



Geological Structure and Hydrocarbon Bearing Prospects of the Northwestern Part of the Persian Gulf Basin (The Western Desert of Iraq)

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Abstract

Before the 1990s, exploration in the Western Desert (WD) of Iraq was focused on Mesozoic–Cenozoic section. As of today there are prospects for the discovery of hydrocarbons (HC) in deep sections—Proterozoic and Paleozoic deposits. Through the literature Analysis, two-dimensional basin modeling and maturity maps of source rocks were provided to identify the HC bearing prospects of three petroleum systems: Vendian-Cambrian (V-Cm), Paleozoic (PZ), and Mesozoic-Cenozoic (MZ-CZ). V-Cm salt sections were detected based on gravity data. It may contain all elements of petroleum system similar to play Ara in Oman. Based on seismic data, there is an angular unconformity apparently between Ordovician and Silurian deposits. This unconformity creates PZ stratigraphic traps filled with HC. In MZ-CZ section, there are mature Jurassic source rocks (SR) to the west of Abu Jir fault system. Their maturity was proved by pyrolysis data from well Merjan-1. Although the MZ-CZ section has a monoclinical slope to the east, it is possible to detect small-sized closed structural traps filled with HC.

Keywords

Western Desert of Iraq • Petroleum systems • Hydrocarbon bearing prospects • Basin modeling

1 Introduction

Until the 1990s, the WD of Iraq was an unpromising region due to the fact that only the upper, Mz-Cz monoclinaly lying part of the section was considered. Lack of prospects was associated with both the lack of evaporite seals of the Jurassic Gotnia formation (Fm) (analogous to Hith Fm in

Saudi Arabia) and the Middle Eocene Lower Fars Fm (Jassim and Goff 2006; Sabah 2006), and with the presence of seeps along Abu Jir fault zone (Al-Ameri 2014). These facts indicate the cessation of long-term lateral migration of HC from the kitchen of Jurassic SR (Baniasad et al. 2017)—the Mesopotamian depression. In 1987–93 years fields were discovered in Pz section of W Iraq and E Jordan (Akkas, S and N Risha fields) (Al-Ameri 2010; Ahlbrandt 2010). These discoveries have breathed new life into the exploration of the region. It is possible that in the Pz deposits of this area there are accumulations of HC similar to those found in other parts of the Persian Gulf Basin (HC in Unaizah Fm and in Khuff Fm in Saudi Arabia). In addition, salt basins, probably of the V-C age, were found in the study area according to the gravity and seismic data (Jassim and Goff 2006). They can also be an exploration target by analogy with the Ara play in Oman (Aqrabi et al. 2012). According to recent geochemical data, it was revealed that the WD of Iraq may have its own mature Jurassic SR that could generate some amount of HC for Cretaceous reservoirs.

2 Geological Settings, Materials, and Methods

The WD of Iraq is located in the northern part of the Arabian Peninsula, in the SW Iraq. The geological section is represented by three complexes—metamorphosed pre-Vendian basement, salt deposits of the V-Cm transition complex, and Phanerozoic sedimentary cover. The basin model (as per MSU methodology) was built along the West Kifl 1 (WK-1) deep well (TD around 5.8 km, age of borehole deposits—Permian). Materials for the model include thickness of deposits that was not penetrated by well (Jassim and Goff 2006; Al-Hadidy 2007), well tops, lithology, age of deposits (Pitman et al. 2004), deposition environments (Jassim and Goff 2006), vitrinite reflections from the nearest published well Misaib, temperatures at the bottom of the well

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Table 1 Source rocks geochemical data in the Western Desert of Iraq for basin modeling

Age	Formation	Composition	Thickness, m	Kerogen type	TOC, wt %	HI, mgHC/gTOC
J3-K1	Sulaiy	Carbonates	40–50	I	0.7	770
J3	Najmah	Carbonates	10–20	IIS	3.4	550
J	Sargelu	Carbonates	Up to 210	IIS	0.8	430
P1	Razzaza	Shales	50–82	III	1	200
D3-C1	Ora	Shales	250–280	III	2.2	200
S	Akkas	Shales	60–65	II	8.5	430
O	Khabour	Shales	Up to 100	II	2.3	370

(Al-Ameri 2014), data on rift periods (Jassim and Goff 2006), data of SR within the Western Desert of Iraq and its neighborhood (<https://www.academia.edu/2343876>; Al-Hadidy 2007; Pitman et al. 2004; Grabowski 2014; Aqrabi and Badics 2015; Baniasad et al. 2017) (Table 1). For the construction of maturity maps, the following data was used: the depths of the oil and gas windows, seismic data (tying well WK-1 to seismic; velocity model) within the eastern part of the Western Desert.

