Understanding the Regional Variations in Pay Thickness of Unconventional Reservoirs in the Powder River Basin by Incorporating Learnings from a Site-Specific, Core-Calibrated, Geologic Model

Luke P. Fritz[1], R. Ness[1], B. Roth[1], and N. Jones[2]

[1]Advanced Resources International
[2]Enhanced Oil Recovery Institute

Abstract

Understanding geologic variations at the basin scale provides guidance for unconventional hydrocarbon exploration, allowing operators to efficiently strategize the development of their assets. An approach to identify and map pay zones for unconventional plays was developed for the Powder River Basin (PRB) based on knowledge learned from core data that was obtained as part of the DOE field laboratory program, Unlocking the Tight Oil Reservoirs of the PRB. For the Turner/Frontier Formations, pay zones are selected using specific wireline log cut-offs for gamma ray, bulk density, and caliper curves that were initially found over cored intervals. For the Mowry Shale, based on regional core analysis, we base pay zones on Middle Member and bentonite thicknesses, as well as thermal maturity. Lithofacies in the Turner were identified in hand samples. When compared to core-derived reservoir properties, these lithofacies identified a high-quality pay interval, with high porosity and So. The Turner/Frontier horizon was interpreted using logs from 1,756 wells across the PRB. Petrophysical cutoffs – correlating to the pay interval – assessed pay thickness, and isopach maps were subsequently gridded. Core analysis of the Mowry Shale shows the Middle Member exhibits the highest porosity, permeability, and TOC values, and lowest Sw. 1,062 wells with logs were used to measure the Middle Member thickness to generate an isopach map and calculate reservoir properties. 76 wells with Tmax data were used to cut off areas of the PRB outside of the oil and gas generation window. Increases in pay thickness in the Turner/Frontier correlates with geographic locations of existing producing fields. Particularly in the Finn-Shurley field, the most productive field in the Turner, pay thickness approaches as much as 80ft. In the Frontier, some pay thicknesses exceeded 150 ft, but most of the basin contained less than 10 ft of pay. The Middle Member of the Mowry is thickest (>180ft) on the northwest flank of the PRB and thinnest in the southern portion of the PRB (~30ft). However, thermal maturity trends do not coincide with thickness. The flanks of the PRB are in the early oil generation window, generally corresponding with structural depth. The highest maturation of the Mowry occurs along the basin axis, where maturities reach the dry gas generation window. The DOE field laboratory program contributed crucial funding for finding novel information on productive zones in the Turner/Frontier and Mowry Formations. Combining modern geophysical logs and core data from this project with publicly accessible data such as logs and thermal maturity values basin-wide makes it possible to understand favorable oil and gas productivity zones. Data from these methods can also be used to assist potential acreage acquisitions or for estimating total resources available for extraction in the basin.