



International Journal of Current Research and Academic Review

ISSN: 2347-3215 Special Issue-2 (January-2015) pp. 20-27

www.ijcrar.com



Origin and geochemistry of the Mishrif, Yamama and Nahr Umr reservoirs, in Nasiriya oilfield, Southern Iraq

Amer Jassim Al-Khafaji*

Babylon University, College of Science for Women, Hillah, Iraq

*Corresponding author email id: a.alkhafaji@uobabylon.edu.org

KEYWORDS

Mishrif,
Nahr Umr,
Yamama,
Nasriya
oilfield.

A B S T R A C T

Forty rock samples taken from cores, cuttings and five oil samples taken from Mishrif, Nahr Umr and Yamama formations in the Nasiriya oilfield wells, located at the unstable plat form, Mesopotamian basin. From the results of GC, GC/Ms, Carbon isotope pyrolysis and TOC analysis: Source rock geochemical analysis suggests for all cretaceous source rocks samples, immature to mature and show that the Sulaiy and Yamama formations to be a good quality source rock with high total organic carbon (up to 8-wt% TOC). Mishrif formation with reserved oil approximately 1009 million ton, show measured porosities up to 40% and the oils are aromatic, medium gravity, high sulfur content and interpreted as being sourced from Type II/III carbonate rocks interbedded and deposited in a reducing marine environment with high salinity based on biomarkers and isotopic analysis; middle-upper Jurassic age and thermally mature source rocks. The reservoirs of the Nahr Umr of approximately 68 million tons reserved oil show measured porosities up to 23% and Late Berriasian- Early Valanginian Yamama formations of 275 million tons reserved oil, measured porosities up to 28.8%. The Nahr Umr and Yamama reservoirs oils are saturated, light to medium API gravity, low to medium sulfur content which are usually derived from marine shale and carbonate source rocks (containing type II-kerogen), Upper Jurassic to Middle Cretaceous age. The migration from the source rock is likely to be largely vertical and possibly along faults before reaching highly permeable reservoirs of the reservoir formations.

Introduction

The structure of Nasiriya consists of longitudinal, asymmetrical anticline with a NW-SE axis direction, it is about 34 km length and 13 km width at Mishrif surface reflection, the field located at the unstable platform – Mesopotamian Basin zone (Buday, 1980). It is situated 38 km North West of Nasiriya city (Figure 1). Nasiriya structure was generated during the Miocene because of a lateral movement related to the

Alpian orogeny, which led to the development of the structure and increase in capacity with the survival of its linear form.

Materials and Methods

Three Mishrif-reservoired oil samples were taken from wells Ns-1 and Ns-3 and two Yamama and Nahr Umr reservoir oil samples were taken from Ns-1 oil well.

Geochemical source rock analysis was conducted on 40 samples taken from cores and cuttings in wells in the Nasiriya oilfield.

Geomark Research Ltd. in Houston (Texas, USA) performed the analysis of samples using gas chromatography, gas chromatography-mass spectrometry, carbon isotope, TOC analysis and pyrolysis in 2010 and other TOC, pyrolysis and some oil sample analysis were performed in the laboratories of the Iraqi Oil Exploration Company (IOEC) during the year 1993.

Result and Discussion

Nasiriya oilfield total petroleum system

The essential elements required for petroleum accumulation in the Mesopotamian Basin are Upper Jurassic-Lower Cretaceous source rocks. This sequence is proven active source rocks in the South Mesopotamian Basin, southern Iraq (Al-Ameri *et al.*, 2009; Al-Khafaji, 2006, 2010; Abeer *et al.*, 2011, 2013).

Cretaceous reservoir formations

The stratigraphic seals in Nasiriya oilfield are based on lithostratigraphic sections of Van Bellen *et al.* (1959–2005), and well sites descriptions of the studied wells. These are illustrated in Figure 2.

Mishrif formation is of Late Cretaceous – Early Tertiary age. It is one of the most important oil reservoirs in the Mesopotamian Basin, southern Iraq (Aqrabi *et al.*, 1998), containing some 30% of Iraq's total oil reserves. Mishrif formation is divided into two main reservoir units (Figure 3), the Upper Mishrif, which is, consists of limonitic clay of chalky limestone and Lower Mishrif. The latter is an important reservoir unit due to rudist deposits.

