

# Is Creativity the Secret to Success in the Spearfish?

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## Introduction

The Spearfish Formation in central Bottineau County, North Dakota (fig. 1) has produced oil for over 66 years but is often overlooked when discussing productive hydrocarbon reservoirs within the Williston Basin of North Dakota. While the Spearfish doesn't have the spectacular production numbers of the Bakken/Three Forks play that rejuvenated the Williston Basin in North Dakota, it still represents an opportunity for operators to make commercially viable wells outside of the Bakken/Three Forks footprint.

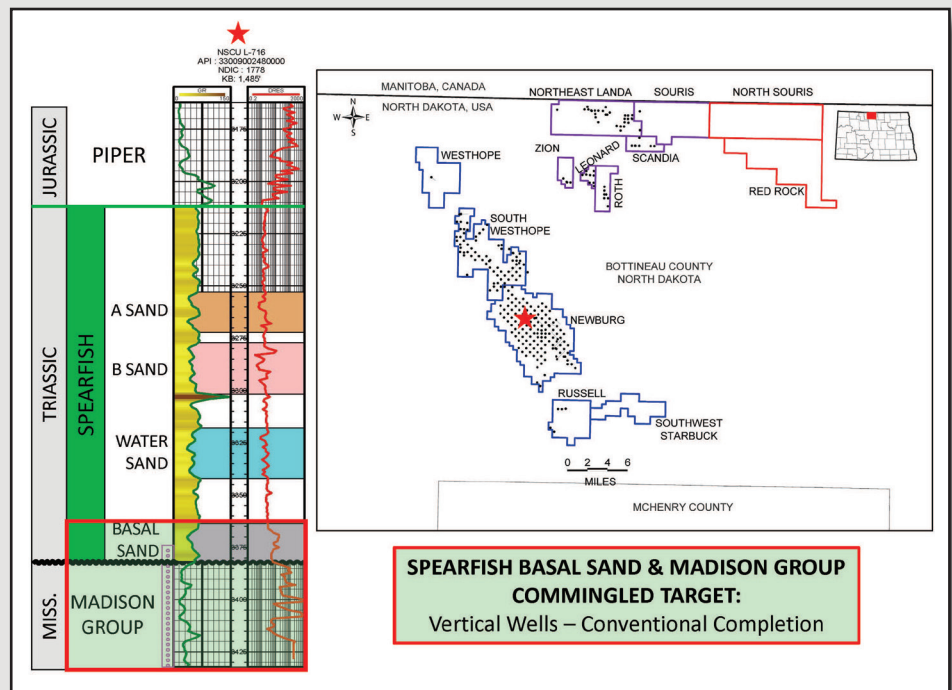
## Stratigraphic Overview

The Spearfish Formation contains up to four sand packages within the lower two-thirds of the formation in central Bottineau County (Husain, 1991; Sebade, 2014; Stollendorf, 2018). In our study area, the Triassic Spearfish Formation rests unconformably above the Mississippian Madison Group (Murphy et al., 2009). In descending stratigraphic order, the informal nomenclature includes A sand, B sand (A sand & B sand are often targeted together and are referred to as the Upper sands herein), Water sand and Basal sand. The sandy packages are generally poorly sorted and consist primarily of very fine- to medium-grained sandstone with varying amounts of siltstone and claystone (Ziegler, 1955; Dow, 1964 Sebade, 2014; Stollendorf, 2018).

## Target Intervals

Play concepts within the Spearfish have evolved over the years and can be separated by target interval. The first attempts to recover oil from Spearfish reservoirs came from vertical wells with perforations in both the Basal sand of the Spearfish and within the underlying Madison

