Integrated 3D Geological Model of the Devonian Bakken Formation, Elm Coulee Field, Williston Basin: Richland County, MT

Adrian Almanza
Department of Geology & Geological Engineering

Abstract

The Bakken Formation of the Williston basin is a oil resource play that was named the largest continuous oil accumulation in the lower 48 states by the United States Geological Survey (USGS) in 2008. Although extensive, the Bakken does not have uniform properties throughout its areal extent. Identifying areas with porosity, permeability, and fractures that permit highly productive wells is essential to commercial petroleum recovery. The Elm Coulee Field is a giant oil field in Eastern Montana that exhibits some of these critical reservoir properties. Geological modeling of these reservoir properties provides a greater understanding of reservoir performance, and aids in exploration and development of the Bakken Formation.

The Bakken Formation in the Elm Coulee Field consists of three members: an upper shale, middle silty dolostone, and lower shale. The Elm Coulee Oil Field is a stratigraphic trap with a pinch-out to the southwest and a diagenetic facies change in the northeast. The primary reservoir is the silty dolostone of the Middle Bakken Member.

The purpose of this research is three fold: (1) complete an examination of the reservoir properties of the Bakken petroleum system in Elm Coulee field; (2) construct a three-dimensional geologic model that will show the distribution of the different facies within the Bakken Formation and their reservoir properties; and (3) build a fracture model and integrate it with the matrix porosity model. This study uses digital logs, core data, petrographic thin sections, XRD analysis, DSTs, production data, and Petrel software to characterize the Elm Coulee Field. Six cores are used to calibrate physical properties to digital well logs, and core descriptions were used to construct detailed facies maps.

The study correlates the core lithofacies to digital well logs resulting in maps of the facies and the calculation of their associated thickness throughout the study area. The data was then used to build a structural geomodel in Petrel software. The geomodel is located in the central part of Elm Coulee in the congressional land blocks: Township 53 Range 56, Township 57 Range 56, and Township 53 Range 58 of Richland County, Montana. The structural model showed a thick Middle Bakken in the study area with a thinning to the north, south, and west. The Lower Bakken Shale is absent in the southern half of Richland county and the Upper Bakken Shale covers the entire study area.
With the structural model in place, the digital well logs were used to distribute petrophysical properties of the Middle Bakken throughout the Petrel model. The data revealed that the reservoir is located in a northwest trend in the southern half of Richland County. The petrophysics shows that the best reservoir properties are associated with Faces B and C. Facies B and C have a high percentage of dolomite which has the best reservoir properties (i.e., higher porosity and permeability). These data were then used to build a matrix reservoir model.

The study also constructed a fracture model for Richland County. The Elm Coulee fracture model was derived from seismic and production trends. The model uses regional fracture trends to establish a fracture fabric. The regional fractures are oriented to the northeast and have a spacing of approximate 1,250 feet. An orthogonal set of fractures are spaced 2,500 feet apart in the northwest direction. Production data allowed for the detection of what is interpreted as fracture swarms. The swarms are oriented in the maximum principal stress direction of N60E, and have an approximate spacing of 25,000 ft.

The fracture model was combined with the matrix model to develop a dual porosity model. This results in a combined model that has both fracture and matrix reservoir properties that can be used in simulation. The dual porosity model reflects the production in the study area, and the best reservoir properties align with the best estimated ultimate recovery (EUR).