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Unconventional Carbonate Reservoir Characterization: An Example from the Late Cretaceous Shilaif Formation, United Arab Emirates

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ABSTRACT

At present, select Middle Eastern countries have begun exploring and appraising their unconventional resources. Examples include oil from Bahrain (Khalij Al Bahrain Basin), gas condensates from Saudi Arabia (Jafurah Basin), and both gas (Ruwais Diyab concession) and oil (Al Dhafra region) from United Arab Emirates. Of note, all three of these countries are targeting unconventional reservoirs that are carbonate-rich and are therefore different relative to the siliciclastic-rich unconventional examples present across Argentina, Canada, and United States. Within Bahrain and United Arab Emirates, strong efforts have been made to attract foreign expertise to help explore, appraise and ultimately develop these unconventional carbonate reservoirs. A great example of this includes PETRONAS Abu Dhabi, who inked a historic agreement in 2022 with Abu Dhabi National Oil Company (ADNOC) to explore and appraise Unconventional Onshore Block 1 covering an area of 2,000 km2 (~500,000 acres) (Fig. 1). Building on this momentum, PETRONAS Abu Dhabi added adjacent Unconventional Onshore Block 5 to its portfolio in 2024, which covers an area of 4,000 km2 (~1,000,000 million acres). The primary reservoir being targeted by PETRONAS Abu Dhabi for oil development is the Late Cretaceous Shilaif Formation. Herein, it will be shown how high-resolution sequence stratigraphy and sedimentology are being utilized to aid reservoir quality characterization and ultimately field wide appraisal within the Shilaif carbonates.

The Shilaif Formation represents a deep-marine carbonate succession deposited within an intrashelf basin. Using Arabian Plate boundary nomenclature present in offsetting wells from various offsetting countries, three primary sequences within the Shilaif Formation can be delineated (from oldest to youngest): K120 (Lower), K130 (Middle), and K140 (Upper). Each of these three sequences can be further sub-divided on well-logs into lowstand (LST), transgressive (TST), highstand (HST), and falling stage (FSST) systems tracts. At the core level, organic rich carbonate facies in each of the three sequences commonly correspond with TST and early stage HST successions. Within these successions, thin-sections reveal significant planktonic foraminifera and calcispheres. Biostratigraphic analysis of core samples suggest much of the organic material is a by-product of phytoplankton (algal) blooms. It is hypothesized that planktonic forams fed on the zooplankton and algal blooms (likely calcispheres in the form of dinoflagellate cysts). Conversely, cleaner non-organic carbonate core facies in each of the three sequences commonly correspond with FSST and LST successions. In these successions, thin-section analysis reveals a higher abundance of fossiliferous fragments thus indicating sediment transport from adjacent platform margins into the basin. Finally, many key stratigraphic surfaces are punctuated by examples of Glossifungities Ichnofacies, reinforcing the importance of ichnology towards reservoir analysis.

Figure 1: United Arab Emirates location map. PETRONAS Unconventional Oil Blocks 1 and 5, highlighted in green, are in the Al Dhafra region (a municipality in the Emirate of Abu Dhabi). PETRONAS currently has 100% equity and operatorship to explore and appraise unconventional oil in the two concession areas for a period up to six years. Following a successful appraisal phase, PETRONAS can enter a production concession in which ADNOC has the option to hold a 50% stake.