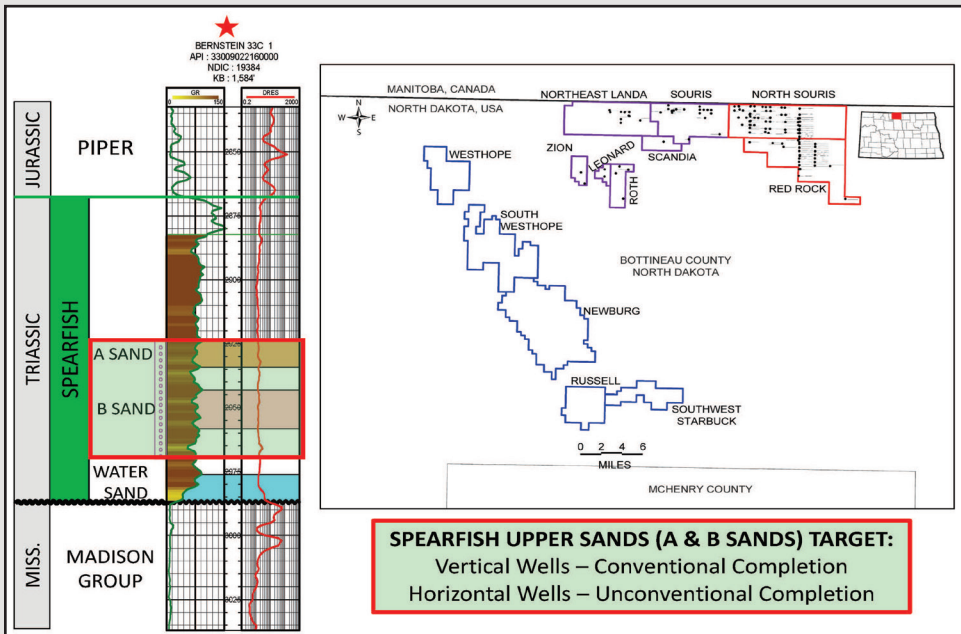
Group (fig. 1). This concept has proven to be the most successful so far, producing over 53 million barrels of oil (90 million barrels of water, 1.57 billions of cubic feet of gas) in North Dakota since 1953. Wells within the Newburg field (fig. 1) have contributed 35 million barrels of oil (~45 million barrels of water, 1.17 billions of cubic feet of gas) (NDIC Production Data), or 65 percent of the total oil produced utilizing both the Spearfish and Madison reservoirs.



**Figure 1.** Location map of Spearfish/Madison commingled producers. Hydrocarbons extracted from this play employed conventional completion techniques in a vertical wellbore. In this play, the Basal sand of the Spearfish and the underlying Madison group are both perforated and produced. Oil fields are color coded by targeted Spearfish interval (Blue = Basal sand, Red = Upper sands (A&B sands), Purple = both Basal and Upper sands are targeted). Stratigraphic column from Murphy et al., 2009.

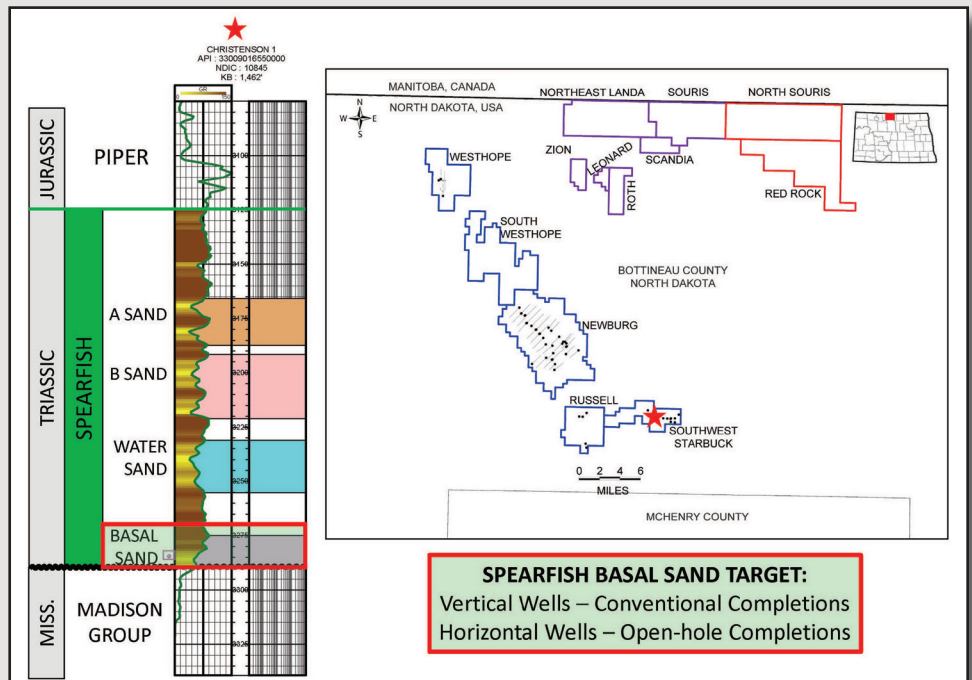
The second play concept targets the Spearfish's upper sands (A sand & B sand) (fig. 2). Wells were first drilled and completed in this interval in 1954 (NDIC Production Data). Development has continued intermittently from the 1950s through 2015 when the last Spearfish wells were completed in North Dakota. Wells completed in this interval have cumulatively produced 5.6 million barrels of oil (20.1 million barrels of water, 1.09 billions of cubic feet of gas) (NDIC Production Data). The North Souris and Red Rock fields in north-central Bottineau County have produced 2.8 million barrels of oil (7.9 million barrels of water, 0.70 billions of cubic feet of gas) and 1.24 million barrels of oil (3.4 million barrels of water, 0.23 billions of cubic feet of gas) (NDIC Production Data) respectively, with over 97 percent of that production coming since 2010.

