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# A Combined Facies Modeling Approach Integrating Core, Log And Seismic Data: A Case Study From Aishwariya Field, Barmer Basin, India

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## ABSTRACT

The Aishwariya field, located in the northern part of hydrocarbon prolific Barmer basin, onshore NW-India was discovered by Cairn in January 2004 and currently under production since 2013. Primary reservoir units are the pre-rift Ghaggar-Hakra formation deposited in Early Cretaceous period and syn-rift Fatehgarh formation deposited after a hiatus in Late Cretaceous to Early Paleocene period. The formations are divided into five major units (FA1 to FA5) which consist of clastic reservoirs deposited in a fluvio-lacustrine setting. These units are having a varying net-to-gross (35% to over 80%) with an average porosity of 23% and multi-Darcy permeability. This paper summarizes the methodologies and results of an integrated facies modeling approach that has been attempted to combine object and pixel-based techniques to capture the reservoir heterogeneity and complex connectivity pattern arising from the combination of Channel, Lake-margin and Sheetflood deposits.

Ghaggar-Hakra formation starts with an incised braided channel complex (FA5b) sitting on basement. The landscape is then drowned to establish a lacustrine mud facies (FA5a). The lake then dries and passes upwards into a succession of sheetflood sandstones (FA4). Finally, the upper part (FA3) is a more straightforward succession of fluvial channels and floodplain muds. Then the Fatehgarh Formation starts with a shutdown of the fluvial system and establishment of widespread, thick floodplain muds, with thin channel margin sands (FA2). FA1 is characterized by fluvial channels, Lake-margin heteroliths, lacustrine muds and thin floodplain muds. There is a good areal and vertical spread of cores in the Aishwariya field. A total of seven facies, i.e. Fluvial channel sandstone/silty sandstone, Lake margin sandstone/silty sandstone, Sheetflood sandstone/silty sandstone and Shales, are differentiated in cores. Log motifs corresponding to the core depositional facies were identified and interpreted in all seventy seven wells of the field. A constrained seismic-derived pseudo VShale volume was used to condition facies distribution away from wells. Individual channel sand thickness were measured and tabulated from well logs. Channel widths were estimated by using analogues of thickness vs. width cross plots from global published datasets. Paleocurrent data, as measured from the image logs, were incorporated in populating the Channel facies.

Channels have been modeled using an object-based method and Lake-margin/Sheetflood reservoirs along with non-reservoir (Shale) have been modeled as background facies with a pixel-based approach. The technique of combining object and pixel-based approaches in one model pragmatically depicts the underlying geological concept. Deterministic channel architectures are preserved while the statistical algorithm captures realistic lateral inter-relationships within the heterogeneous background facies association. This combined facies modeling workflow has resulted in geologically viable model which replicate the regional understanding of depositional environment variability. Production data from the field indicates decent connectivity whereas, in a low NTG system, building that connectivity in the model has always been

challenging. This combined modeling approach successfully takes care of the connectivity issue with Channels playing the key role in accessing the more widely distributed background reservoir facies.

This integrated static modeling approach improved the combination of lateral trends from seismic attributes and vertical trends from core and log data to define the facies distribution. This combined approach provided the flexibility of describing the statistical uncertainty without compromising on key geological concepts and defined deterministic elements. The final static model is being used in revising the reservoir simulation model and history matching at well and field level. Initial observations have been encouraging in addressing the connectivity issues as compared to earlier version of static model. The connectivity as captured in the static model corroborates the field dynamic and production behavior to a large extent, thereby significantly improving in predicting the production performance of this field.