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Carbonate Platform High-Frequency Cycles, Natih Sequence I (E Member), Sultanate of Oman: Constrasting Transgressive & Regressive Constrained Reservoir Scale Heterogeneities

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SUMMARY

Thick, apparently layer-cake, proximal carbonate platform deposits of the Natih Formation (Late Albian - Early Turonian) show stratigraphic heterogeneity that differs between transgressive and regressive stacking patterns of high frequency cycles. In Natih Sequence I (E member), stylolite-seamed mudstones to wackestones of deepening half-cycles form permeability barriers in landward stepping configurations, as do the dolomitised, early-cemented bed tops of progradational half cycles in seaward stepping mode. These laterally extensive permeability barriers, spaced at 1m to 10m intervals, should be taken into account when putting together models for fluid flow in similar thick "homogenous" reservoirs.

The Natih Formation carbonate system and depositional sequences of Oman are well established, and the heterogeneities at the reservoir scale, studied on outcrops of the Oman Mountains and Adam foothills, have already proven useful for static reservoir modelling. The carbonate depositional system of the Natih E has been shown to prograde from three nucleation areas in North Oman: West, North and East. Whereas attention has been focused on the margin to basin facies of the outcrops of the eastern and western platforms, since they tie directly into several oilfields through adjacent 3-D seismic surveys, the build up of the Northern platform provides insight on facies and reservoir heterogeneities from accumulations of more proximal, shallower carbonate platform environments where clay intervals are absent.

Stacks of metre-thick to several-metres-thick high-frequency cycles (genetic units) may form an apparent layer cake up to one hundred metres in thickness. Although these thick and laterally extensive carbonates do not show any clay intervals that would hinder fluid flow across thinner units, stylolite-rich seams and heavily dolomitised beds (or bed surfaces) do create potential flow barriers that should be taken into account for reservoir modelling of such apparently more homogeneous, thick layers.

The > 100 m thick proximal platform carbonates of the Natih sequence I (E member) in particular show two highly different facies associations, during transgressive ("landward stepping") and during regressive ("seaward stepping") stacking patterns. Landward stepping high-frequency cycles show a progradational half-cycle with cross bedded to homogeneous low-angle clinoform-set bounded packstones and wackestones, followed by a transgressive half-cycle of wackestones to mudstones with more or less pronounced horsetail stylolite seams. The cycle thickness diminishes from 10m or so to 2–3 m and cycles become more and more symmetrical up-section. A most pronounced stylolite-seamed bed is at the turn around from this first facies association to the second, and is interpreted to be the MFS of Sequence I. Seaward stepping high-frequency cycles become more and more asymmetrical up-section and are terminated by a well developed karst penetrating >10m below an emersion surface, the SB between sequences I and II. The seaward stepping high-frequency cycles show wackestones to packstones with a more or less intensely bioturbated upper part, covered by a thin stylolite-seamed wackestone to mudstone. The bioturbated bed tops are commonly dolomitised, and early cementation of the upper parts of the bed is shown to have preserved the burrow pattern shape.

The dolomitised, early cemented grainstones to packstones of the seaward stepping units, and the stylolite-seamed mudstone to wackestones of the landward stepping units create extensive, layer parallel permeability barriers at the 1–10 m scale and should be taken into when constructing models for fluid flow in such apparently homogeneous units.