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The Western Desert versus Nile Delta: A comparative molecular biomarker study

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ABSTRACT

The Western Desert and the Nile Delta are prolific petroleum-producing basins; the correlation and matching between their petroleum systems have been briefly studied.

Overall, geochemical and biological marker analyses of twelve crude oil and condensate samples taken from seven oil-gasfields located in the Nile Delta and the Western Desert basins of Egypt, were effective in identifying and geographically defining two major oil families related by age and source rock depositional environment. These samples were classified, respectively, as Late Cretaceous/Tertiary and Jurassic–Early Cretaceous. The source rocks giving rise to the Late Cretaceous/Tertiary oils are associated with abundant terrestrial organic matter. The source rocks giving rise to Jurassic–Early Cretaceous oil are presumably generated from a mixed terrestrial/marine source. Meanwhile, the Western Desert oil samples show prominent C_{30} steranes, elevated C_{27} monoaromatic steroids, and a distinct homohopane distribution, suggesting this oil type is derived from a more marine-influenced source rock than terrigenous-sourced oil in the Nile Delta.

The most crucial geochemical fingerprinting biomarkers that have been used to differentiate between Nile Delta and the Western Desert oil are oleananes, highly-branched isoprenoids (HBI), sterane isomerization, 24-norcholestanes, aromatic steroid hydrocarbons and C_{30} 24-*n*-propylcholestanes.

1. Introduction

The study areas represented in this investigation include the north Western Desert and the offshore Nile Delta (Fig. 1). These two hydrocarbon provinces plus the Gulf of Suez represent Egypt's main oil and gas supply. Companies producing non-associated gas operate in the Nile Delta and its offshore extensions into the Mediterranean, as well as in the Western Desert. The Mediterranean is by far the largest gas producer in Egypt, accounting for 60% of the country's 68 TCF of proven reserves of natural gas. At a minimum, the Mediterranean could hold at least another 60–80 TCF of probable reserves, not yet found. Since late 2003, most gas production has come from deep-water offshore Mediterranean fields north of the Nile Delta, the Western Desert and Sinai. EGPC's equities in gas-producing ventures have been taken over by the new Egyptian Natural Gas Holding Company (Egas), which was created in August 2001. The main operators in the Nile Delta and the east Mediterranean gas fields are Petrobel (Egas/Agip), Agip-BP JV, Bapetco (Egas/Shell), the Western Desert Petroleum Company (WEPCO, Egas/Apache), and BG. Petrobel is the biggest gas producer in Egypt, as a result of its present output exceeding 980 MCF/d and expected to peak at 1304 MCF/d by 2010 (El Diasty, 2010).

The geochemical characteristics of the Mesozoic and Tertiary hydrocarbons in the Western Desert and Nile Delta were briefly addressed in a paper by Halim et al. (1996). However, it did not differentiate the two with detailed molecular biomarker characteristics that can distinguish Western Desert and the Nile Delta oil. They conclude that the studied oil and condensate samples are genetically related to a common source rock that contained mainly terrigenous organic matter of coaly facies. However, despite similarities between the Nile Delta, Western Desert and offshore Mediterranean liquid hydrocarbons, oleanane is detected only in the Nile Delta oils and can be used to differentiate between the Tertiary and Mesozoic source rocks.

Zein El Din et al. (1990) divided the oils from the northern Western Desert hydrocarbon province into two main oil groups based on oil characterization procedures. Group-I (Umbarka group), is characterized by high pristane/phytane, high API gravity (≥30°), low-sulfur oils/condensates that are common in the

