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# Organic geochemistry characterisation of crude oils from Mishrif reservoir rocks in the southern Mesopotamian Basin, South Iraq: Implication for source input and paleoenvironmental conditions

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## ABSTRACT

Seven crude oils from Cretaceous Mishrif reservoir rocks in the southern Mesopotamian Basin, South Iraq were studied to describe oil characteristics, providing information on the source of organic matter input and the genetic link between oils and their potential source rock in the basin. This study is based on biomarker and non-biomarker analyses performed on oil samples. The analysed oils are aromatic intermediate oils as indicated by high aromatic hydrocarbon fractions with more than 50%. These oils are also characterized by high sulfur and trace metal (Ni, V) contents and relatively low API gravity values (19.0–27.2° API). The results of this study indicate that these oils were derived from a marine carbonate source rocks bearing Type II-S kerogen that were deposited under sulphate-reducing conditions. This is primarily achieved from their biomarkers and bulk carbon isotope and inorganic element contents (i.e., S, Ni and V). The absence of 18a (H)-oleanane biomarker also suggests a source age older than Late Cretaceous. The biomarker characteristics of these oils are consistent with those of the Late Jurassic to Early Cretaceous source rocks in the basin. However, biomarker maturity data also indicate that the oils were generated from early maturity source rocks. This appears to result from the type of kerogen of the source rock, characterized by a high-S kerogen (Type II-S).

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## 1. Introduction

Mesopotamian basin is one of the main basins in Iraq, which is extended from north to south Iraq (Fig. 1a). Mesopotamian Basin is considered as one of the richest petroleum systems in the world [1–3]. The Mesopotamian Basin is an important hydrocarbon province in Iraq and contains several, well known oil fields (Fig. 1a). The dataset used herein is from the oil field, which are located in the southern part of the Mesopotamian Basin (Fig. 1b). The Mesopotamian Basin has attracted the interest of numerous researchers and oil companies. Several studies have been undertaken on the potential source rocks in the basin [4–6]. The presence of possible source rocks in the Mesopotamian Basin is Late Jurassic to Cretaceous units, which are including Sulaiy (Late Jurassic), Yamama and Ratawi (Early Cretaceous) and Zubair (Middle Cretaceous) Formations [5,6]. Abeed et al. [6] concluded that the best quality

source rocks in the southern Mesopotamian Basin are the Late Jurassic–Early Cretaceous marine carbonates (Sulaiy Formation and possibly also Yamama Formation). They are bituminite limestones and black shales, which have high organic matter (TOC) with more than 3 wt% [6]. These source rocks were deposited in a carbonate-rich, anoxic environment and favoured by salinity stratification [6]. The Sulaiy and Yamama source rocks have also high sulfur contents (>3 wt%) [6], suggest the presence of kerogen Type II-S, and thus have to be generated early-mature sulfur-rich oils. However, the quality of crude oils and the origin of organic matter input and depositional environment conditions of their potential source rocks in the Mesopotamian Basin are limited. The main objectives of the current study were to: (1) characterize the oil types and compositions in the southern Mesopotamian Basin, South Iraq; (2) to provide insight into the source organic matter input, palaeo-depositional conditions, and thermal maturity of the respective their source rocks. In this study, seven (7) crude oils from Early Cretaceous Mishrif petroleum reservoir rock in the three oilfields (i.e., West Qurna, Zubair, and Nasriah), Southern Mesopotamian Basin (Fig. 1b) were analysed by a variety of geochemical techniques.

