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Integration of Core, Borehole Image and Open Hole Well Log Data to Identify Hydraulic Flow Units in the Unayzah Formation

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ABSTRACT

Hydraulic Flow Units (HFUs) utilize a probabilistic methodology to estimate the flow behavior of various lithofacies, grouped together using petrophysical data applied to delineate the reservoir into “units” with similar fluid flow characteristics using Flow Zone Indicators (FZIs). This paper considers the HFU and FZI concepts, to define high resolution flow units within uncored intervals of the Unayzah formation, through integrating borehole images and open hole well log data with core defined HFUs. Detailed analysis — of the reservoir properties and their interrelationships with geological and engineering parameters — is required for the successful evaluation of reservoir units.

The workflow includes five main steps:

1) Identification of core based FZI and HFU using routine core analysis (RCA) “porosity-permeability.”
2) Supervised neural network calibration of open hole log based rock classes with core HFU data.
3) Fluid substitution transform of Borehole Image (BHI) resistivity arrays to water wet state to alleviate effects of fluid changes.
4) Utilization of core and well log HFUs to calibrate BHI resistivity thresholds.
5) Integration of high resolution core derived HFU with BHI based grain size and electrofacies to extrapolate into uncored intervals while constraining the geological framework.

The workflow was applied to 10 sections from wells in the clastic Unayzah Formation of central Saudi Arabia. The data set comprised 352 core samples (RCA) analysis, 4000 ft of BHI and 5300 ft of conventional well logs. Initially two sections with the widest range of cored lithofacies were used to characterize the FZIs and HFU. These provided the learning set for reiterative neural net training and analysis of the remaining cored sections. Five HFUs were consistently identified and confirmed by blind testing against two remaining datasets. Comparison of HFU results from cored sections allow confident extrapolation into uncored intervals. The results of this work can help in determining porosity and saturation height functions, while the lithofacies approach provides a consistent geological link for 3D high resolution static reservoir modeling.

Use of core derived HFU — with extrapolation into uncored intervals through integration of BHI data — significantly improves the HFU resolution. This use also provides a link between depositional trends, grain size characteristics and FZI, to optimize geological modeling, well placement, completion and reservoir stimulation.