Revealing the Complex Geological Architecture of Deep-water Reservoirs using High-resolution Borehole Imaging Technology

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Abstract

Subsurface geological evaluation is a vital component of effective reservoir assessment, primarily established through a combination of macro-scale seismic profiles, high-resolution borehole imaging, and cores. In deep-water GoM plays, where seismic signals are often attenuated by salt canopies and depth, borehole imaging takes on a critical role. A technological leap forward in this arena is a next-generation wireline oil-based mud (OBM) micro-electrical borehole imager that has supplanted legacy imagers as the tool of choice. Recognized as operationally efficient, the tool delivers an unparalleled high-resolution circumferential view of the wellbore that rivals even water-base imagers. The images produced have proven to be a revolutionary advance for borehole image-based geological interpretation, including enhanced structural evaluation and especially detailed sedimentological assessment.

This paper details examples from wells in the deepwater Gulf of Mexico, wherein the OBM-adapted borehole images were acquired as part of wireline logging suites. Because of the high resolution and the large borehole coverage of the images, fine details of the reservoir sands are observed. Differing modes of sedimentation can be clearly distinguished; lower-energy sands are easily discriminated from higher-energy channel-axial deposition and irregularly-bedded or chaotic sands. Channel scours, imbricated rip-up clasts, cross-beds and other flow-regime indicators are now clearly observed. In the shales, where previous imagers have been seriously challenged, these photorealistic images crisply delineate the laminations and bedding to permit accurate structural dip determination. Additionally, the differentiation of the quieter environment sediments from the higher energy deposits – including debris flows and mass transport deposits – demonstrates complex depositional changes occurring in the basin. With legacy technology, these various deposits were nearly impossible to accurately characterize.

The examples discussed in this paper demonstrate the ability of these high-resolution borehole images to allow enhanced interpretation of various reservoir sand architectures, within the framework of surrounding structural elements; to more accurately position them within the depositional system. As such, they further enhance the detail and understanding of other petrophysical measurements, allowing asset geoscientist and petrophysicists an improved realization of these very complex reservoirs.