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Regional Characterization of Middle Triassic-Middle Jurassic Tight Reservoirs in Abu Dhabi, UAE

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SUMMARY

With an increasing demand of hydrocarbon resource from tight reservoirs, some of the exploration studies have been re-focused on the previously under-explored tight formations in Abu Dhabi.

The Middle Triassic to the Middle Jurassic formations, mainly Gulailah, Minjur, Marrat, Hamlah and Izhara from deeper to shallower, are the play fairways of tight hydrocarbon resource in Abu Dhabi. However, due to lack of systematic data integration, these tight formations were poorly mapped without a clear definition of their tight reservoirs. This paper is focused on re-mapping these tight formations on a regional scale and characterizing the tight reservoirs in the updated geological framework. The reservoirs were characterized in terms of geometry, quality and its controlling factors of deposition, diagenesis and hydrocarbon migration. This characterization was based on the unification of regional well correlation, reflection pattern interpretation of re-processed 3D PSTM seismic data and geochemical measurement results of cutting samples and fluid inclusions. As a result, a layer-cake to jigsaw-puzzle reservoir model is associated to the Middle Triassic to Middle Jurassic tight reservoirs.

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Method

To characterize the tight reservoirs on a regional scale, a detailed stratigraphic framework of the Middle Triassic-Middle Jurassic formations, up to 4th-order sequence, was built by unifying previous inconsistent well correlations across Abu Dhabi from onshore to offshore, based on cycles of GR log and interpreted lithology. Variation of reflection patterns from regional 3D seismic is used to constrain the stacking geometry of well correlation (Figure 1). In addition, seismic attributes, e.g. RMS amplitude and relative acoustic impedance, were extracted in different windows to investigate the large-scale depositional features within the new framework.

Facies distribution and sedimentary environment were studied based on the description of available core and cutting samples. Supervised artificial neural network was applied to extend lithology interpretation to un-cored wells based on log responses. By integrating the lithology distribution and depositional patterns in the new stratigraphic framework, a general geological model of facies and sedimentary environment was build and the outline of tight reservoirs and non-reservoirs were mapped on a regional scale combining average porosity maps and well test data (Figure 1). Besides, sedimentation and diagenesis of tight reservoirs were further studied based on isotope data and fluid inclusion analysis to investigate the controlling factors of tight reservoir property and tight reservoir distribution.

Conclusions

The new stratigraphic framework indicates a potential self-sourced petroleum system in the Middle Triassic-Middle Jurassic tight formations. Except the Minjur Clastics as a labyrinth reservoir with discontinuous sand bodies on a fluvial plain, reservoirs of the other carbonate tight formations are framed in a series of carbonate ramp and intra-shelf basin sequences (Figure 1). Facies variation in the intra-shelf basin sequences results in lateral change from deep-water source rocks in the south and east to shallow-water tight reservoirs in the north and west. Because of the restricted condition and frequent clastic influx, large scale bio-reefs of high reservoir qualities were not developed. The primary tight carbonate reservoirs are dolomitic pack- to grain-stone facies in a shallow-water shoal environment. Generally, these carbonate tight reservoirs are characterized by relatively high porosity (up to 30%) but very low permeability (normally less than 0.1 mD). The tight reservoir geometry in Abu Dhabi is a mixure of layer-cake in the gentel ramps and jigsaw puzzle in the prograding sequences of intra-shelf basin. The tidal channels recognized on seismic attributes from several seismic cubes indicate a wide-spread peritidal environment, where the pack- to wacke-stone sediments are secondary tight reservoirs of lower porosity and permeability.

Besides the stratigraphic framework and depositional setting, dolomitization is the major control of tight reservoir properties (Figure 1). Isotope analysis and outcrop analogue suggest a two-stage dolomitization model in the subsurface tight reservoirs in Abu Dhabi, including both early-stage environment-related dolomitization and late-stage burial dolomitization on a regional scale. The early-stage dolomitization enhances reservoir properties by increasing porosity in the shallow-water peritidal-shoal settings, which forms dolomization corridors for the burial hypothermal fluids. The late-stage burial dolomitization mainly deteriorates reservoir properties by precipitating dolomite cements and dramaticly reduces permeability. Unconformity-related dissolution in the west associated with Qatar Arch activities has minor inflence over reservoir properties, which is commonly over-printed by late-stage dolomite cements. Fluid inclusion analysis indicates that dolomitzation fluid upwelling and hydrocarbon migration in the tight reservoirs happened at the same time, structure traps and diagentic traps were formed in the west and north, where hydrocarbon shows are concentrated (Figure 1).

