History of Exploration and Development in the Middle Three Forks (2nd bench)

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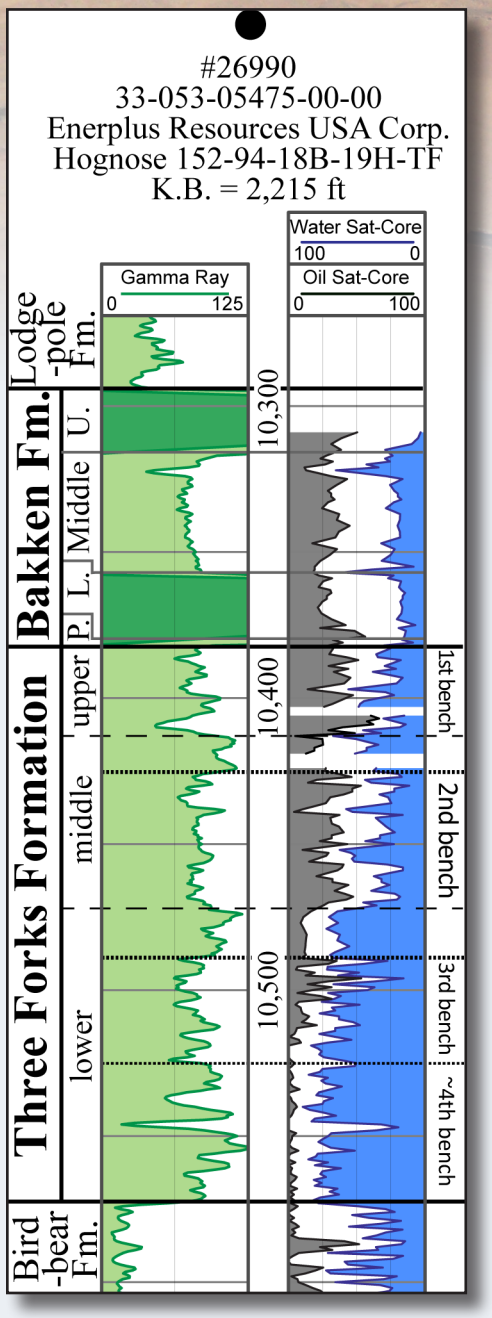

Introduction

Bakken-Three Forks production has expanded over the past two decades from a handful of scattered vertical and horizontal wells, to the most prominent oil play in the history of the Williston Basin. Even though fluctuating oil prices cause drilling and production activity to vary year to year, the Bakken-Three Forks play has created thousands of in-state jobs which has bolstered North Dakota's population and economy. While decades of future production appear on the horizon, developmental drilling activity will eventually slow in the play as the remaining, undrilled well inventory decreases over time. Many factors will influence the longevity of that drilling activity, and one important factor includes the economic viability of the middle and lower Three Forks, or what industry refers to as the 2nd and 3rd benches of the Three Forks Formation.

The Bakken-Three Forks unconventional emergence in the basin started with the discovery of Elm Coulee Field in eastern Montana during 2000. Bakken exploration expanded into western North Dakota during 2004 and especially took off after the discovery of Parshall Field in 2006 (LeFever, 2008). During that time, the Middle Bakken was the primary reservoir target for exploration and development (fig. 1). However, operators began to drill and test the upper Three Forks Formation during 2006-07 (fig. 1), which yielded good results and quickly developed into a second viable reservoir target that essentially doubled the amount of in-place resource based on various assessments (Nordeng and Helms, 2010; Gaswirth and Marra, 2015). Another in-play discovery occurred during 2010-11 within an interval later defined as the Pronghorn Member of the Bakken Formation, which developed into a localized sweet spot towards the southern margins of the basin. The most recent new reservoir development in the play began in late 2013, when operators began to further expand their exploratory drilling efforts into the middle and lower Three Forks (fig. 1). Some skepticism surrounded the economic viability of the middle and lower Three Forks as the units are positioned up to 30 to 100 feet or more below the nearest oil-generation source, the Lower Bakken shale (fig. 1). However, more than 300 productive oil wells have been drilled and completed in those two units to date, the majority of which (>250 wells) have targeted the middle Three Forks. The following material provides a review of historical exploration and development efforts into the middle Three Forks, which has emerged as another economically viable reservoir within the Bakken-Three Forks Petroleum System.

Figure 1. Wireline log example with core-plug oil and water saturations of the Bakken and Three Forks Formations from Enerplus Resources' Hognose 152-94-18B-19H-TF (NDIC: 26990, API: 33-053-05475-00-00, Sec. 7 - T152N - R94W). Depths are in feet below K.B. Fm. = Formation; K.B. = Kelly Bushing; L. = Lower Member, P. = Pronghorn Member, and U. = Upper Member.