Nahr Umr formation is of Albian age. It is widespread throughout the Mesopotamian zone (Buday, 1980). The average thickness of the formation is about 119 m; the reserved oil is approximately 68 million ton. Porosity ranging from 10 to 23% and permeability from 50 to 400 md in the upper part of the formation (Van Bellen *et al.*, 1959–2005).

Yamama formation is of Late Berriasian-Early Valanginian age. The average thickness of the formation is about 236 m. The estimated reserved oil in Yamama formation is around 275 million tons. Upper part of the formation was the main reservoir with porosity varied between 6.5 and 28.8%, permeability varied between 0.1 and 2329 mD.

Mishrif oil geochemistry–API gravity and sulfur content: API gravities average $27^{\circ} \pm 1.5^{\circ}$ with weight percent sulfur $4.26\% \pm 0.3$. A comparison with oils from different petroleum systems is showing in Figures 4 and 5. Medium gravity and high sulfur crudes are usually derived from carbonate source rocks (containing type IIS kerogen). V/(V+N) ratio equal to 0.9 indicate marine source organic matter (Table 1).

The low abundance of C₂₉ steranes further indicates that there is little or no contribution from terrestrial higher plants (Hunt, 1996). The relative distribution of C₂₇, C₂₈ and C₂₉ aaa (20S) + (20R) and abb (20S) + (20R) steranes which shows that the steranes of most oils are shifted towards C₂₇, indicating the close similarity and marine origin of the source of the oils (Figures 5).

As illustrated in Figure 6, Peters *et al.* (2005) reported many researchers suggesting C₂₈/C₂₉ regular sterane ratios ($\alpha\beta\beta$ 20R isomers based on peak heights from the m/z

= 218 mass chromatogram), as <0.4 for Lower Palaeozoic or older oils, 0.4–0.7 for Upper Palaeozoic-Lower Jurassic oils and >0.7 for Upper Jurassic to Miocene oils. The calculated C₂₈/C₂₉ ratio of 0.66, employing both regular and triaromatic steranes (C₂₇R/C₂₈R; peak areas from the m/z = 231 mass chromatograms) of about 1.3, and weighted using a saturate to aromatic hydrocarbon ratio of about 0.49, suggests that the Cretaceous Mishrif-reservoired oils were generated from Middle to Upper Jurassic carbonate source rocks.

Nahr Umr and Yamama oil geochemistry: Yamama and Nahr Umr reservoir crude oil samples bulk properties: API gravities average 31.2° and 29.7° respectively with weight percent sulfur 2.08% and 2.66% respectively. Light to medium gravity, low sulfur crudes are usually derived from marine shale and carbonate source rocks (containing type II kerogen). Peters *et al.* (2005) suggested that oils of clastic source rocks origin are typically low in sulfur. It might be derived from the most mature source rocks, generating oils of low density.

Source rock evaluation: The organic geochemical results indicate that the Sulaiy and Yamama formations have a medium petroleum generative potential. Many samples of Sulaiy have a relatively high hydrogen index (HI), up to 226 mg HC/g TOC, indicating predominantly Type II and Type III kerogen (Figure 7) derived from marine algal organic matter

- The Upper Jurassic-Lower Cretaceous Sulaiy and the Lower Cretaceous Yamama formations have the best oil source potential with TOC values up to 3.7wt%. They represent immature to mature (T_{max} of 425–436°C), kerogen types II and III. These rocks have

medium to fair current petroleum potential and have generated relatively low amounts of hydrocarbons.

- The Jurassic Najmah and Sargelu formations were not subjected to pyrolysis because of their position below the good regional seal of Gotnia Anhydrites. Accordingly, the most likely source rock for the Mishrif, Yamama and Nahr Umr reservoir oils are the Middle -Upper Jurassic source rock which are probably responsible for hydrocarbon generation and expulsion.
- Peak oil generation and expulsion of petroleum in the Upper Jurassic source rocks began in the Late Paleocene (Abeed *et al.* 2013). These generated and expelled hydrocarbons had possessed vertical migrations along faults and compression joints in the anticline crest. They had charged the already formed traps of the Middle Cretaceous Mishrif, Nahr Umr and Yamama formations that formed during the Upper Cretaceous time by the mechanism of basement movements in preexisted trends as response to thick sediment accumulations in the Mesopotamian Basin and the global cratonic reaction to plate collision. Accordingly, these traps are mainly structural.