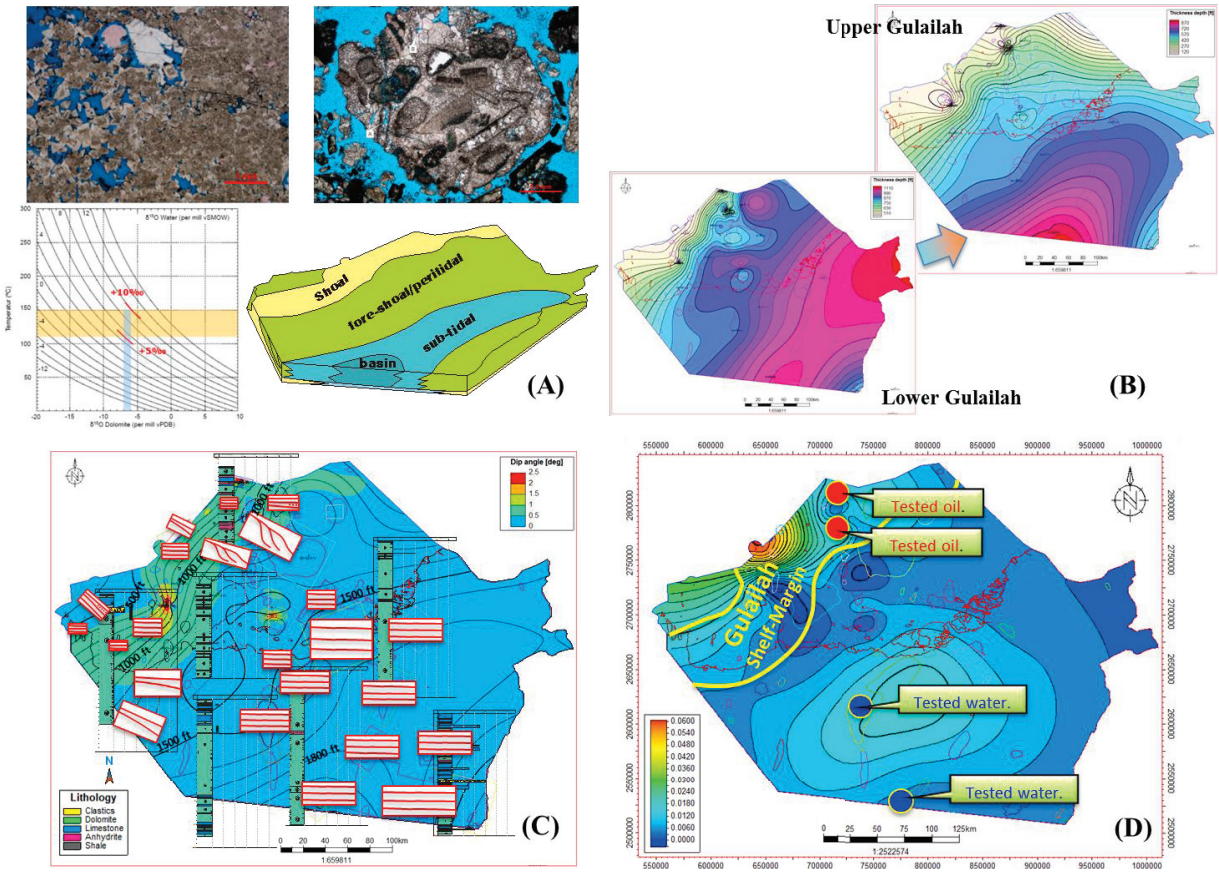

Figure 1 ***(A)*** *Depositional environment map of Upper Gulailah shows lateral variation of depositional settings from shallow-water peritidal and shoal to relatively deep-water sub-tidal and intra-shelf basin, pack-grainstone cuttings from shallow-water shoals are strongly dolomitized, the isotope fraction chart indicates a high-temperature brine origin.* ***(B)*** *Isochore maps of Lower Gulailah and Upper Gulailah show an evolution from carbonate ramp to intra-shelf basin.* ***(C)*** *Gulailah isochore contours overlying with thickness gradient map, seismic reflection patterns and mud logs, showing an increase in water depth from thin dolomitic sediments with anhydrite in the north-west to thick muddy limestone in the south, stacking geometry shows a lateral change from progradation along the shelf break to parallel in the basin centre.* ***(D)*** *Gulailah average porosity map with well test results shows hydrocarbon shows concentrate at the grainy shoals along shelf break of high porosity, which outlines the distribution of tight reservoirs.*

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References

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