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How Sequence Stratigraphy Impacts the Dynamic Modeling of Bypassed Oil Accumulations in Two Upper Jurassic Carbonate Reservoirs, Berri Field, Saudi Arabia

In the mature stages of reservoir depletion, production of bypassed oil accumulations becomes a major concern. Reservoir simulation depends on a reservoir characterization that contains the spatial information necessary to predict the size and location of these bypassed oil accumulations from production/injection rate history. The Hadriya and Hanifa reservoirs in Berri field, which have been on production for over 25 years, illustrate the importance of proper geological modeling to reservoir characterization and, ultimately, to successful exploitation of bypassed oil.

The impact of carbonate sedimentation on reservoir performance of the Hadriya and Hanifa reservoirs can be explained in a sequence stratigraphic framework. In the Hadriya reservoir, fluid flow is controlled by depositional facies and syndepositional diagenesis (i.e. marine cementation) that parallels the depositional fabric, imposing vertical permeability barriers/baffles within the highstand interval. Coupled with high-rate crestal production, this vertical permeability baffling has inhibited gravity-induced cross flow of the injection water, enabling it to flow updip in the high permeability, transgressive grainstones over the oil-filled middle and lower Hadriya intervals.

In the Hanifa reservoir, the distribution of depositional facies (i.e. particularly, boundstones and rudstones) and the inherent permeability contrasts between these facies are the primary factors affecting reservoir performance. Bypassed oil covers a large downflank area and occurs at the top of the reservoir (i.e. within the transgressive grainstones) above low permeability boundstones (i.e. lowstand systems tract). These boundstones reduce the impact of the peripheral waterflood, which is providing an overall "bottom up" water drive reservoir depletion mechanism.

Over the years, both reservoirs developed significant bypassed oil accumulations. These were predicted by reservoir simulation models using sequence stratigraphy based reservoir characterizations. Horizontal well drilling programs to recover this oil have been and are still being guided by analyses of simulation results.