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Diagenetic Controls on Rock Property Variations in Lower Shuaiba Reservoirs, Sultanate of Oman

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ABSTRACT

This case study focuses on the Lower Shuaiba reservoirs across central north Oman, where the Shuaiba reservoir is represented by shallow water, low energy facies deposited in a carbonate platform top setting. The area of interest is some 100 km by 70 km in extent, where oil is typically located in the topmost Shuaiba trapped in low profile anticlinal structures. Relatively subtle changes in reservoir permeability within the upper part of the reservoir impacts oil transition zone saturations and the flow rates of horizontal wells. Key uncertainties are the depositional and diagenetic controls on rock properties both at field scale and regionally.

The current study has assessed some 840 metres of core from 32 wells and log data from several hundred vertical and horizontal wells. Microporosity is volumetrically the most important pore type located in the muddy matrix of wackestone and packstone facies. A well-defined porosity-permeability relationship with porosity in the range 20-35% and permeability between 0.5 and 4mD is characteristic of microporous facies. The main reservoir heterogeneity is the occurrence of vugs located in relatively common algal-rich facies and less common rudist-rich facies. Open vugs result in higher core permeability values of 3 to 30mD and a much larger data scatter on porosity-permeability cross-plots. Log saturation profiles over vuggy intervals show higher saturation than found in microporous facies. The two main diagenetic processes that impact rock properties are dissolution and cementation. Dissolution creates vugs, but only in those depositional facies where algae or rudists are present.

An early phase of meteoric diagenesis has often been cited as the likely cause of dissolution and enhanced permeability near top Shuaiba. However the current data analysis shows that a late-stage dissolution phase, likely linked to hydrocarbon charge is the more important diagenetic event. The evidence includes:

- Petrographic fabrics that show a dissolution phase that corrodes/ removes early cement phases.

- Sparse grain-rich facies near top Shuaiba that exhibit an enhanced interparticle porosity that would be unlikely to survive compaction and is probably post-burial.

- Algal-rich facies in the water-leg are calcite cemented and contain only microporosity, while the same facies in the oil leg contain open vuggy pores as indicated by higher permeability values.

- Several fields exhibit a porosity-depth trend restricted to the oil-leg. Porosity is highest in the field crest, decreases to the oil-water contact and is constant in the water-leg. This porosity-depth trend is evident in some fields and not in others.

- The late-stage dissolution could be related to the arrival of gaseous compounds ahead of the oil charge and a change in pore water chemistry. Such a mechanism could explain the porosity-depth trend and a pattern of dissolution related to trap configuration.