The final play concept targeted the Basal sand of the Spearfish (fig. 3). The Basal sand is often the cleanest sand and was first developed as a stand-alone play in the Russell field (fig. 3) with the Carl Kersten 1 (API: 330090076700), which was completed in 1963. This well has since produced 0.29 million barrels of oil (0.16 million barrels of water) (NDIC Production Data) and is still producing. Horizontal wells drilled in the Newburg field dominate production in the Basal sand stand-alone play. These open-hole completions have produced 2.05 million barrels of oil (10.8 million barrels of oil, 0.21 billions of cubic feet of gas) (NDIC Production Data), or 65 percent of the total 3.17 million barrels of oil (11.6 million barrels of water, 0.21 billions of cubic feet of gas) produced exclusively from the Basal sand of the Spearfish.



**Figure 2.** Location map of Spearfish Upper sands (A & B sands) producers. The Spearfish Upper sands (A & B sands) are produced using a conventional completion in a vertical wellbore and in horizontal wells with unconventional completions. In this play, the Upper sands (A & B sands) of the Spearfish are targeted and produced. Oil fields are color coded by targeted Spearfish interval (Blue = Basal sand, Red = Upper sands (A&B sands), Purple = both Basal and Upper sands are targeted). Stratigraphic column from Murphy et al., 2009.

**Figure 3.** Location map of exclusive Spearfish Basal sand producers. The exclusive Spearfish Basal sand has been produced using a conventional completion in a vertical wellbore and in horizontal wells with open-hole completions. In this play, only the Basal sand of the Spearfish is targeted and produced. Oil fields are color coded by targeted Spearfish interval (Blue = Basal sand, Red = Upper sands (A&B sands), Purple = both Basal and Upper sands are targeted). Stratigraphic column from Murphy et al., 2009.





## Completion Styles

In addition to varying target intervals within the Spearfish, multiple completion techniques (fig. 4) have been used to extract hydrocarbons from the low permeability or “tight” rock. Initially, all wells targeting the Spearfish or Spearfish/Madison were vertical wells with conventional completions. A conventional completion includes simple perforations within the interval of interest and little to no hydraulic fracturing relative to more recent unconventional style completions. Vertical wells with conventional completions have produced 2.4 million barrels of oil (8.9 million barrels of water, 0.02 billions of cubic feet of gas) exclusively from the Spearfish in North Dakota and over 52 million barrels of oil (87 million barrels of water, 1.6 billions of cubic feet of gas) (NDIC Production Data) from commingled Spearfish/Madison production.

In 2000, the first horizontal well targeting the Spearfish was drilled in the Newburg field. The NSCU R-712AH (API: 330090203500) featured a 2,644 ft. lateral with an open hole completion. An open-hole completion is the unaltered original wellbore, void of perforations, production tubing/casing, cement and isn’t typically hydraulically fractured (fig. 4). Horizontal wells with open-hole completions have combined to produce 2.05 million barrels of oil (10.8 million barrels of water, 0.20 billions of cubic feet of gas) (NDIC Production Data).

