

Sequence Stratigraphy of the Bakken and Three Forks Formations, Williston Basin, USA

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Abstract

The Williston Basin Bakken petroleum system is a giant continuous accumulation. The petroleum system consists of source beds in the upper and lower Bakken shales and reservoirs in the middle, and upper Three Forks, Pronghorn member of the Bakken and the middle Bakken. The Petroleum System is characterized by low-porosity and permeability reservoirs, organic-rich source rocks, and regional hydrocarbon charge. USGS (2013) mean technologically recoverable resource estimates for the Bakken Petroleum System is 7.375 billion barrels oil, 6.7 TCF gas, and 527 million barrels of natural gas liquids.

The Three Forks is a silty dolostone throughout much of its stratigraphic interval. The Three Forks ranges in thickness from less than 25 ft to over 250 ft in the mapped area. Thickness patterns are controlled by paleostructural features such as the Poplar Dome, Nesson, Antelope, Cedar Creek, and Bottineau anticlines. Thinning and/or truncation occurs over the crest of the highs and thickening of strata occurs on the flanks of the highs. The Three Forks can be subdivided into three units (up to six by some authors). Most of the development activity in the Three Forks targets the upper Three Forks. The Three Forks consists of at least five system tracts: a lowstand system tract consisting of the lower continental to supratidal sediments (overlies marine Birdbear carbonates and evaporites); overlain by a transgressive system tract of subtidal dolostone; overlain by a highstand systems tract of the middle Three Forks consisting mainly of peritidal sediments; in turn overlain by a transgressive system tract representing subtidal dolostones; which in turn is overlain by highstand systems tract of the upper Three Forks consisting of peritidal dolostones. A major unconformity separates the Three Forks from the Bakken Formations probably representing tectonic movement from the Acadian/Antler orogenies. The unconformity is complex in that it probably represents both a lowstand surface of erosion and a transgressive surface of erosion.

The Bakken Formation regionally in the Williston Basin consists of four members: upper and lower organic-rich black shale; a middle member (silty dolostone or limestone to sandstone lithology); a basal member (dolostone, limestone, and siltstone) recently named the Pronghorn. The Bakken Formation ranges in thickness from a wedge edge to over 140 ft with the thickest area in the Bakken located in northwest North Dakota, east of the Nesson anticline.

The Bakken in the U.S. Williston Basin consists of five system tracts: the Pronghorn member represents a lowstand to transgressive system tract (proximal and distal members); a lower transgressive system tract consisting of the Lower Bakken Shale; a highstand systems tract consisting of the lower Middle Member; a falling stage to lowstand systems tract consisting of the oolitic, bioclastic, sandy Middle Member; overlain by a transgressive system tract consisting of the upper Middle Bakken and the Upper Bakken Shale. The Upper Bakken Shale is overlain sharply by the Lodgepole Formation which represents a highstand systems tract. Sharp downlap surfaces are noted at the base of the middle Bakken and the base of the Lodgepole. The downlap surfaces represent the transition from transgressive system tracts to highstand system tracts. Maximum flooding surfaces are found in the middle and upper portions of the upper and lower Bakken shales.

Relative sea level changes occur in the Bakken and Three Forks intervals related to both tectonics and glaciation. These changes result in the numerous system tracts identified in this study.

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