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Research paper

Assessments of oil characterization, source affinities, and hydrocarbon dynamic of East Baghdad oil fields, Central Iraq

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ABSTRACT

Bulk properties, stable carbon isotopes, whole crude Gas-Chromatography and oil mode ratios of sterane and terpanes data of analyzed samples of oil from the Cretaceous Formation reservoirs of East Baghdad oil field are from five producing wells (EB21, EB68, EB92, EB5 and EB31) from reservoirs of Zubair, Khasib, and Tanuma Formations. They are discussed with aids of characters, hopane, tricyclic terpane, isotopic δ_C13 saturate, aromatics, and pristine-phytane diagrams. The analized oil have indicated light and medium oil in the Zubair reservoirs and heavy oil for the Khasib and Tannuma oil, with about 15% asphalt and porpherine range of 16.7–35.1 Ni and 68–117 ppm, giant reservoirs. The oil source environment and lithology are of marine algal type II and deltaic type II/III that are non biodegraded deposited in anoxic environments of carbonate and shale. Source maturation at the time of the oil generation, aided by pristine-phytane and Tmax equivalent from MDR (Methyldibenzothiophene ratio) diagrams, are showing mature with Tmax 430–435 °C while source age assessment are taken from δ_C13 (%) and the calculated C28/C29 sterane ratio to be of Middle and Upper Jurassic as well as Lower Cretaceous age that could be correlated mainly with the Chia Gara and Zubair Formations as well as the Middle Jurassic Sargelu Formation source rocks for oil that are accumulated in the reservoirs of Zubair, Khasib and Tannumah Formations.

Source rocks are mainly Upper Jurassic-Lower Cretaceous Chia Gara Formation with contribution from the Middle Jurassic Sargelu and Lower Cretaceous Zubair Formations. The richness of the source rocks, mostly due to shale rich in TOC, and the type of kerogen is mixed type II/III and type III. The formations have good petroleum potentiality (PP) and the OM reaches the Early of hydrocarbon generation. Oil, and gas are the most probable product, and the generated hydrocarbons can be expelled at this level of thermal maturity which is confirmed by petromod software basin modeling to suggest migration and accumulation during the Upper Cretaceous time.

Hydrocarbon dynamic in East Baghdad Oil Field are performed using seismic section, logs and porosities. Model assessments of the hydrocarbon generation, migration paths and accumulation sites as well as places of enriched oil are used to assess reservoir location and suggestion for drilling sites.

1. Introduction

East Baghdad Oil Field is located in Baghdad Governorate, in Central Iraq; it lies east of the River Tigris, and about some kilometers east of the Baghdad city. The field includes ninety-six (96) wells, all of these wells have attained the Khasib Formation, while only six of these wells have attained the deep Zubair Formation (EB10, EB25, EB58, EB81, EB82, and EB92) and one deep well (EB01) down in the Jurassic formations.

Crude oils are complex mixtures of organic compounds covering a wide range of polarity, molecular weight, size, shape, solubility, and elemental composition and containing a large number of closely related compounds (Hunt, 1996; Tissot and Welte, 1984). Variations in crude oil composition are to a certain extent inherited from different source rocks.

The compounds are controlled initially by the nature of the organic matter in the source rock. Crude oils as well as bitumen extracts from source rocks are divided into fractions corresponding

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to the main structural types. Specific compounds within each structural group can be obtained by Gas chromatography Mass spectrometry. Hydrocarbons contain only organic carbon and hydrogen. A part from the organic matters; the alkanes are non-cyclic compounds that contain carbons and hydrogen while the cycloalkanes are cyclic compounds that contain carbons and hydrogen. High-sulfur crude oils frequently related to carbonate-type source rock. A side from the influence of source rock facies, the state of maturity of the source material is also of importance. The processes of crude oil alteration (thermal alteration, deasphalting, biodegradation and water washing) tend to obscure the original character of the oil, and therefore affects crude oil correlation, furthermore influence the quality and economic value of petroleum (Tissot and Welte, 1984).

Therefore, the present study throw more light on the composition, classification and the geochemical characterization of crude oil samples, through several routine and advanced geochemical analyses from productive fields within the study area.

East Baghdad oil field was discovered by INOC (Iraqi National Oil Company) in March, 1975 on the outskirts of Baghdad city. They indicated that, the Khasib Formation represent the main reservoir which has the heavy oil ranges "between" (15–16 API), but locally lighter (25–27 API) at the crest while the widespread layer of heavy oil and asphalt is at the base of reservoir (Pittion, 1983). Light oil was discovered in the Zubair Formation by the end 1979, and hence about 80 oil wells had been drilled. The development drilling began in the following year with technical assistance from total who ordered directional drilling from multi-well sites; they reported that East Baghdad Oil Field has commenced production at 50,000 b/d of 23 API in April, 1989 following the Iraq–Iran war.

East Baghdad oil field is located between longitudes (44.5) – latitude (33.2) to longitude (44.5) – latitude (32.6), in Baghdad government, Central Iraq (Fig. 1a) and detailed map of the field is showing in Fig. 1b. It is a block – faulted anticline that covers 120 km long and 20–30 km width (Sadooni, 1997).

