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Geochemical Characterization and Volumetric Assessment of the Prolific Mesozoic Source Rocks of the Northeastern Arabian Plate

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The Middle–Upper Jurassic and Lower Cretaceous strata of the NE Arabian Plate contain several prolific world-class source rocks for some of the largest petroleum systems globally. They are located within the Zagros and Mesopotamian foreland basins covering the northern, central and southeastern parts of Iraq, together with western and southwestern parts of Iran, particularly the Lurestan and Khuzestan provinces. These source rocks principally include the Bajocian–Bathonian Sargelu, the Callovian–Early Kimmeridgian Naokelekan and the Late Tithonian–Early Berriasian Chia Gara and Sulaiy formations of Iraq and their chronostratigraphic equivalents in Iran. They have charged the main Cretaceous and Tertiary reservoirs throughout Iraq and Iran (in various trap types and sizes) with more than 250 billion barrels of proven recoverable hydrocarbons.

Stratigraphically, these formations represent transgression system tracts (TST) sequences deposited within the deep basinal settings of anoxic environments. Lithologically, they are dominated by black shales and bituminous marly limestones with high total organic carbon (TOC) contents (ranging from 1–18 weight % TOC) and by Type II kerogen. Their Rock Eval S2 yields may reach up to 60 mg HC/g Rock, particularly along the depocenter of the Mesopotamian Foreland Basin. The immature Hydrogen Index (HI) values might have been up to 700 mg HC/g TOC; the present-day observed values vary depending on the location within the basin and the present-day maturity. The Source-Potential Index (SPI) [i.e. mass of hydrocarbons in tons, which could be generated from an area of 1.0 sq m in case of 100% Transformation Ratio] ranges from 1–4 in the paleo shallow-water areas reaching 10–12 in the basin centre, with maximum values of 16–18 in the paleo-depocentres.

Assuming a mean gross formation thickness of 178 m (and net source rock thickness of 110 m having >1% TOC), a mature area of 327,000 sq km, with a 3.71 wt% of mean immature TOC and HI of 600 mg HC/g TOC, the Sargelu Formation could have generated up to 9,200 billion barrel of oil and 1,800 billion barrel of oil-equivalent gas within the Mesopotamian foreland and Zagros basins. The Naokelekan Formation is a very thin condensed section, so a net source rock thickness of 15 m (having > 1% TOC), in a mature area of 205,000 sq km, with a 5.0 wt% mean immature TOC and HI of 650 mg HC/g TOC, this formation could have generated up to 1,237 billion barrel of oil and 250 billion barrel of oil-equivalent gas in the same basins. Finally, the Chia Gara Formation with a net source rock thickness of 55 m (having > 1% TOC), in a mature area of 166,000 sq km with a 3.70 wt% mean immature TOC and HI of 550 mg HC/g TOC could have generated up to 1,900 billion barrel of oil and 391 billion barrel of oil-equivalent gas in the Mesopotamian foreland and Zagros basins of NE Arabian Plate.