Implication of Depositional Architecture and its Control on Vertical and Lateral Variation of Reservoir Facies – A Case Study from North Kuwait Field*

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Abstract

An attempt has been made to illustrate the depositional architecture of the Neogene sequence and layer characteristics of the reservoir and non-reservoir rocks from North Kuwait field.

The Neogene sequence in the study area can be rationalized into six largely fluvio-deltaic depositional facies, essentially ranging from proximal fluvial channel-fill sand bodies and floodplain mud rocks to distal, marine-influenced deltaic deposits including distributary channelfills, mouthbars, interdistributary bays/lagoons as well as shallow marine lower shoreface and offshore facies associations. The latter are associated with distinct transgressive events that episodically have transformed the fluvio-deltaic complex into a shoreface-type depositional environment. We postulated that, at least, parts of the delta system were influenced by estuarine conditions, although the full extent of this cannot be assessed by the available dataset.

Field-wide correlatable flooding, transgressive and erosion surfaces (sequence boundaries) are present in this formation and provide the sequence stratigraphic framework for the interpretation of the succession's depositional evolution and zonation. The gross vertical organisation of the sediments, together with field-wide correlations, suggest that the depositional heterogeneity increases from the base to the top of the succession; this is highlighted by a higher proportion of inter bedded mud-prone fluvial/deltaic and marine influenced deposits up-hole.

The main reservoir sandbodies are fluvial and rarer distributary channel-fills, which commonly have multistory/multilateral depositional architectures. While the majority of the clean fluvial/distributary sand bodies have up to excellent reservoir qualities, poorer qualities are generally associated with more argillaceous channel-fill sandstones.

Although they occur in various proportions within individual layers, mapping of the argillaceous channel-fills shows that they tend to be more commonly distributed in the upper parts/towards the top of the sandstone-dominated part and towards the marginal areas of the field, notably to

the south/southeast and north. The vertical and lateral facies distributions, together with biofacies trends, are detailed for each layer in this study and are illustrated on layer-specific facies maps.

Discussion

The channel-fill sandbodies are locally separated by/interbedded with rare mud-rich channel abandonment fills and more common muddy floodplain deposits, which are likely to form intra layer baffles. Their preservation potential within the sandstone-dominated layers is low and their lateral extent is largely controlled by channel erosion. This probably results in lozenge-shaped floodplain geometries, that can only rarely traced laterally between adjacent wells, suggesting that their true proportion may be underestimated by the available well dataset (which may have implications for the production technology/recovery factor). The mud-prone layers are mainly composed of interdistributary bay/lagoonal deposits. Given their muddy composition and field-wide extent, they are considered fluid flow barriers in the field, although increasing sand content.

A schematic diagram illustrating the workflow is shown in Figure 1.

Summary and Conclusions

1.Detailed core sedimentological analysis integrated with high-resolution biostratigraphic data helped to constrain better the deltaic-estuarine scenario as this may have implications for intra-sand body reservoir heterogeneities (i.e. Biogenic overprint, argillaceous content/distribution, all of which are expected to influence reservoir quality and its distribution (on pore to bed-scale reservoir heterogeneities).

2. The depositional heterogeneity of the Neogene sediments in this field shows overall increases from the base to the top of the succession with multilateral/multistory, clean fluvial and minor distributary channel-fill sandbodies forming the best reservoir. Generally, sand body connectivity is expected to be best along the depositional dip section (S/SW to N/NE) for the sandstone-dominated layers, although local variations imply that fluid flow pathways may be more complex. There exists good control on the distribution of more argillaceous/poorer quality channel-fill sandstones for each layer (possibly increasing sand body-scale heterogeneities), which tend to be more common in the upper parts of the above layers and the marginal areas of the field, particularly to the north and south/southeast.

3. The distribution of mud-prone, possibly lozenge-shaped floodplain baffles within the sandstone-dominated layers seems to follow the distribution of the argillaceous channel-fill sand bodies. However, as their lateral extent may be smaller than the current well spacing, it is possible that the true proportion of these floodplain baffles may be underestimated by the available dataset. This could have implications for reservoir behaviour and may influence the selection of the appropriate production technology/recovery factor. Additional well data will help to constrain their true proportion.