The most recent completion style came about with the U.S. shale boom. This style is often referred to as an unconventional

completion and typically includes a horizontal well with cemented production casing/tubing, multi-stage hydraulic fractures and proppant (typically sand) pumped into the formation to preserve the permeability created by the hydraulic fractures (fig. 4). Spearfish wells drilled and completed using this method have produced 4.3 million barrels of oil (11.7 million barrels of water, 1.05 billions of cubic feet of gas) to date in North Dakota (NDIC Production Data).

## Outlook

The Spearfish Formation remains among the unheralded reservoirs in the Williston Basin of North Dakota despite a long history of production. Low commodity prices pushed operators out of the play in 2015 and despite an increase in oil prices, drilling activity in the play has remained limited in recent years. Reservoir challenges, including low permeability, high water production and limited oil saturations likely means that the play will remain as-is until either oil prices increase or well costs decrease. Despite the challenges, operators have proven that with a little creativity, and some help from oil prices, the play can be commercially viable. It’s likely only a matter of time before we see renewed interest in the Spearfish play of North Dakota. In the meantime, better understanding of the reservoir targets and innovative completion techniques might be the creative solution the Spearfish requires.

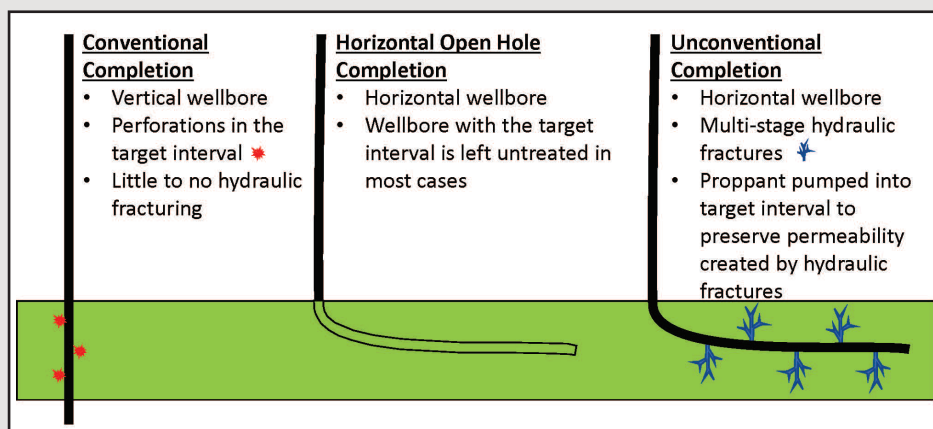


Figure 4. Generalized schematic of the three primary drilling and completions techniques used in the Spearfish play. Horizontal wellbores with unconventional completions have offered the most success in Spearfish-exclusive production in terms of cumulative oil produced.

## References

- Dow, W. G., 1964, The Spearfish Formation in western North Dakota: Williston Basin Symposium, p.127-131.
- Husain, M., 1991, Regional geology and petroleum potential of the Lower Amaranth Formation, Coulter-Pierson area, southwestern Manitoba: Williston Basin Symposium, p. 151-160.
- Murphy, E.C., Nordeng, S.H., Juenker, B.J., and Hoganson, J.W., 2009, North Dakota Stratigraphic Column: North Dakota Geological Survey, MS-91, 1p.
- North Dakota Industrial Commission, Department of Mineral Resources, Oil and Gas Production Data reported herein is based on perforated interval rather than pool in order to accurately reflect the producing formation’s production, retrieved May 2019, <https://www.dmr.nd.gov/>
- Sebade, M.J., 2014, The depositional environment and diagenetic effects on sand bodies within the unconventional resource play of the Spearfish Formation (Triassic) in north central North Dakota: unpublished M.S. thesis, University of North Dakota, 131 p.
- Stolldorf, T.D., 2018, Spearfish Formation – Williston Basin, in 26th Williston Basin Petroleum Conference Core Workshop: North Dakota Geological Survey, Geologic Investigations No. 208, p. 57-75.
- Ziegler, D.L., 1955, Pre-Piper post Minnekahta “red beds” in the Williston Basin: North Dakota Geologic Society, 1955 Field Conference Guidebook, p. 49-55.