Sequence Stratigraphic Framework of the Wara Formation, Wafra Field, Partitioned Zone of Saudi Arabia and Kuwait

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Abstract

The Cretaceous Ahmadi-Wara interval in the Wafra Field, Partitioned Zone of Saudi Arabia and Kuwait was evaluated using comprehensive well-log sequence stratigraphy. Historically, the Wara Formation has been interpreted to be deposited as a tidally-influenced delta plain with laterally extensive parasequences. The main reservoir facies were interpreted as stacked channel sandstones, mouth bars, and tidal bars. However, drilling and production data suggests a much more complicated reservoir architecture, one overprinted by both stratigraphic heterogeneity and structural compartmentalization. The goal of this investigation was to develop an improved understanding of a complex and highly variable siliciclastic depositional system and the associated production trends. This project included the interpretation and correlation of 135 wells, organized into 7 N-S and 12 W-E cross sections. Depositional units were defined using available core data and integrated with well log data to construct lithofacies maps. Channel incisions, prograding sequences, and shifts in facies within sequences were identified, and horizon datuming was used to support the interpretation of lateral and vertical facies relationships. The interpretation and integration of core and well log data indicates four general lithofacies associations are present: 1) amalgamated channelized sandstones, 2) coastal plain/tidal flat heterolithic sequences, 3) shallow to marginal marine sandstones, and 4) offshore/prodelta mudstones. Mauddud Formation carbonates are unconformably overlain by offshore mudstones of the Wara Formation. The base of the Wara reservoir facies is marked by a sequence boundary and consists of sharp-based

amalgamated sandstones interpreted as channel fills and regressive-transgressive cycles with fining upward components interpreted as deltaic deposits with tidal influence. In the Wara, there is great vertical and lateral heterogeneity even in closely spaced wells due to anastomosing channel cuts that erode each other. The main reservoir facies are overlain by field-wide correlative parasequences of Ahmadi Formation consisting of prodelta mudstones with shallow marine sandstones in an overall transgression. Facies distribution maps and paleoenvironmental reconstructions show that the marine transgression started in the north and continued towards the south with a main sediment flow direction from south to north during the Wara-Ahmadi interval. This new Wara sequence stratigraphic framework resulted in a new understanding of sediment transport direction and a better understanding of the complex stratigraphic architecture of the Wara reservoir and the long and complex production history. It has potential to significantly improve oil production trends, minimize produced water, and increase estimates of ultimate recovery.