

THE OIL POTENTIAL OF THE BAKKEN SOURCE SYSTEM

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The Bakken Pool or Bakken Source System

The Bakken Pool is generally defined by the North Dakota Oil and Gas Division as the entire Bakken Formation (the Upper shale, Middle member, and Lower shale), the basal 50 feet of the overlying Lodgepole Formation, and the upper 50 feet of the underlying Three Forks Formation. This same 200 to 250-foot-thick stratigraphic interval is also referred to as the Bakken Source System (fig. 1). Both terminologies acknowledge the significant infusion of oil into these rocks from the prolific hydrocarbon-generating Bakken shales. Over the years some geologists have theorized that much of the oil found in rocks above the Bakken Formation had been generated from the Bakken shales. More widely held views attribute the majority of oil within the Bakken Pool or Bakken Source System to the Bakken shales. This oil has migrated from the shales into the lower Lodgepole Formation, the

Middle member of the Bakken Formation, and into the upper Three Forks Formation sometime since the Late Cretaceous, within the last 70 million years or so (Nordeng, 2008).

Over the years, the North Dakota Geological Survey and the Oil and Gas Division have done a number of assessments of the oil potential of stratigraphic units within the Williston Basin. Obviously, the more information that is available on the geology, permeability, oil saturation, and oil production of a given rock unit, the more accurate the assessment. It is preferable that geophysical logs (specifically porosity logs) penetrate the stratigraphic unit in question throughout the study area. Assessments require that the pay thickness, oil saturation, porosity, formation volume factor, and a recovery factor be determined for the interval in question. Values for some of these parameters can be obtained from technical



Figure 1. Photographs of core scaled to average thicknesses are plotted against the 241-foot-high North Dakota State Capitol. The Bakken Pool or Bakken Source System is an average of 200 feet thick and would extend from the 3rd to the 15th floor of the capitol. The Bakken is on average 100 feet thick and would extend from the 7th to the 12th floor and the Middle Bakken from the 9th to the 11th floor.

exhibits presented to the North Dakota Industrial Commission at public hearings.

Bakken Source System: Bakken Assessment

On April 28, 2008, three years after the discovery of the Parshall Field, the North Dakota Department of Mineral Resources released an assessment of the oil potential of the Bakken Formation within the North Dakota portion of the Williston Basin (Bohrer et al., 2008). The assessment concluded there were 149 billion barrels of oil in place within the Bakken Formation of which 2.1 billion barrels could be expected to be produced using available technologies (expected ultimate recovery) (fig. 2). We anticipated that the expected ultimate recovery would significantly increase with time beyond our estimate of 1.4% due to advances in well completion techniques. We were unable to generate numbers for either the Lodgepole or Three Forks Formations at that time because there was not enough production data from which to do the calculations.

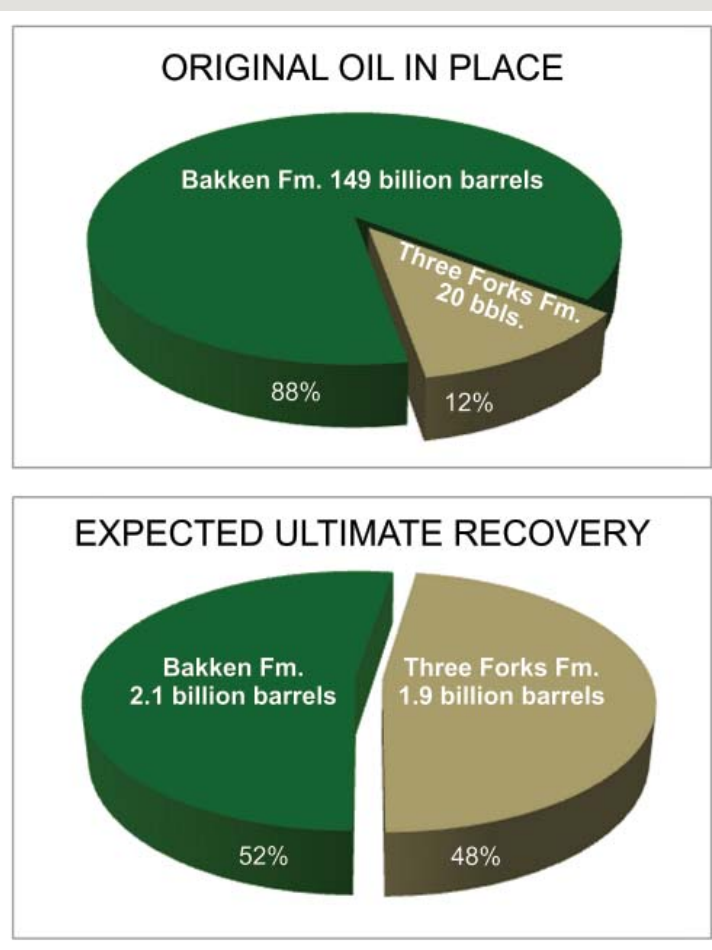


Figure 2. Pie charts of the oil in place and expected ultimate recoveries for the Bakken and Three Forks portions of the Bakken Source System from the 2008 and 2010 DMR assessments.

