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Fingerprinting of biomarker characteristics of some Egyptian crude oils in Northern Western Desert as evidence for organic matter input and maturity level assessment

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ABSTRACT

This study describes the fingerprinting of crude oils from different Egyptian oil formations using gas chromatography (GC) and gas chromatography mass spectrometry (GC–MS). The samples were obtained from Gindi, Abu El gharadig, south deep Abu El gharadig, Dahab- Merier and Faghur basins from Western Desert. Diagnostic biomarkers parameters applied in this study provide evidences about the source of organic matter, the depositional environment and maturity of the studied oils. The results showed that the crude oils of Faghur basin are believed to be originated from mixed source predominately terrestrial with chief contribution of clastic rocks deposited under oxic conditions. However, the crude oils from Gindi, Abu El gharadig, South deep Abu El gharadig and Dahab- Merier basins were generated from marine carbonate source rock deposited under anoxic depositional environment.

1. Introduction

The chemical fingerprinting of petroleum is made possible by the multitude of individual hydrocarbon compounds that are present and by the great variability in the relative abundances of these compounds among different crude oils. This variability, which is the basis for chemical fingerprinting, is due to variability in the organisms contributing to the organic matter, the environment in which this organic material was deposited, the thermal maturation history of the sediments, and post-generation modifications [1]. Biomarkers found in crude oils, rocks, and sediments show little or no changes in structures from their parent organic molecules or biogenic precursors (e.g., hopanoids, sterols, and steroids) in living organisms [2].

The North Western consists of a series of small rift basins, most commercial accumulation of petroleum discoveries occur in the basins located in the northern parts of the Desert. The productive studied wells lies in the North Western Desert between latitudes 29° 00′ and 30° 10′ N and longitudes 25° 20′ and 29° 30′ E (Fig. 1). It is one of the most productive oilfields in the North Western Desert of Egypt and is defined as Late Cretaceous basin. This represents the commercial hydrocarbon bearing formations. Geochemical evaluation of crude oils in the Northern Western Desert oil fields was described in detail by many authors as mentioned in [3–12]. They divided the oil of some oil fields of the North Western Desert into two types. “Type I” waxy oil was originated from non-marine origin. “Type II” non-waxy oil was sourced from carbonates source rocks, as well as, revealed that close genetic relationship in the origin and maturation for the oils and extracts of the Khatatba and Alam El Bueib source rocks. More recently, El Nady and Harb [13] show that the Abu Gharadig oil samples are of marine origin; their source rocks are rich in clay content and were deposited under reducing conditions. Also, these oils have a high maturity level. El Nady and El Naggar [14] showed that the crude oil of some wells in the North Western Desert is originated mainly from marine organic sources deposited in reducing environment.

The main objective of the present study is essentially to describe a comprehensive geochemical study on crude oils from Western Desert using gas chromatography (GC) and gas chromatography mass spectrometry (GC–MS), to characterize the source depositional environments, and to assess the thermal maturity. This target achieved throughout the biomarkers characteristics as n-C15+ alkanes, isoprenoids, triterpanes and steranes.

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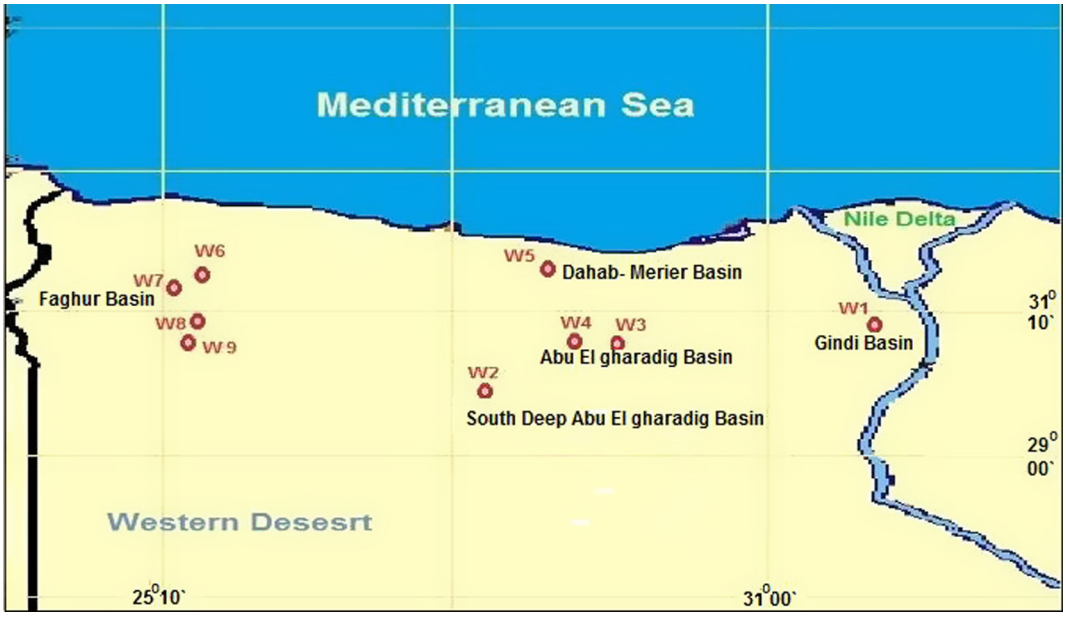

Fig. 1. Location map showing the studied crude oil in the North Western Desert, Egypt.

