AAPG Datapages/Search and Discovery Article #90319 ©2018 GEO 2018 13th Middle East Geosciences Conference and Exhibition, Manama, Bahrain, March 5-8, 2018

Sedimentology and Source Rock Characterization of the Organic-Rich Facies of the Tuwaiq Mountain, Hanifa, and Jubaila Formations

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ABSTRACT

The Jurassic Tuwaiq Mountain, Hanifa, and Jubaila formations are among the most prolific source rocks in the world. These organic-rich intervals accumulated in a clastic-starved, shallow (<300 m depth) intra-shelf basin. An intense and comprehensive exploration campaign recovered thousands of feet of conventional and sidewall cores, which allowed for a detailed characterization. The main organic rich level is found in the upper Tuwaiq Mountain. This unit is mainly composed of TOC rich to very rich calcareous mudrocks with extremely low levels of macro-bioturbation. This event shows a coupled enrichment of redox sensitive elements (Mo, U, Cu, etc), and a slight increase on productivity indicators (P, Ba). The maximum level coincides with the upper part of a 3rd order transgressive system track. A second organic rich level is found in the lower Hanifa, which lies above a sharp erosive contact. Episodic highly bioturbated, organic lean, and cemented carbonate mudflows are interbedded with organic fair calcareous mudrocks. The organic content decreases towards the top of the unit, while bioturbation increases. This sub-unit exhibits low to moderate levels of bioturbation, and is characterized by punctuated enrichment of Mo, U, Cu, & etc, associated with the organic fair mudrocks. The upper Hanifa is composed of mildly to highly bioturbated, organic poor to lean mudstones and wackestones. Halite and anhydrite grains become abundant towards the top. The middle part has a large increase in redox sensitive trace elements that are decoupled from the TOC enrichment observed elsewhere. This event marks the onset of a drastic restriction to the shallow intra-shelf basin, and is capped by a 2 to 20 ft deep-water anhydrite. A third organic rich level is found in the basal Jubaila; the contact is sharp, erosive and contains coarse granules and pebble size lithoclasts of the Hanifa anhydrite, and corresponds to a transgressive lag. Overall the basal Jubaila is composed of mildly to highly bioturbated, organic lean, calcareous mudstones. The TOC rich section shows an increase in detrital components with clays up to 15 wt%, and low concentrations of redox sensitive elements. A detailed sedimentological analysis, coupled with inorganic & organic geochemical proxies, tie and constrain the driving mechanisms responsible for the accumulation of these units, which has reduced the depositional uncertainty; critical for the evaluation of unconventional resources.