Pre-Drilling Activity

Prior to any horizontal drilling or production from the middle Three Forks, an increase in coring activity signaled industry's building interest in the unit. During 2006-10, while industry was still focused on exploration in the Middle Bakken and upper Three Forks, operators collected a total of 21 cores of the middle Three Forks (~4 cores/year), and most of those early cores extended only partway through the unit (fig. 2). Then during 2011 and 2012, in the immediate two years prior to the first middle Three Forks well completion, coring rates quadrupled as operators cut 32 middle Three Forks cores (16 cores/year) followed by an additional 10 cores in 2013 (fig. 2). Much of the middle Three Forks coring activity during 2011-13 was focused in McKenzie and northern Dunn counties, where 21 (66%) of the cores were cut during that time. While some of the collected cores only contained minimal to negligible oil saturations, other middle Three Forks cores contained very high oil saturations that were comparable to the upper Three Forks and Middle Bakken (fig. 1).

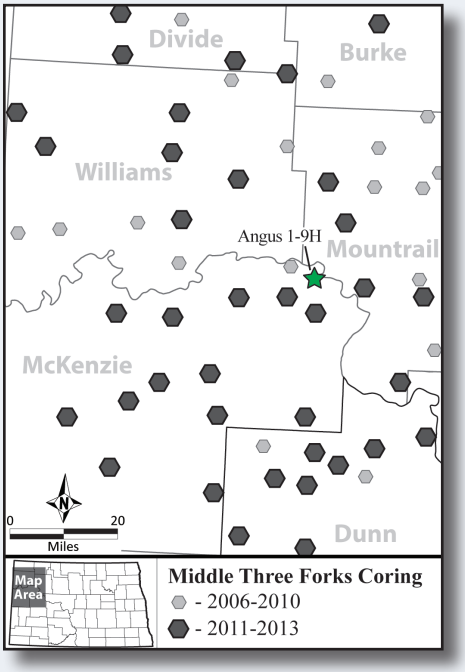

Figure 2. Middle Three Forks core location map. The green star shows the location of the first completed, commercially productive middle Three Forks well, Continental Resources' Angus 2-9H (SESW Sec. 9-T153N-R94W).

Drilling and Development

Continental Resources and Kodiak Oil and Gas began drilling the first round of horizontal wells within the middle Three Forks during late 2012 (fig. 3). While a few wells were spudded (drilled) slightly earlier, the first commercially productive middle Three Forks well was Continental Resources' Angus 2-9H (SESW Sec. 9-T153N-R94W), located in the Elm Tree Field of northeastern McKenzie County (fig. 2). The Angus 2-9H was completed on February 13th, 2013 with a 30-stage hydraulic fracture stimulation that yielded an initial production rate of 598 barrels of oil per day (BOPD) and 2,629 MCF of gas. The Angus 2-9H went on to average 1,027 BOPD during the following month and is currently still producing 80-100 BOPD with a cumulative production total of >390,000 barrels of oil.

Following the completion of the Angus 2-9H, more than 80 middle Three Forks wells were drilled and completed by the end of 2014 which spanned an area of several thousand square miles and six different western North Dakota counties (fig. 4a). This early phase of activity followed the normal pattern of exploration where spatially dispersed wells are drilled and tested to establish the extent of the play as well as to delineate more productive from less productive acreage. The initial production rates of the early, spatially distributed middle Three Forks wells were highly variable, ranging from <100 to >1,000 BOPD. Likewise, the eventual 700-day oil cumulative production totals were also highly variable ranging from <50,000 to >300,000 barrels of oil (fig. 4a). The 700-day cumulative oil totals are perhaps more important than the initial production rates, because the ~2-year mark represents the approximate time when oil wells are supposed to have paid for initial drilling and completion costs. During this early phase of drilling, when oil prices were relatively high and many intermediately productive wells were at least marginally economic, the average middle Three Forks well yielded a 700-day cumulative production total of approximately 109,000 barrels of oil. However, this early exploratory drilling phase for the middle Three Forks came to a close as oil prices dropped and economics altered the trajectory of the play (fig. 3).