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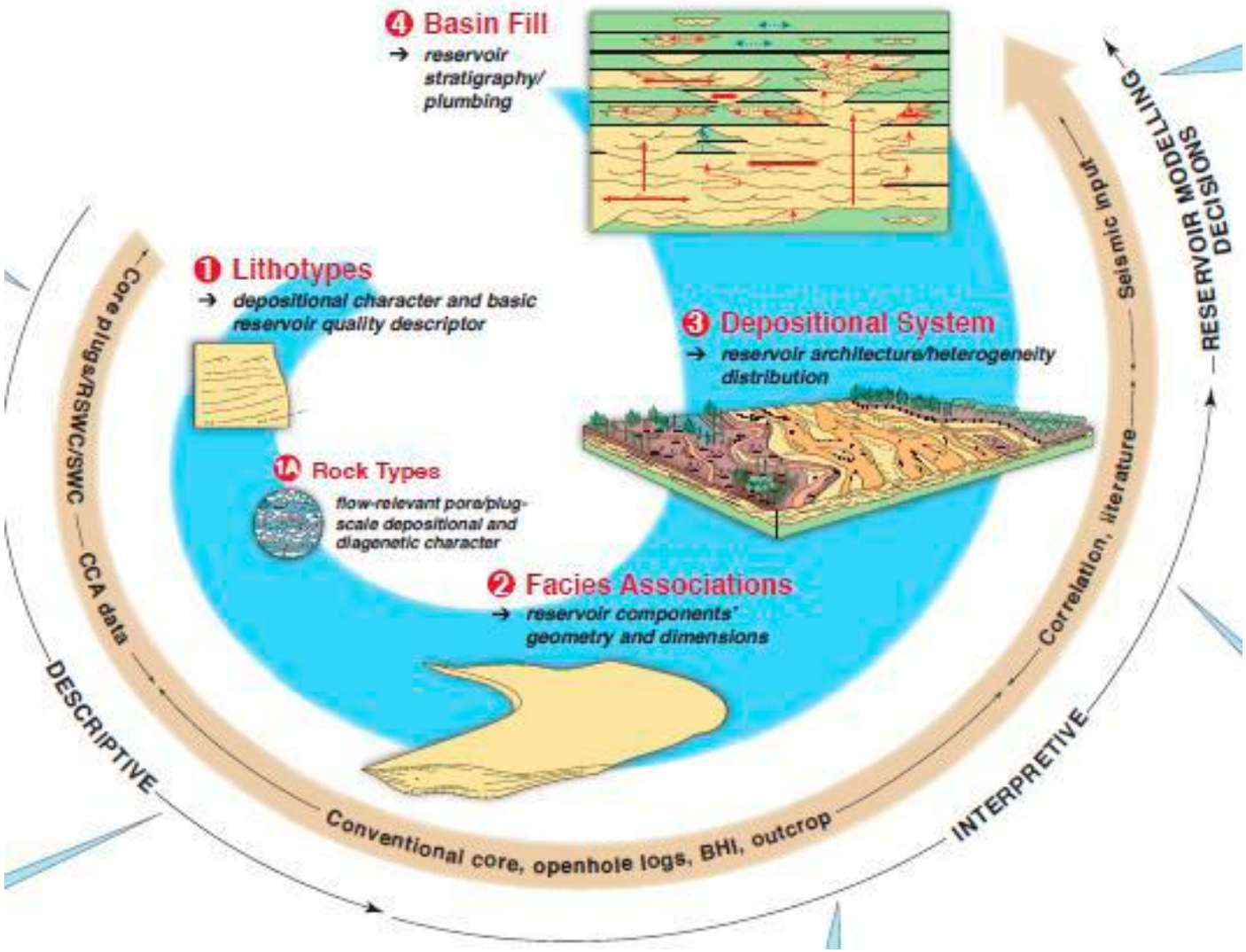

Figure 1. A synergetic approach has been followed by integrating the core data, sedimentology, biostratigraphy and electrolog analysis for inferring the facies associations and inferring depositional systems.