Stratigraphic Variability and Petrophysical Characteristics of the Pennsylvanian Prue Sandstone, Central Lincoln County, Oklahoma

Morgan E. Levrets[1], Matthew J. Pranter[1], Anna M. Turnini[1], and Jerry M. Spalvieri[2]*
School of Geosciences, The University of Oklahoma[1], Buckeye Exploration Company[2]

ABSTRACT

In east-central Oklahoma, the Prue Sandstone consists of fluvial and deltaic deposits and is the youngest of four sandstone intervals deposited during the Pennsylvanian Period. Each of the four sandstone intervals is separated by shales and limestones that formed during periods of marine transgression. The Prue sandstone in Lincoln County is interpreted to be deposited in an upper delta plain environment. Facies include sandstones with localized flaser and wavy laminations, planar-laminated sandstone and dark mudstone exhibiting bioturbation, and dark shales.

While the Prue Sandstone is a well-known reservoir for oil and gas in Oklahoma, the stratigraphy, sedimentology, and reservoir characteristics of the Prue have not been extensively studied. Therefore, this study explores the lithologies, facies, and the spatial variability of the Prue structure, thickness, sandstone percent, total porosity, effective porosity, and water saturation through well-log petrophysical analysis and 3-D geostatistical modeling. In the 224 mi^2 (580 km^2) study area, there are 198 wells each with a combination of gamma-ray, neutron-porosity, bulk density, and resistivity logs, with some also having photoelectric effect logs. Two wells close to the study area provide core from selected intervals.

The Prue Sandstone in central Lincoln County is bounded at the top by the Oswego Limestone and at the base by Verdigris Limestone deposited during periods of marine transgression. The stratigraphic framework of the Prue Sandstone appears to include three primary reservoir zones based on lithological and petrophysical constraints. Subsurface correlation and mapping of the Prue Sandstone was based on well-log signatures using primarily gamma-ray and deep resistivity logs. Both the Oswego and Verdigris limestones exhibit high deep-resistivity signatures. Using gamma-ray, deep-resistivity, bulk-density, and neutron-porosity logs, log analysis was performed to determine lithologies and petrophysical values. Sandstones and shales within the interval were classified using gamma-ray logs and coal was determined based on bulk density and neutron-porosity curves. From bulk-density logs, a density-porosity log was calculated and used with neutron-porosity logs to calculate total porosity. Shale corrections were applied to generate effective porosity logs using a calculated shale volume. Water saturation logs were calculated for each well. The Prue Sandstone interval thickness varies from 40-160 ft (12-48.7 m), with net sandstone thickness ranging from 0 to 120 ft (0-36.6 m), and sandstone percentage ranging from 0 to 100%. Initial petrophysical analysis indicates effective porosity values from 0.5 to 28% and water saturation values from 16 to 100% within the sandstones. Areas with higher net sandstone likely represent are stacked distributary channels and areas of lower net sandstone correspond to individual distributary-channel fills. Three-dimensional reservoir models of the Prue Sandstone illustrate the high reservoir heterogeneity across the study area that is controlled by the stratigraphic variability of lithofacies and their depositional trends.

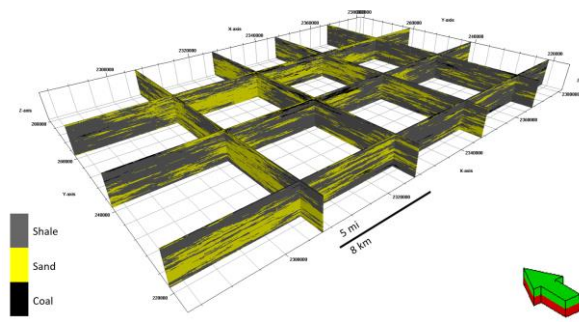

Figure 1: Prue Sandstone 3D lithology model fence diagram that illustrates the spacial variablity of lithology within in the Prue Sandstone interval.

Acknowledgments

The authors thank Buckeye Exploration Company, Oklahoma Geological Survey, slb Petrel, GVERSE GeoGraphix, Oklahoma Petroleum Information Center, and Enverus.