Fifty Shades Darker: Integrating Sedimentology, Sequence Stratigraphy, Chemostratigraphy and Geophysics to Identify Sweet Spots the Liquids-Rich Duvernay Shale Play, Kaybob Alberta.

Lindsay A. Dunn
Justin A. Humenjuk

Athabasca Oil Corp.

The Frasnian Duvernay Formation of Alberta Canada is a proven source rock that is becoming one of the hottest liquids-rich shale plays in North America. In the Kaybob region, the play is rapidly moving from an early exploration phase that began in late 2010, towards multi-well pad development. With this progression companies are actively high grading their acreage.

Conventional sedimentology, sequence stratigraphic and chemostratigraphic work flows provide the framework for developing a predictive model for deciphering rock quality to reservoir quality relationships vertically and laterally. Relative amounts of TOC, biogenic silica, clay, and carbonate control reservoir quality in the Duvernay. Twelve lithofacies have been classified into three end-member rock types that display decreasing reservoir quality from highly siliceous organic rich mudstones, argillaceous mudstones down to non-reservoir carbonates. The deposition and distribution of these lithofacies and their associated system tracts are controlled by the basin bathymetry and morphology. The highest reservoir quality rocks are associated with the transgressive systems tracts to early highstands, where enhanced preservation of organic material has led to the development of dominantly intra-kerogen porosity within the highly siliceous mudstones. During highstands, reservoir potential is diluted due to carbonate shedding from the platform and the contemporaneous Leduc reefs and through the increased influx of axial derived detrital clay. Similarly channelized (?) lowstand deposits diminish reservoir quality as a result of the influx of detrital carbonate.

Due to the close association between reservoir quality and rock type X-Ray Florence (XRF) on cuttings calibrated to core and X-Ray Diffraction has proven to be a fast, cheap and accurate tool to identify zones of enhanced reservoir quality in vertical and in horizontal wells. Through regression work between petrophysically derived properties and the XRF data we can predict petrophysical properties in horizontal wells in the absence of logs. This data has been used to optimally land and steer wells and place frac stages in the Duvernay.

The next step in the collaborative process is to determine the most effective workflow to identify sweet spots on the existing 3C-3D seismic data in the study area, utilizing key

attributes that relate to the depositional lithofacies defined through the sedimentologic, stratigraphic and petrophysical approaches.

As mentioned above, the three main rock types within the Kaybob study area are siliceous organic rich mudstone, argillaceous mudstone and carbonate. They can be separated into distinct clusters by cross plotting Young's Modulus and Poisson's Ratio logs. These same petrophysical attributes can be generated from the results of seismic inversion.

With the benefit of having both PP and PS data components processed, a PP pre-stack, PS post-stack inversion was performed. The resultant volumes were used to generate Young's modulus and Poisson's ratio volumes.

Based on the sweet spot criteria, established from sedimentology, stratigraphy, petrophysical analysis and inversion derived volumes; facies volumes, gross thickness and sweet spot maps were generated that can be used not only to high grade geographic areas but can also be used to pick optimum horizontal drilling targets and/or completion zones.