In conclusion, Mishrif and Yamama formation are the main reservoirs in Nasiriya oilfield and Nahr Umr is secondary reservoir. The organic geochemical of crude oil accumulated in Mishrif Formation is aromatic, low maturity and show non-biodegradation, rich in sulfur, medium gravity and high maturation sources. Mishrif crude oils derived from low oxidation carbonate source rocks.

Table.1 Analysis chart of GC oil biomarkers and carbon isotope data

Oils	Formation	API Gravity	% S	% C15	Ppm V	ppm Ni	Pr/Ph	Pr/n-C17	Ph/n-C18	n-C27/n-C17	CPI	C15+ Saturate	C15+ Aromatic	Canonical Variable	% Aro	%NS O% Asph	Sat/Aro
1	Mishrif	27.2	4.20	34.9	55	15	0.79	0.22	0.33	0.17		-27.23	-27.53	-3.87	56.2	18.8	0.44
2	Mishrif	26.8	4.33	35.7	55	13	0.82	0.23	0.32	0.13		27.24	-27.47	-3.72	57.4	17.8	0.43
3	Mishrif	27.5	4.15				0.74	0.37	0.32		0.92				50.3	18.6	0.61
4	Nahr Umr	29.7	2.66				0.84	0.18	0.29		1.08				40.8	20.82	0.94
5	Yamama	31.2	2.08				0.55	0.14	0.28		0.95				45.1	13.86	0.89

Figure.1 Location map of the studied wells along with oilfields



Figure.2 Stratigraphic column of Nasiriya Oilfield with hydrocarbon generation parameter

