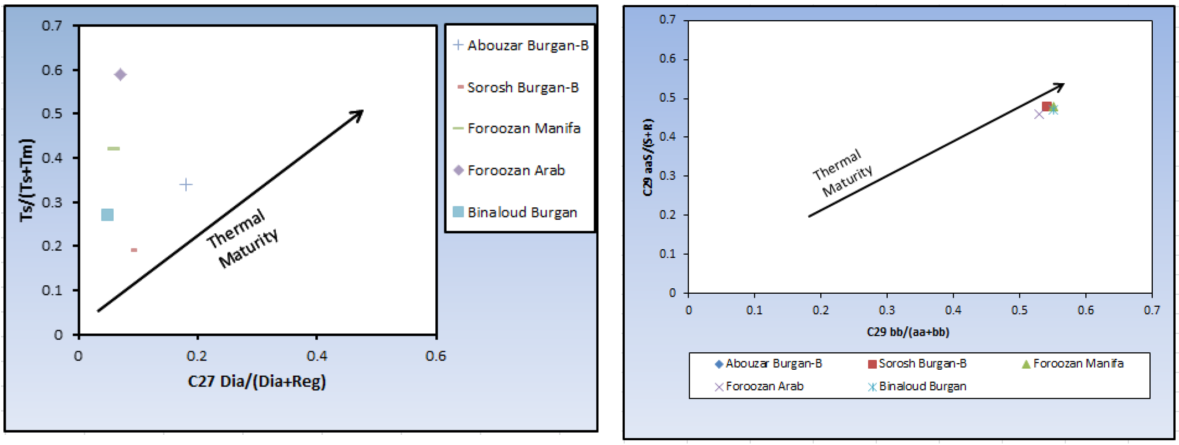

Figure 3: Cross-plots of Ts/Ts+Tm vs. C27 Dia/(Dia+Reg) (a) and C29 ααS/(S+R) vs. C29 ββ/(αα+ββ) ratios (b) for the studied crude oil samples

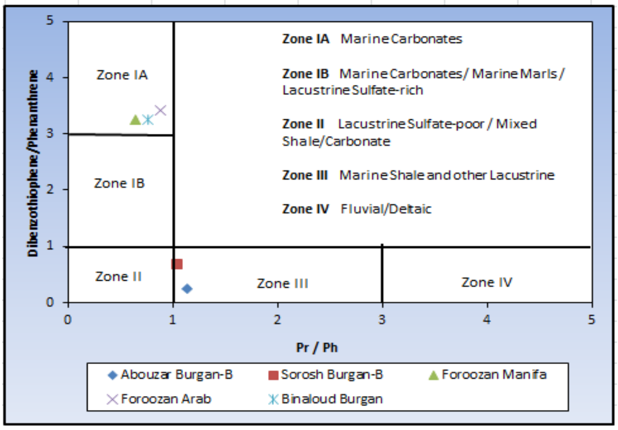

Figure 4: Cross-plots of DBT/Phen vs. Pr/Ph for the studied crude oil samples

Table 2: Some biomarker parameters in studied oil samples

Sample	C27 Sterane (%)	C28 Sterane (%)	C29 Sterane (%)	C27 Dia/(Dia+Reg)	C35S/C34S Hopane	DBT/Phen	Ts/Tm+Ts	C29-Sterane ββ/(αα+ββ)
Abouzar Burgan-B	33.72	29.07	37.22	0.18	0.48	0.25	0.34	0.54
Sorosh Burgan-B	37.41	24.21	38.38	0.09	0.48	0.69	0.19	0.54
Foroozan Manifa	34.77	20.92	44.3	0.06	0.48	3.26	0.42	0.55
Foroozan Arab	38.43	20.7	40.87	0.07	0.46	3.42	0.59	0.53
Binaloud Burgan	32.22	20.47	47.31	0.05	0.47	3.25	0.27	0.55

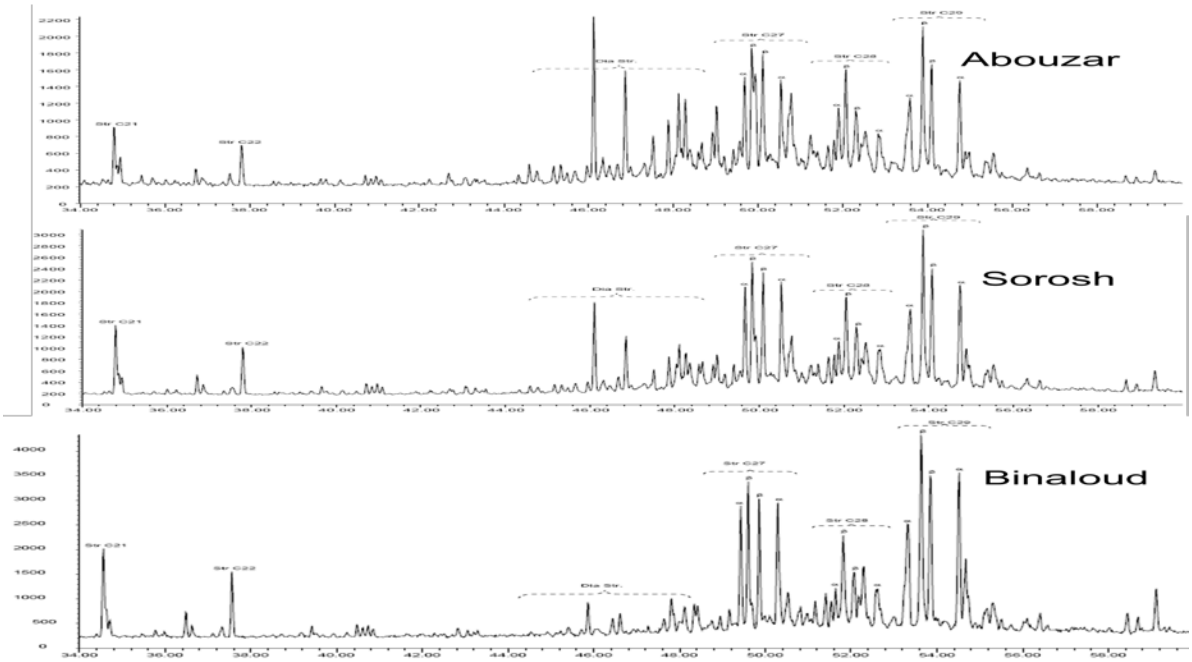

Figure 5: GCMS of studied oil samples (m/z 217)

C28 Sterane content of oil samples can be considered for source rock age in Persian Gulf based on available data. C28 Sterane is about 20% in Group II oil samples which is indicator of Jurassic source rock but Lower Cretaceous source rock seems to be main contributor source rock for Group I samples.

Conclusions

Considering different biomarker parameters containing maturity and source dependent parameters, and GC of the studied oil samples, the Azadegan sandstone reservoir of Binaloud-B charged mainly by the same source rock as Foroozan's older reservoirs alongside a secondary source rock.

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