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The stratigraphic record of Khawr Al Maqta, Abu Dhabi, United Arab Emirates

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Well-constrained modern depositional analogues are vital to the development of accurate geological reservoir models. The development of realistic hydrocarbon reservoir models requires the application of high-precision, well-constrained outcrop and sub-surface data sets with accurately-documented facies geometries and depositional sequence architectures.

The Abu Dhabi coastline provides the best modern analogue for the study of ramp-style carbonate depositional facies akin to those observed in the sub-surface reservoirs of the United Arab Emirates (UAE). However, all previous studies have relied on temporally limited surface datasets. This study employed thirty five shallow subsurface cores spanning the width of the Khawr Al Maqta – the narrow shallow tidal channel that separates Abu Dhabi Island from the mainland. The cores were taken over a transect measuring 1.2 km in length by 50 m wide thus providing a high-resolution record of sub-surface facies geometries in a stratigraphically complex setting.

Geometries in these Pleistocene to Holocene facies are complex with interdigitating, laterally heterogeneous carbonate, siliciclastic and evaporite units represented throughout the area of the study. Carbonate facies range from molluscan rudstones to marls and are all indicative of deposition in a shallow, relatively low energy marine setting akin to that seen in the environs of Abu Dhabi Island today. Texturally mature quartz sands occur as thin lenses and as thin cross bedded or laminated horizons up to twenty five centimetres thick. Glauconitic mudstones are common and locally exhibit evidence of rootlets and desiccation cracks. Evaporites are present in the form of gypsum occurring as isolated crystals and nodules or as massive chicken-wire units in excess of three metres thick. All of these textures are consistent with evaporite development in the shallow subsurface.
Early, shallow-burial diagenesis has been important. Bioclasts are pervasively leached throughout the stratigraphic sequence thereby resulting in a significant enhancement in porosity in the carbonate lithologies. This pervasive mouldic porosity is locally occluded by the precipitation of gypsum cements. The displacive precipitation of significant quantities of gypsum has resulted in the deformation of primary sedimentary structures.

This complex sequence of mixed carbonate-siliciclastic-evaporite lithofacies is interpreted to record repeated episodes of flooding and sub-aerial exposure associated with the waxing and waning of the Pleistocene ice-sheets. During periods of relative sea-level fall carbonate sequences entered the meteoric realm with the consequent dissolution of unstable bioclasts. Transgression and reflooding once again isolated Abu Dhabi Island from the mainland, thus permitting the precipitation of shallow-water carbonate lithofacies. During sea-level highstands the north-westerly Shamal wind transported carbonate sediments into the lee-of the island resulting in the south-easterly shore-wards development of a tombolo. However, the strong tidal currents of the Khawr Al Maqta prevented final connection to the mainland, thus ensuring the isolation of Abu Dhabi until the subsequent regression.