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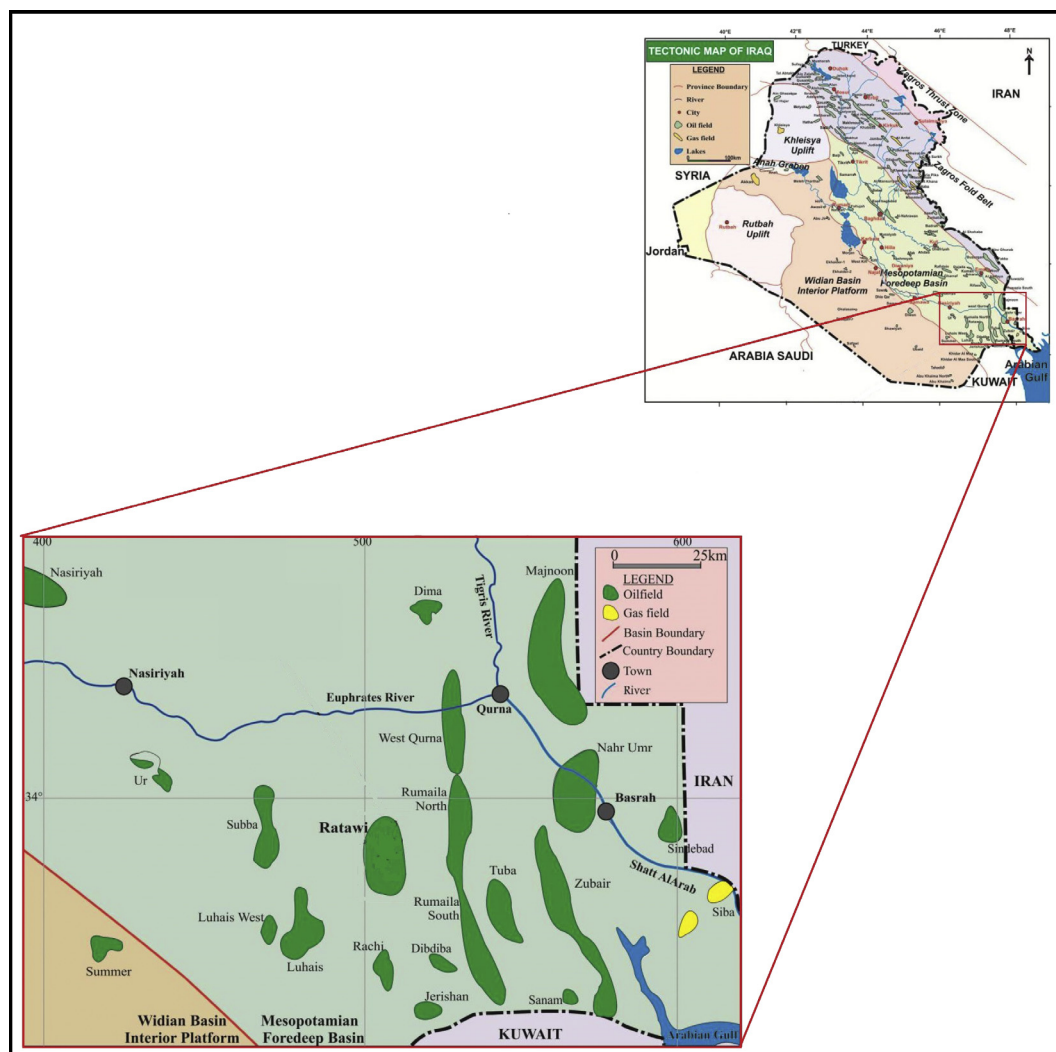


Fig. 1. Location map for the northeast Arabian Peninsula in Iraq, which shows Mesopotamian and Zagross Fold Belt basins with oil and gas field locations, including study oilfield locations.

## 2. Geological setting

Mesopotamian Basin is extended from north to south Iraq (Fig. 1a), which the Cretaceous oil habitat of the oil fields in southern Iraq is a result of many processes that started during the Triassic, when a new ocean began to form at the southern end of the Palaeo-Tethys Ocean [6]. The basin is an asymmetric fore deep, with a regional dip to the east-northeast [6]. In the basin, the base Upper Jurassic surface lies 2000–3500 m below sea level in the west, deepening to >6000 m below sea level in the east [6]. The western margin of the basin is interpreted to be bounded by significant NNW–SSE trending fault zones. The amount of displacement along these fault zones is poorly constrained and may be very limited [7].

The stratigraphic section in the southern Mesopotamian Basin is dominated by a thick Mesozoic succession and ranges in age from Jurassic to Cretaceous (Fig. 2). The Jurassic–Cretaceous depositional environment and hydrocarbon habitat have been studied by several researchers [4–6,8–11]. However, during Jurassic–Early Cretaceous time several sediments were deposited in the southern Iraq, which are include Sargelu, Najmah, Gotnia, and Sulaiy sediments (Fig. 2). The Middle Jurassic extends through northern and

southern of the basin. It is composed of thin bedded, bituminous limestone, dolomitic limestone and black shales [12]. The Sargelu Formation is considered as oil-source rock in the basin [6,7,13]. The Sargelu Formation is overlain conformably by the bituminous limestone of the Upper Jurassic Najmah Formation (Fig. 2). The Upper Jurassic Najmah Formation is extended into Kuwait and also is considered as oil-source rock [14,15]. The Najmah Formation is overlain conformably by Upper Jurassic Gotnia Formation, which is considered as the main seal rocks in south Iraq [16]. The Gotnia Formation is primarily composed of bedded evaporites with subordinate pseudo-oolitic limestone (Fig. 2). During latest Jurassic to Early Cretaceous time, the accumulation of carbonates in marine deposits of the Sulaiy Formation was accompanied in the basin (Fig. 2). The Sulaiy Formation contains bituminite limestones and black shales, which is considered as oil-source rock in the south Iraq [6]. The Sulaiy Formation has kerogen Type II-S and was deposited in marine anoxic conditions stratification [6]. This formation is overlain conformably by Cretaceous units (Fig. 2). The Cretaceous units comprise the Yamama, Ratawi, Zubair, Shuaiba, Nahr Umr, Maudud Ahmadi, Rumaila and Mishrif deposited during Early Cretaceous to Late Cretaceous time (Fig. 2). These sedimentary rocks are composed of mainly marine carbonates and subordinate

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