

Tuwaiq Mountain Formation: An Emerging Organic-Rich Unconventional Limestone Reservoir in the Jafurah Basin, Saudi Arabia

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Abstract

The Tuwaiq Mountain Formation (Middle Jurassic, Callovian) is an organic-rich limestone which is the main source rock for supergiant Jurassic carbonate reservoirs in Saudi Arabia. It composes up to 90% limestone of the whole rock, followed by 1% to 17% total organic carbon (TOC). Clay content is low ranging from 5% to 8% up section in the basal Jubaila Formation (lower Kimmeridgian) and is predominantly illite and illite/smectite, with subordinate kaolinite and chlorite.

The Tuwaiq Mountain was deposited in an outer ramp to basin depositional environment where dysoxic to anoxic conditions prevailed and allowed for preservation of organic matter that is mainly concentrated in fecal pellets. Most of the organic matter was transported down-dip below a pycnocline by storm events while lesser amounts were deposited by settling of organic matter from organisms that lived in the shallow, oxygenated part of the water column. Most of the porosity is related to TOC maturation and expulsion that formed organopores. Connectivity between organopores and to a lesser extent expulsion fractures and microfractures are responsible for permeability within the source rock and are comparable to other productive carbonate-rich unconventional plays.

Four main lithofacies based on core description have been recognized in the section targeted as an unconventional reservoir: 1) anoxic, black, laminated, skeletal bivalve detritus, pellet wackestone to mud-dominated packstone, containing starved ripples; 2) anoxic, black, laminated, bivalve skeletal detritus, pellet wackestone to mud-dominated packstone, with no apparent ripples; 3) anoxic, black, massive appearing very thin to thin bedded, bivalve skeletal detritus, pellet wackestone to mud-dominated packstone; and 4) dysoxic, black, horizontally micro-bioturbated, laminated to very thin bedded, bivalve skeletal detritus, pellet wackestone to mud-dominated packstone. These lithofacies shallow-upward into oxygenated, gray, bioturbated, thin bedded, wackestone to mud-dominated packstone, which is considered a non-reservoir facies.

All of this core-based data has been utilized to characterize and explore for unconventional Jurassic limestone source rocks in Saudi Arabia. This play is in an early stage of appraisal and is the first organic-rich unconventional limestone reservoir to produce hydrocarbons in the Kingdom.