Architecture of the Shu'aiba Carbonate Reservoirs in the Middle East

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Abstract

The carbonates of the Aptian Shu'aiba Formation are one of the most prolific and widespread reservoirs in the Middle East with, according to published data, more than 56 billion BOE recoverable hydrocarbons. Shu'aiba fields show a complex internal stratigraphic architecture and significant regional variations in reservoir character which makes it difficult to find the right analogue data when comparing fields.

The construction of a regional sequence stratigraphic framework, by integrating seismic geometries with well data, significantly improved the understanding of the controlling factors of these regional variations in reservoir properties and geometries.

The Shu'aiba Formation represents a depositional cycle of up to some 150 m thick within the Cretaceous epeiric carbonate platform of the Arabian Plate and is composed of a Transgressive (TST), Highstand (HST) and early Lowstand (LST) Systems Tract. A distinct relationship between systems tracts and reservoir facies and architecture can be recognized which is related to 1) changes in stacking patterns in response to variations in available accommodation space 2) the response of the carbonate factory to variations in the influx of clays and nutrient content of the water and 3) duration of exposure at the sequence boundary.

Reservoirs within the early TST are laterally extensive but hardgrounds and condensed intervals form horizontal baffles significantly reducing vertical permeabilities. The reservoirs did not experience significant early fresh-water leaching but transgressive lags may form high permeability streaks. The early HST reservoirs consist of rudist biostrome mounds with a highly complex internal architecture. They show strong variations in permeability related to progradational geometries, channeling and impact of early fresh water diagenesis on the rock fabric. The Late HST reservoirs show a simpler reservoir architecture with a gradual shallowing upward trend towards higher energy better reservoir facies. Low angle clinoforms however may affect the lateral connectivity. The gradual vertical change in reservoir properties also results in long transition zones. Reservoirs in the early LST consist of porous pelletoidal pack/grainstone wedges with a strong impact of early fresh water diagenesis on rock fabric. Interbedded clays and hardgrounds related to flooded exposure surfaces however significantly reduce vertical permeabilities. Horizontal permeability may be affected by progradational geometries. Wedges and pinch-outs are common and there is a high potential for stratigraphic trapping.

A good understanding of the regional sequence stratigraphic framework is essential to understand the variation in reservoir/flow properties between fields and also allows grouping of fields according to stratigraphic setting for comparison / analogues in reservoir studies. Furthermore it can be used to predict reservoir properties in undrilled areas.