3 Results

Oil window is placed on depths from 2.4 to 5.3 km (%Ro 0.55–1.3%) and gas window—from 5.3 km (%Ro > 1.3%). In well WK-1 transformation ratio (TR) increased from 5 to 70% in lower-middle Triassic for Akkas Fm, from 5 to 60–70 in lower Cretaceous for Ora and Razzaza Fm, from 5 to 20–25 in upper Cretaceous-Tertiary for Sargelu and Najmah Fm. So all of mentioned SRs are mature and there was expulsion from each. The expulsion threshold for II type of kerogen is up to 10% of TR; for III type of kerogen is fluctuating from 30 to 50% of TR. Boundaries between oil and gas window, between oil window and immature rocks, have N–S trend as W D of Iraq has monoclinial slope to the east. The position of these boundaries relative to well WK-1 is presented on Table 2.

Migration pathways and traps. Faults mainly has sub-meridional extension and do not reach Ordovician deposits so migration from Silurian hot shales (Akkas Fm) is downward and lateral to underlying Ordovician sandstones (Khabour Fm) (see Fig. 1).

Table 2 Position of maturity boundaries for source rocks relative to well WK-1

Age of source rock	Formation	Gas and oil window boundary (distance west of WK-1, km)	Oil window and immature rocks boundary (distance west of WK-1)
J	Sargelu	–	20
P1	Razzaza	40	150
S	Akkas	100	230

Based on seismic data, there is an angular unconformity apparently between Ordovician and Silurian deposits. This unconformity creates stratigraphic trap that may be filled with hydrocarbons. Migration pathways from D3-C1 (Ora Fm) and P (Razzaza) SRs are mainly lateral as overlying Triassic deposits are mainly thick seals composed of shales and salts. Traps are small-sized structural. Migration routes from Jurassic mature SR are lateral and vertical. Traps are also small-sized structural.

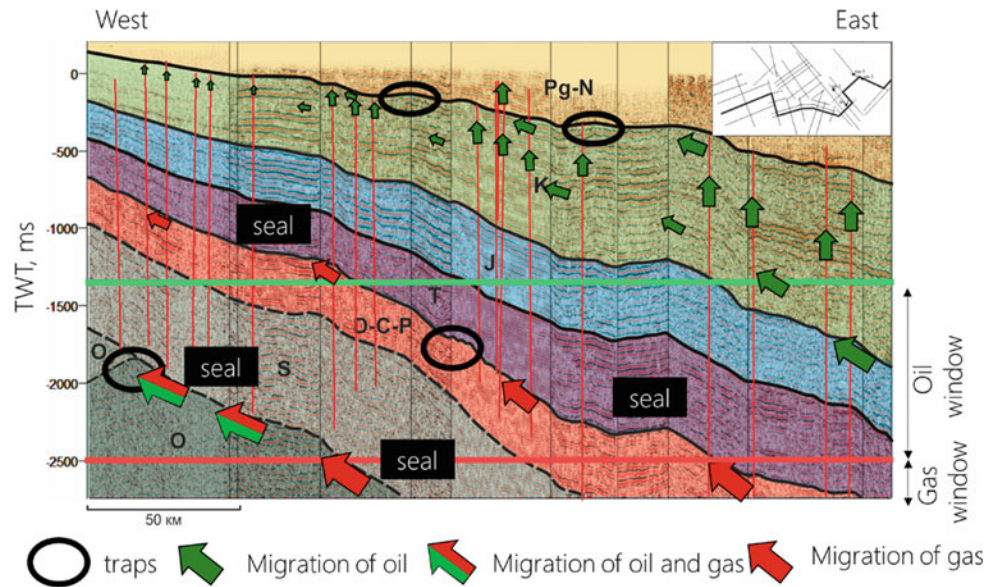
4 Discussion

Hercinian erosion that destroyed many hundreds of sediments within Salman zone is not supported by seismic data within the research area. The Monoclinial slope of seismic reflections are observed under Permian deposits (Chia Zairi Fm) instead of angular unconformity. Moreover, the angular unconformity is recognized apparently between Ordovician and Silurian deposits on the central part of W D of Iraq. The mentioned features were not well documented and are crucial not only for understanding the Pz section of Western Desert of Iraq but also for a rational exploration.

5 Conclusions

The Vendian-Cambrian petroleum system lies quite deep (7–9 km) and is of future exploration interest. The Pz petroleum system has prospects in the lower part (the Silurian and Ordovician sandstones of the Khabour Fm in stratigraphic traps) and in the upper part (the Permian carbonates of the

Fig. 1 Seismic section through the eastern part of Western Desert of Iraq with horizon interpretation, traps, major seals, oil and gas windows, and migration pathways



Chia Zairi Fm in small-sized structural traps). Paleozoic SRs are mature and they are able to fill exploration targets with both oil and gas. The predominant migration path is lateral. In the Mz-Cz, it is possible to detect small structural traps in which HCs are possible due to the presence of mature Jurassic SR (migration path is lateral and vertical).

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