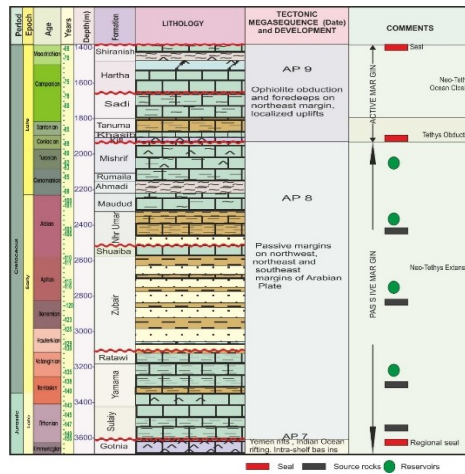


Figure.3 Main oil reservoirs in Ns-1 oil well, Nasiriya oilfield

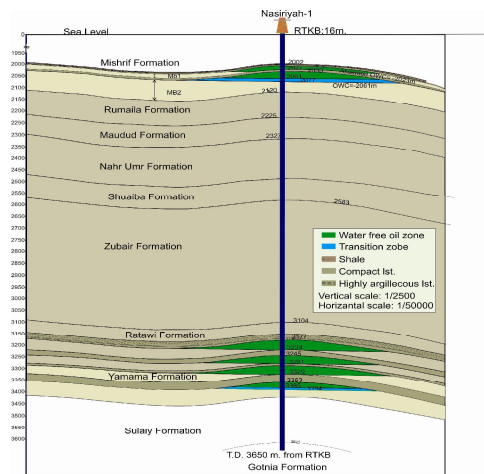


Figure.4 Pristane-n C17 versus Phytane-n C18 plot

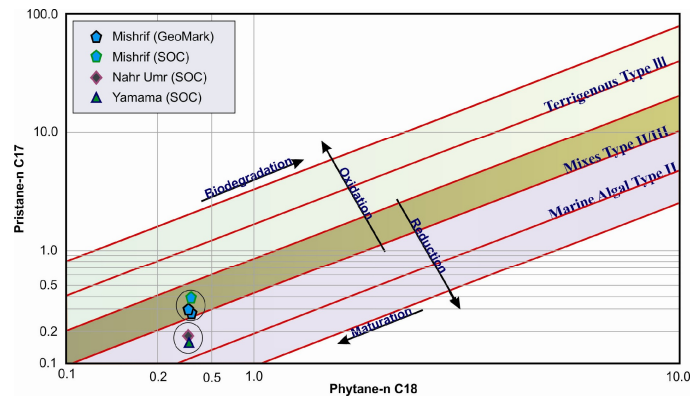


Figure.5 Average API Gravity and weight % sulfur

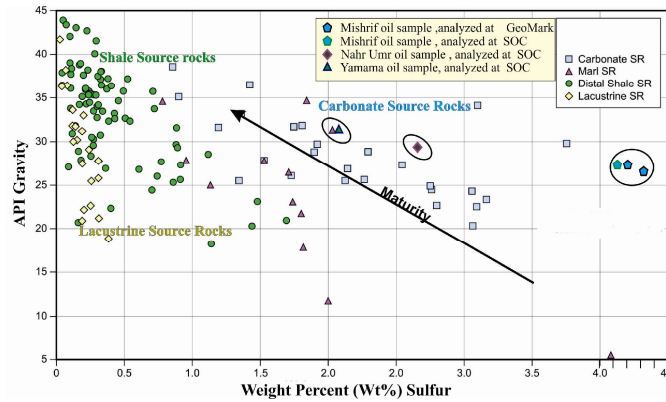


Figure.5 Average hopane ratios of Mishrif-reservoired oils from southern Iraq suggesting a carbonate source rock

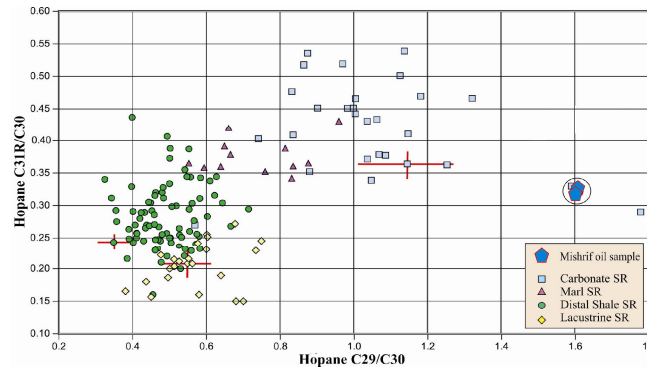


Figure.6 Calculated average C28/C29 sterane ratio (0.61; based on both regular steranes and triaromaticsteranes) of Mishrif-reservoired oils from southern Iraq suggesting a source rock of Middle to Upper Jurassic age

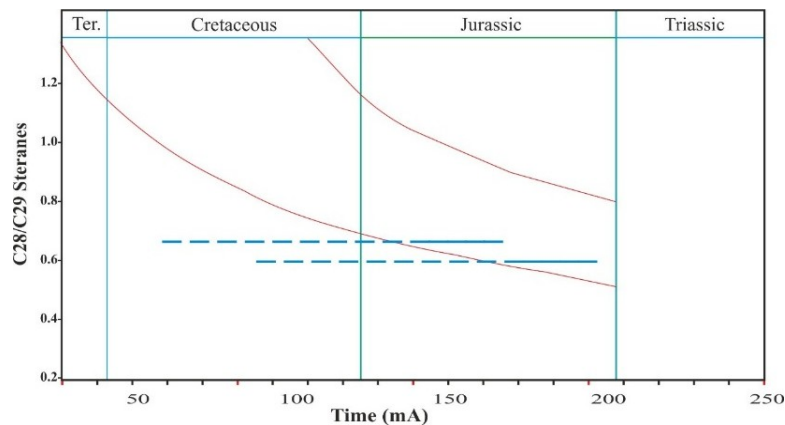
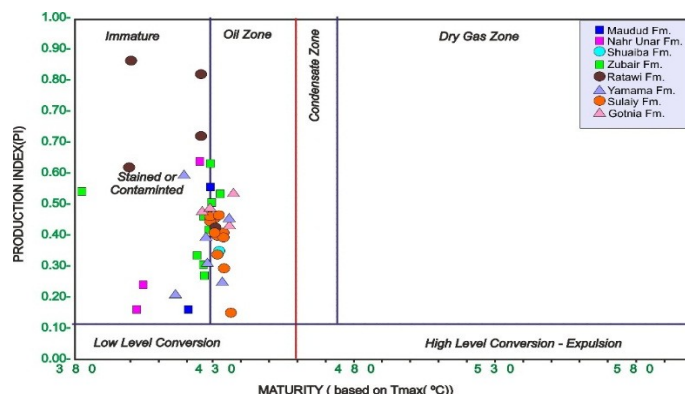


Figure.7 Pyrolysis output plots for source rocks of the Upper Jurassic – Lower Cretaceous Formations in Nasiriya oilfield



The calculated C_{28}/C_{29} ratio and triaromaticsteranes, and weighted using a saturate to aromatic hydrocarbon ratio suggests that the Cretaceous Mishrif-reservoired oils were generate from Middle to Upper Jurassic carbonate source rocks. Oils generated from a source rock of low to moderate thermal maturity within the oil window.