Bakken Source System: Three Forks Assessment

Two years later, on April 29, 2010, the Department of Mineral Resources and Geological Survey released an assessment of the Three Forks Formation (Nordeng and Helms, 2010). We concluded that the Three Forks Formation contains 20 billion barrels of oil in place, of which 1.9 billion barrels could be produced using available technologies (expected ultimate recovery) (fig. 2). The

expected ultimate recovery is 9.5% for the Three Forks Formation, significantly above that estimated for the Bakken Formation in 2008. There are several possible explanations for this percentage increase, including differences in rock properties between the two formations and, most importantly, the introduction of multi-stage hydraulic fracturing into the Williston Basin since 2008 with subsequent increased rates of production. As with the 2008 assessment, this data was calculated and presented on a county basis in order to make it more expedient to generate assessment updates.

Bakken Source System: Lodgepole Assessment

We are currently collecting data to revise the 2008 assessment of the Bakken Formation. We are also collecting data on the Lodgepole Formation, but there is little production data outside of the Dickinson area to draw from. Bakken oil may have migrated upwards into the Lodgepole Formation where it could be locally trapped. So far, the only significant Lodgepole production has been from isolated mounds in the Dickinson area.

North Dakota Oil Production

The four billion barrels of expected ultimate recovery from the Bakken and Three Forks Formations represents twice the amount of oil that has been produced to date in North Dakota. In 58 years of oil production (April 1951 - December 2009), North Dakota has produced 1.7 billion barrels.

The majority of produced oil (55%) has come from Mississippian carbonates in the Madison Group. Rocks of Devonian age (including Bakken, Three Forks, Birdbear, Duperow, Souris River, and Dawson Bay Formations) account for 10% of historical production while the Red River, Stony Mountain, and Stonewall Formations (Upper Ordovician) account for 15% (fig. 3). In 2009, the Bakken and Three Forks led all oil production with 50 million barrels. If you add in the rest of Devonian production, the total was 52 million. Production in the Big Horn Group (primarily Red River B) was 14 million barrels and Madison production came in at 11 million barrels. These three geologic periods (Mississippian, Devonian, and Late Ordovician) accounted for 97% of North Dakota's oil production in 2009. Bakken production is projected to exceed 70 million barrels in 2010, almost a 70-fold increase from 2005. Meanwhile, by the end of 2010, Madison production will likely have decreased 25% from where it was in 2005 (fig. 4). Even at this record-setting pace, the Bakken and Three Forks Formations may not overtake the Madison Group as North Dakota's largest producing unit of all time until 2030. On the one hand, given production trends, it may not take that long for the Bakken and Three Forks to move into first place. On the other, will these Bakken wells still be producing in 50 or 60 years like some of their Madison counterparts, what will their decline curves look like in another five or ten years, and is secondary or tertiary Bakken recovery feasible? This assumption also does not take into account the potential for future Madison plays using horizontal/multi-stage frac wells. For example, there is potential for production in the Ratcliffe interval along the east flank of the Nesson anticline similar to what has been seen in the Foreman Butte Field.

North Dakota's recent rise in oil production has been nothing short of phenomenal. During a 30-month period, March 2007