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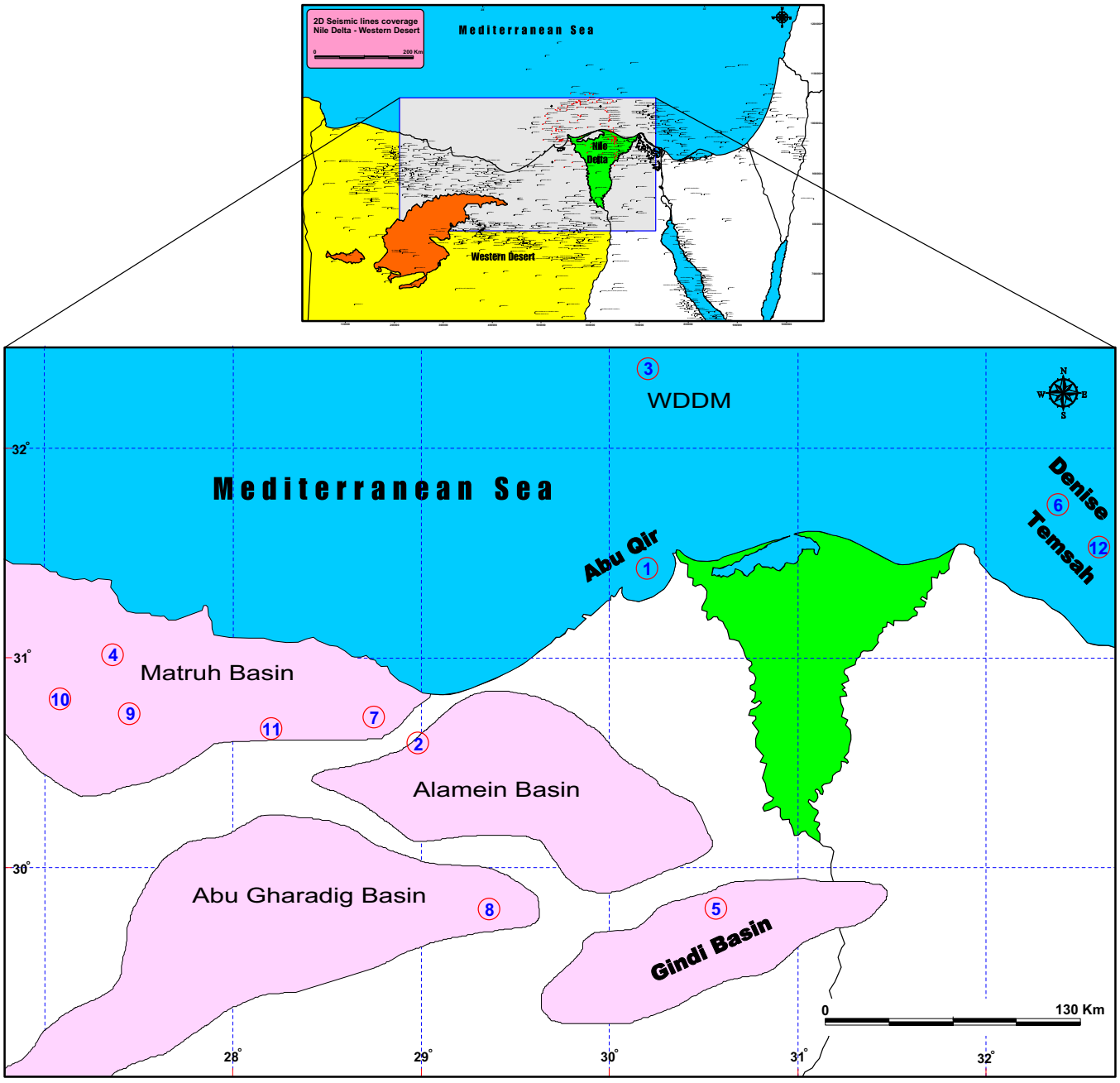

Figure 1. Map showing sample locations in the Nile Delta and north Western Desert basins. Numbers of samples refer to Table 1.

northwestern part of the Western Desert. This oil often has high wax content and is generally thought to be derived from highly mature source rock of terrestrial origin. The coal-rich sediments from the Middle Jurassic Khatatba Formation represent the most likely source for this oil type (EGPC, 1992; Bagge and Keeley, 1994). Group-II (Abu Gharadig group), is of intermediate maturity, low to moderate pristane/phytane (~1.0), low waxy content, moderate API gravity (~30°) and high sulfur content (up to 1.8%). This oil has slightly more negative $\delta^{13}C$ values than the oil belonging to Group-I, and was probably derived predominantly from marine source rocks. The argillaceous limestones from the Upper Cretaceous Abu Roash-F Member represent the prime source rock candidates (EGPC, 1992; El Diasty and Moldowan, 2012). This type of oil is common in the Abu Gharadig basin and its eastern extension in the Gindi basin.

El Diasty (2010) stated that the analyzed oil and condensate from northwest offshore Nile Delta originated from non-marine, clay-rich source rocks, as judged from scarcity or absence of the C_{30} *n*-propylcholestanes and high diasterane/sterane ratios. However, source- and age-related biomarker data show that these fluids originated from organic-rich and mature Late Cretaceous–Early Tertiary deposits, which are confirmed by high oleanane and C_{26} 24-norcholestane indices. These likely source rocks may extend beneath the entire length of the Nile Delta.

El Diasty and Moldowan (2012) conducted detailed geochemical analyses on crude oil and condensate samples from the Abu Gharadig Field in the north Western Desert of Egypt. The analyses reveal three genetic oil families, designated as A, B and C. Oils from Family-A and C were derived from Cretaceous marine source rocks (shales, calcareous shale) with Type II/III kerogen. Oil from Family-B