The crude oils, which accumulated in Nahr Umr and Yamama reservoirs, are saturated, mature oil and show high reduction, marine anoxic palaeoenvironments, and marine algal kerogen type II, low to medium gravity (API) and medium to low sulfur crudes are usually derived from low oxidation shale and carbonate source rocks.

Lower Cretaceous Sulaiy source rock samples show mature to early maturation generated hydrocarbon but they have not reached to expulsion stage. For this, it is unlikely that these source rocks may be charge the studied reservoirs, probably the Upper –Middle Jurassic source rock responsible for hydrocarbon generation and expulsion.

Upper Jurassic Gotnia anhydrite is the lower regional seal and during Late Cretaceous the

studied reservoirs trap mainly formed before oil generation and expulsion.

Acknowledgment

We would like to give sincere thanks to Iraqi Oil Exploration Company (IOEC) and South Oil Company (SOC) for the supplies of rock samples and crude oil. Pyrolysis for these rock samples are performed in the Iraqi Oil Exploration Company while oil analysis of these samples were done in Geomark Research, Ltd. in Houston, TX, USA.

References

- Abeed, Q., Al-Khafaji, A.J., Littke, R. 2011. Source rock potential of the upper Jurassic lower Cretaceous succession in the southern part of the Mesopotamian Basin Zubair subzone, southern Iraq. *J. Petrol. Geol.*, 34: 117–134.
- Abeed, Q., Littke, R., Strozyk, F., Uffmann, A.K. 2013. The upper Jurassic-Cretaceous petroleum system of southern Iraq: A 3-D basin modelling study. *GeoArabia*, 18(1): 179–200.
- Al-Ameri, Th.K., Al-Khafaji, A.J., John Zumberge, 2009. Petroleum system analysis of the Mishrif reservoir in the Ratawi, Zubair, North and South

- Rumaila oilfields, southern Iraq. *GeoArabia*, 14(4): 91–108.
- Al-Khafaji, A.J. 2006. Relation of Mishrif Reservoir crude oil with the Mishrif formation and source rocks, using biomarkers and carbon isotopes, Ratawi, South and North Rumaila Oilfields, Southern Iraq. M.Sc. Thesis, unpublished, Baghdad University.
- Al-Khafaji, A.J. 2010. Jurassic–Cretaceous petroleum systems of the middle Euphrates Region Kifl, West Kifl, Afaq, Musaiyab, Morjan, and Ekheither oil fields, Middle Iraq. Ph.D. Thesis, University of Baghdad, Department of Earth Sciences. 198 Pp.
- Aqrawi, A.A.M., Tehni, G.A., Sherwani, G.H., Kareem, B.M.A. 1998. Mid-Cretaceous rudist bearing carbonates of the Mishrif formation: An important reservoir sequence in the Mesopotamian Basin, Iraq. *J. Petrol. Geol.*, 21(1): 57–82.
- Buday, T. 1980. The regional geology of Iraq, Stratigraphy and palaeogeography, State Organization for Minerals, Baghdad. 455 Pp.
- Hunt, J.M. 1996. Petroleum geochemistry and geology. W.H. Freeman and Company, New York. 743 Pp.
- Peters, K.E., Walters, C.C., Moldowan, M. 2005. The biomarker guide, Vol. 2. Biomarkers and isotopes in petroleum exploration and Earth history. Cambridge University Press, UK. 674 Pp.
- Van Bellen, R.C., Dunnington, H.V., Wetzel, R., Morton, D.M. 1959–2005. Lexique Stratigraphique International. 03 10 Asie, Iraq, 333 Pp. Reprinted by permission of CNRS by Gulf PetroLink,