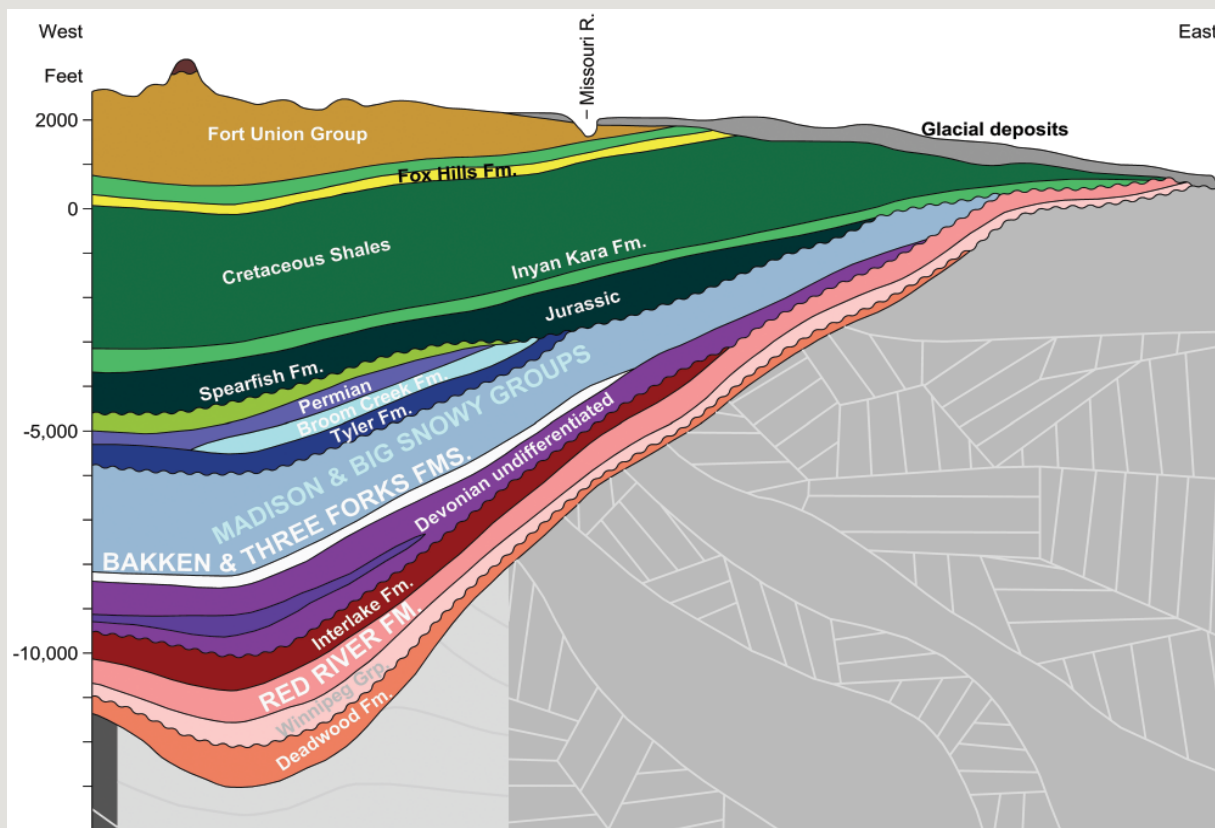


Figure 3. An east-west cross-section through the central North Dakota portion of the Williston Basin. The drawing has a vertical exaggeration of 67x. The colored layers are sedimentary rocks within the Williston Basin and the gray, patterned rocks are Precambrian igneous and metamorphic rocks of, from east to west, the Superior, Trans Hudson, and Wyoming provinces.

to September 2009, North Dakota doubled its average daily oil production, going from 118,000 barrels of oil per day to 238,000 barrels. In doing so, we rose from the eighth largest oil producing state in the nation to the fourth, only behind Texas, Alaska, and California. Production from the Bakken Pool is entirely responsible for that gain. In 2009, more oil was produced from the Bakken Pool in North Dakota than was produced in North Dakota in 2007. Projecting the first four months of 2010 production through the rest of the calendar year places Bakken Pool production at 70 million barrels, eight million barrels more than all of North Dakota's oil production in 2008. With an economic success rate of 89% for wells recently drilled into the Bakken Pool (Helms, 2010), this upward trend in North Dakota oil production shows no sign of slowing in the near future.

References

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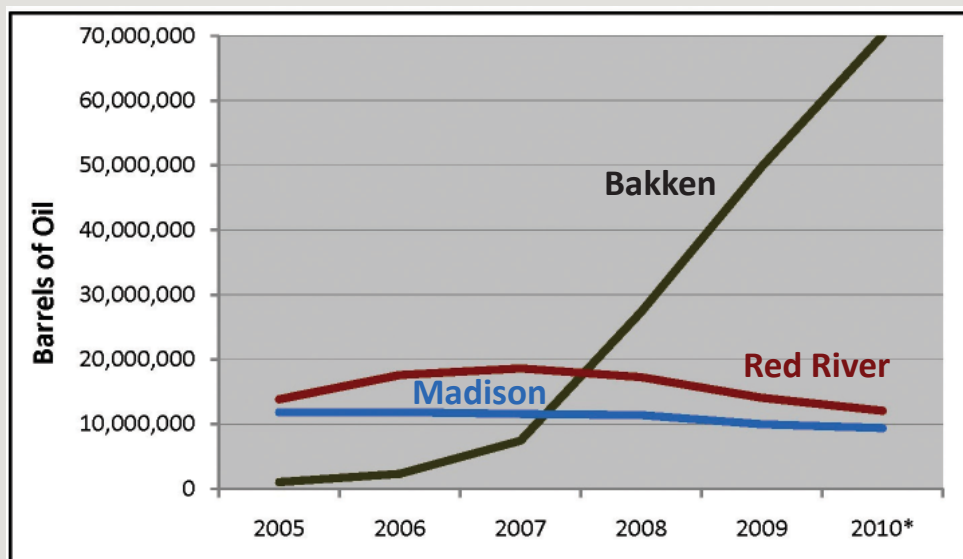


Figure 4. North Dakota oil production from the Bakken, Madison, and Red River pools from 2005-2010 (2010 *estimated). In this graph the Bakken includes Bakken, Bakken/Three Forks, Sanish, and Three Forks; the Madison includes Madison, Midale/Nesson, Mission Canyon, Ratcliffe, Rival, and Lodgepole; and the Red River includes the Red River and Red River B. Infield drilling and tertiary recovery in the Cedar Hills Field pushed Red River B production up to 17 million barrels in 2007. It is projected to decline to around 11 million barrels by the end of 2010. Data from the ND Oil and Gas Division.