2. Materials and methods

Nine crude oils (W1 – W9) were collected from different Western Desert basins namely: Gindi basin, South Deep Abu El-Gharadig basin, Abu El-Gharadig basin, Faghur Basin and Dahab- Merier basin (Fig. 1). The following methods were approved:

1. Each Crude oil sample was distilled up to 200 °C at atmospheric pressure. The residual fraction (>200 °C) was deasphalted according to IP-143 standard procedure. The deasphalted fraction (maltene) was separated into saturates, naphthens, aromatics and resins by liquid column chromatography. The column used was packed with 1:1 alumina overlying silica gel. Saturates, aromatics and resins fractions were obtained by successive elution with n-pentane, toluene and methanol, respectively.
2. Saturated fractions were analyzed using Agilent 7890 plus HP gas chromatograph equipped with FID (Flame Ionization Detector) using fused silica capillary column HP–5 of 30 m in length, 0.32 mm in internal diameter and 0.25 μm of film thickness. The elution of the studied liquid was achieved with temperature programming form 80 °C to 310 °C at a rate of 3 °C/min. Helium was used as a carrier gas flowing at a rate of 1 ml/min. The injector and detector temperatures were 320 °C and 350 °C, respectively.
3. Biomarkers traces in the saturate fractions were analyzed using PerkinElmer Claruss 500 gas chromatograph equipped with mass spectrometry detector using fused silica capillary column HP–5 ms of 30 m in length, 0.32 mm in internal diameter and 0.25 μm of film thickness. The elution of the studied fraction was achieved with temperature programming form 80 °C to 310 °C at a rate of 3 °C/min. Helium was used as a carrier gas flowing at a rate of 1.5 ml/min. The injector temperature was 300 °C [2].

3. Results and discussions

3.1. Organic matter input

3.1.1. Normal and isoprenoid alkanes

The oil samples (W1-W5) from Gindi, South Deep Abu El gharadig, Abu El gharadig and Dahab- Merier basins (Fig. 2) show unimodal distribution with predominance of low to medium molecular weight hydrocarbons (n-C_{13}–n-C_{35}). A presence of significant amount of waxy alkanes (n-C_{23}+), dominated by odd carbon number was observed giving moderate CPI values ranges from 0.99 to 1.10 (Table 1). These alkanes profiles are consistent with sediment receiving a substantial input of long chain alkanes, either from algae or plant cuticular waxes [15]. On the other, hand the oil samples (W6 – W9) from Faghur basin (Fi. 2) show extended n-alkanes ranging from (n-C_{13} – n-C_{35}) with bimodal distribution pattern and are characterize by high degree of waxiness ranging from 1.76 to 2.32 and high terrigenous aquatic ratio (TAR) ranging between 0.80 to 1.06 (Table 1) suggesting high contribution of terrigenous organic matter [16].

The pristane and phytane ratio for group I oils (W1-W5) from Gindi, South Deep Abu-Ghradig and Abu-Gharadig, Dahab- Merier basins are in the range of 0.77–1.49 (Table 1) suggested their generation from organic matter input deposited in marine environment under anoxic to relatively suboxic conditions. In contrast, the oil samples from Faghur basin (group II) W6 – W9 possess high Pr/Ph ratios ranging from 2.63 to 3.60 (Table 1) suggesting high contribution of terreginous organic matter deposited under relatively oxic conditions. The lower Pr/-C_{17} and Ph/n-C_{18} ratios in most of the studied oil samples are probably due to their maturity [17].

3.1.2. Tricyclic and Tetracyclic terpanes

The distribution of tricyclic terpanes in oils and source rocks formed in a variety of depositional environment and showed that the C_{19} and C_{20} members are more abundant in terrestrial oils while the C_{23} member is often the dominant homologue in the crude oils of marine source [18]. C_{19}/C_{23} and C_{20}/C_{23}TT ratios are useful parameters to differentiate terrestrial versus marine input. The crude oil samples W6 – W9 exhibit these ratios in the range from 3.08 to 20.73 and from 2.18 to 13.08 respectively (Table 1). These high ratios indicate higher contribution of terrestrial organic matter. Also, C_{24} tetracyclic terpane is present in significant amount in all of the studied oil samples with high relative percentage in Dahab -Merier and Faghur samples (Fig. 3, see peak identification in Table 2). The C_{19}TT/(C_{19}TT + C_{23}TT) ratio of oil sample from Faghur basin is in the range from 0.76–0.95(Table 1) indicating mixed input predominantly terrestrial organic matter input [2].

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