The Stratigraphic succession in East Baghdad oil fields could be represented by the deep oil well EB-1 drilled in Al-Madaen south east of Baghdad town which penetrated deep to early Jurassic Addayah Formation (Fig. 2) with total depth of 4842 m. Jurassic and Cretaceous units are the main target for the Jurassic oil source and the Cretaceous oil reservoirs in East Baghdad field. Stratigraphically, in Iraq they are divided into Late Toarcian-Early Tithonian Megasequence (AP7) that were deposited during a period of isolation of the main intra-shelf basin of Mesopotamian from the Neo- Tethyan Ocean probably due to renewed rifting along the NE margin of the Arabian plate. Deposition within the basin occurred in a restricted, relatively deep water, environment during the Mid Jurassic. The main source rocks in this sequence (AP7) for hydrocarbon genereation is Sargelu and Naokelekan Formations (Al-Ameri and Zumberge, 2012) which were dated by Al-Ameri and Al-Naqshbandi (2015) on palynomorphs taxa as ranging through Bajocian and Bathonian for the Sargelu Formation and Callovian for Naokelekan Formation. The basin became evaporitic during late Kimmeridgian – Early Tithonian time. The base of megasequence in an area of interest started with the basinal Sargelu formation. The upper evaporitic part of the mega sequence comprises evaporates of the Gotnia Formation.

The Late Tithonian-Early Turonian Megasequence (AP8) contain the reservoirs of the, Ratawi, Zubair, Nahr Umr and Mishrif Formations. The main source rocks in this sequence (AP8) for hydrocarbon generation is Chia Gara and Zubair Formations (Al-Ameri and Zumberge, 2012 and Al-Ameri, 2011) which were dated by Al-Ameri and Al-Naqshbandi (2015), Al-Ameri et al. 2011 and Al-Ameri and Batten 1997 on palynomorphs taxa as ranging through Tithonian and Berriassian for the Chia Gara Formation and Barremian to Early Aptian for Zubair Formation.

The Late Turonian-Danian Megasequence (AP9) included the reservoirs of Khasib, Tannuma, Saadi and Hartha Formations (Sharland et al., 2001, Jassim and Goff, 2006). Early Middle Miocene Jeribe Formation is the only reservoir in the megasequence (AP10) of Tertiary (Paleocene- Miocene). The overlying Middle Miocene-Pliocene Megasequence (AP10) constitutes upper regional seal of Fatha (Lower Fars) Formation on top of Jeribe Formation.

Al-Ameri (2011) described well EB-1 of East Baghdad oil field for a complete stratigraphic succession (Fig. 2b) while the succession of the source rocks are illustrated in stratigraphic correlations of selected wells (including the deepest well EB-01) in East Baghdad (Fig. 2c). The total petroleum system of these successions is bounded stratigraphically by:-

1 Upper regional seal of Middle Miocene Lower Fars Formation of non permeable anhydrite lithology, of 400 m thick, comprise highest seal for stopping the vertical migration of the oil, while some may seep to the ground surface through its fractures.
2 Lower regional seal of Upper Jurassic Kimmeridgian Gotnia Anhydrites, of non permeable 80 m thick, comprise lowest seal to prevent mixing hydrocarbon supply from the Jurassic source rocks to some extent with our Cretaceous and Cenozoic petroleum system, sometimes the lower regional seal may extend down to the Lower Jurassic Allan Anhydrites Formation if there were faults and fractures along Gotnia Anhydrite.

The main objectives of this study are assessment of oil characters and their source affinity in East Baghdad Oil Fields with possible variations in their characters and the hydrocarbon dynamic and hence risk assessment for suggested oil pays in structural and stratigraphic extent could be performed in each location within East Baghdad field.

2. Material and methods

Seven crude oil samples are collected for this study from drilled wells of EB92, EB21, EB68, EB5 and EB31 (Fig. 1b). Bulk properties are tabulated in Table 1. On the other hand, the terpane and sterane biomarkers by the use of Gas Chromatography/Mass Spectrometry devise as well as $\delta^{13}C$ aromatic and sterane isotope ratios are performed in Geomark Research Ltd in Houston–Texas (Table 2a&b).

These crude oil are analyzed in Geomark Research laboratories - USA to determine the bulk properties and the carbon isotope parameters of whole crude oils in addition to biomarker parameters determination using Gas Chromatography (GC), Mass Spectrometry (MS), and GCMS analytical technique for the saturates as well as the aromatics. Examples of the analysis from geochemical summary sheet with interpretation are showing in Fig. 3a–e.

Thirteen core rock samples of the Zubair Formation of well EB92 are processed in Geomark Research Ltd for the their extracted organic matters (Fig. 3) to confirm oil-source affinity for this formation as case study for one formation and the values documented in (Table 3). Many other source rock samples of Upper-Jurassic and Lower Cretaceous rock samples of drilled wells are processed too for their organic matter extracts in pyrolysis device (Table 4) in the Iraqi oil Exploration Company to explain the hydrocarbon generation.

Seismic section images and logs are from the Oil Exploration Company of the Ministry of oil in Iraq.

3. Petroleum geochemistry

Crude oils are technically separated to saturate HC (hydrocarbon), aromatic HC with benzothiophenes and then analyzed using