Oil prices began to plummet in late 2014 as production overtook demand and crude oil inventories surged both domestically and internationally. Prices dropped from above $100/barrel to below $50/barrel by early 2015, eventually touching below $30/barrel in early 2016, and have yet to return to pre-2015 prices of $80-$100+/barrel (fig. 3). This considerable, sustained drop in commodity price has led operators to focus middle Three Forks drilling activity to the most productive acreage, located in and around northeastern McKenzie County (figs. 4a & b). This area corresponds with where the lower Bakken shale reaches its greatest thicknesses and thermal maturity with regards to oil generation, and the middle Three Forks contains its highest overall oil saturations (Nesheim, 2019). By targeting this best acreage, as well as improvements to drilling and completions, the 700-day cumulative oil production of middle Three Forks wells averages approximately 206,000 barrels of oil, nearly double that of pre-2015 wells.

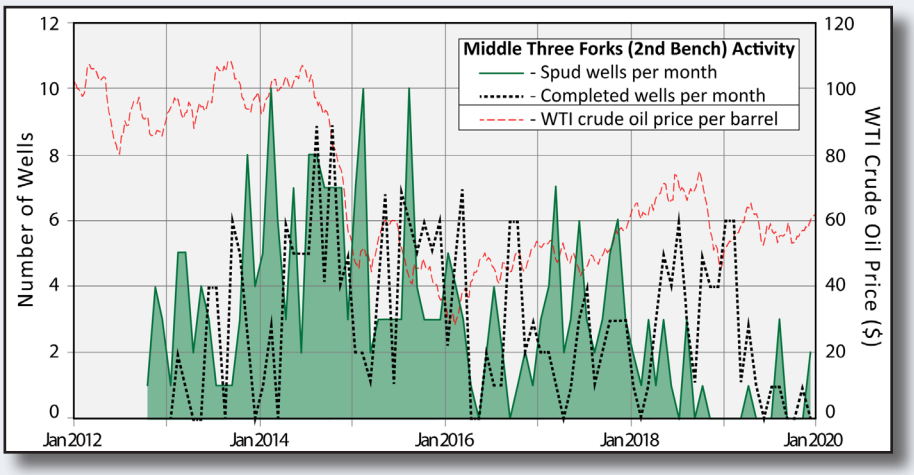

Figure 3. Diagram depicting the monthly number of middle Three Forks wells spudded and completed versus WTI (West Texas Intermediate) crude oil price. Note that drilling and completion numbers in late 2019 may be incomplete due to 6-month well confidentially permits.

