The Permian Upper Minnelusa Formation, Powder River Basin, Wyoming: Regional Analysis and Application to Exploration and Development

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The dominantly aeolian Permian (Wolfcampian) Upper Minnelusa Formation in the Powder River Basin (PRB) forms the second-most productive oil reservoir in the State of Wyoming, with total production to date at over 600 MMBO. A regional analysis of the Upper Minnelusa play was carried out in a 7400 km^2 subset of the NE PRB. Data were mined and integrated from a combination of public and private databases across the PRB. The dataset includes core, raster and digital wireline logs, corebased petrophysical measurements, and production data.

The Upper Minnelusa Formation can be divided into five separate stratigraphic sequences (Z, A-D), comprising dolomite/ anhydrite and sandstone pairs. Wireline log picks for more than 7100 wells were made for the internal Minnelusa stratigraphy and the overlying Minnekahta and Opeche formations. These picks were used to map out the internal geometry of the Minnelusa in a regional sense, including horizon, subcrop, and isopach maps.

Normalized digital gamma and sonic logs were available for more than 5600 of the wells. Compared to core, these logs show a high affinity with observed facies associations within the Minnelusa: reservoir sandstone, non-reservoir sandstone, laminated dolomitic mudstone-sandstone, dolomite, and massive anhydrite. An unconstrained estimation model was carried out using neural networks to correlate the gamma and sonic logs to the seven facies associations. These facies were integrated with the sonic logs to provide estimates of sonic porosity. The sonic porosity estimates were then calibrated with core-based porosity and permeability measurements.

A reservoir model across the study area was generated based upon the regional mapping for the Upper Minnelusa section. Model zones were constructed for each of the internal units. The facies- and sonic-porosity logs were upscaled into the model, and stochastically populated across the study area using sequential Gaussian simulation. Results provide a series of time-slices through the model zones illustrating changes in facies association and sonic porosity through time. This type of regional mapping has implications for both production and exploration. Within presently producing fields, potential sand-body connectivity can be assessed and integrated with production data to define individual flow units. At the larger scale, this work provides a regional exploration assessment of undrilled areas with porous, potentially hydrocarbon-bearing, sandstones.