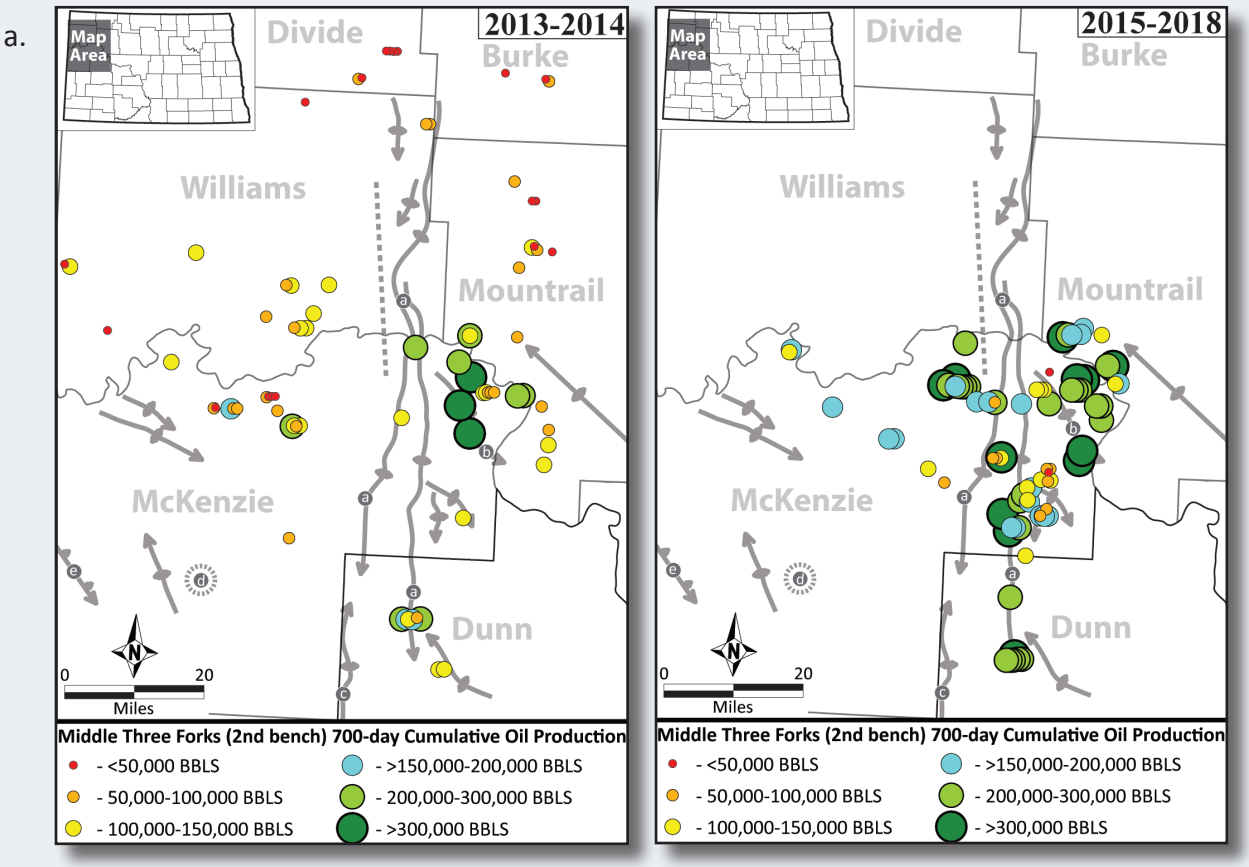

Figure 4. 700-day cumulative oil production map for middle Three Forks wells drilled and completed during a) 2012-2014, and b) 2015-2018. Thick grey lines represent the axial traces of various Williston Basin structures, including a = Nesson anticline; b = Antelope anticline; c = Little Knife anticline; d = Red Wing Creek structure; e = Mondak monocline.

Current Status and Future Outlook

To date, over 250 horizontal wells have been drilled and completed within the middle Three Forks, and the number of producing wells has steadily climbed since early 2013 (fig. 5). Production rates ranged from between 1 and 1.5 million barrels of oil per month (33,000-50,000 BOPD) during 2018 and 2019 (fig. 5), and during this time the middle Three Forks accounted for approximately 3% of the total Bakken-Three Forks production. Cumulatively, the middle Three Forks has produced more than 57 million barrels of oil and 120 billion cubic feet of gas.

Middle Three Forks activity had grown substantially before oil prices plummeted in late 2014-15, and the continuation of some activity during $40-$60/barrel oil prices demonstrates the viability of the unit's production economics within portions of the basin. If/when oil prices climb back to pre-2015 levels, the development footprint of the middle Three Forks will likely expand back to some of the pre-2015 activity extent, where large portions of prospective middle Three Forks acreage remain untested. While more comprehensive, detailed evaluation of the unit is needed, the spatial production footprint of the middle Three Forks is suggestive that thousands of future wells may be needed to develop this lower reservoir within the Bakken-Three Forks petroleum system, which in turn will add to the longevity of the play.

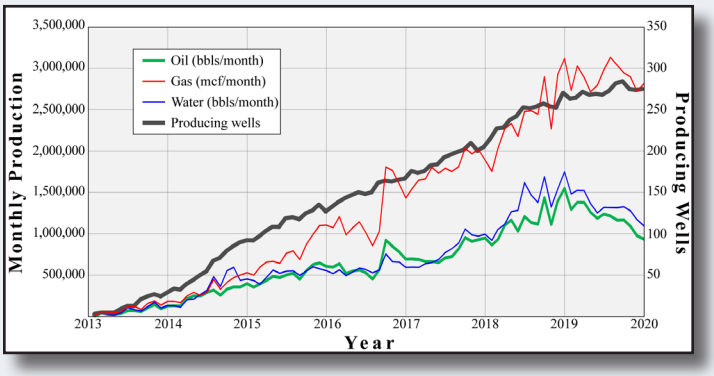

Figure 5. Monthly production volumes for the middle Three Forks and the number of actively producing wells.

References:

Gaswirth, S.B., Marra, K.R., 2015, U.S. Geological Survey 2013 assessment of undiscovered resources in the Bakken and three Forks formations of the U.S. Williston basin Province: American Association of Petroleum Geologists Bulletin 99 (4), 639–660.

LeFever, J.A., 2008, What's happing at Parshall, North Dakota: North Dakota Department of Mineral Resources, Geo Newsletter, v. 35, no.1, p. 1-2.

Nesheim, T.O., 2019, Examination of downward hydrocarbon charge within the Bakken-Three Forks petroleum system – Williston Basin, North America: Marine and Petroleum Geology, v. 104, p. 346-360.

Nordeng, S.H., Helms, L.D., 2010, Bakken source system – Three Forks Formation assessment: North Dakota Geological Survey. https://www.dmr.nd.gov/ndgs/bakken/bakkenthree.asp