THE SEARCH FOR DEVONIAN AND MISSISSIPPIAN SOURCE ROCKS

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The North Dakota Geological Survey has embarked on a project to uncover additional unknown source beds in the North Dakota portion of the Williston Basin. This will add to the understanding of the petroleum deposits regionally present within the basin and potentially identify drilling targets for future technology advancements.

Background

Three major oil types were described for the Williston Basin by Williams in 1974. The stratigraphy of these oils suggests that Type I oils are common in Ordovician rocks (Winnipeg Group – Icebox Formation) and found in Ordovician and Silurian reservoirs, Type II oils (Bakken Formation) are represented in the Upper Devonian, Mississippian and Jurassic age rocks, and Type III (Tyler Formation) are present only in Pennsylvanian rocks. Based on the distribution of oil types, Williams (1974) suggested that there are no significant sources in the Silurian, Lower Devonian, and post-Mississippian rocks. Williams stated that selected oils within the dataset unrelated to the major source types were probably related to local source beds. These local source beds may have sufficient volume for local accumulations.

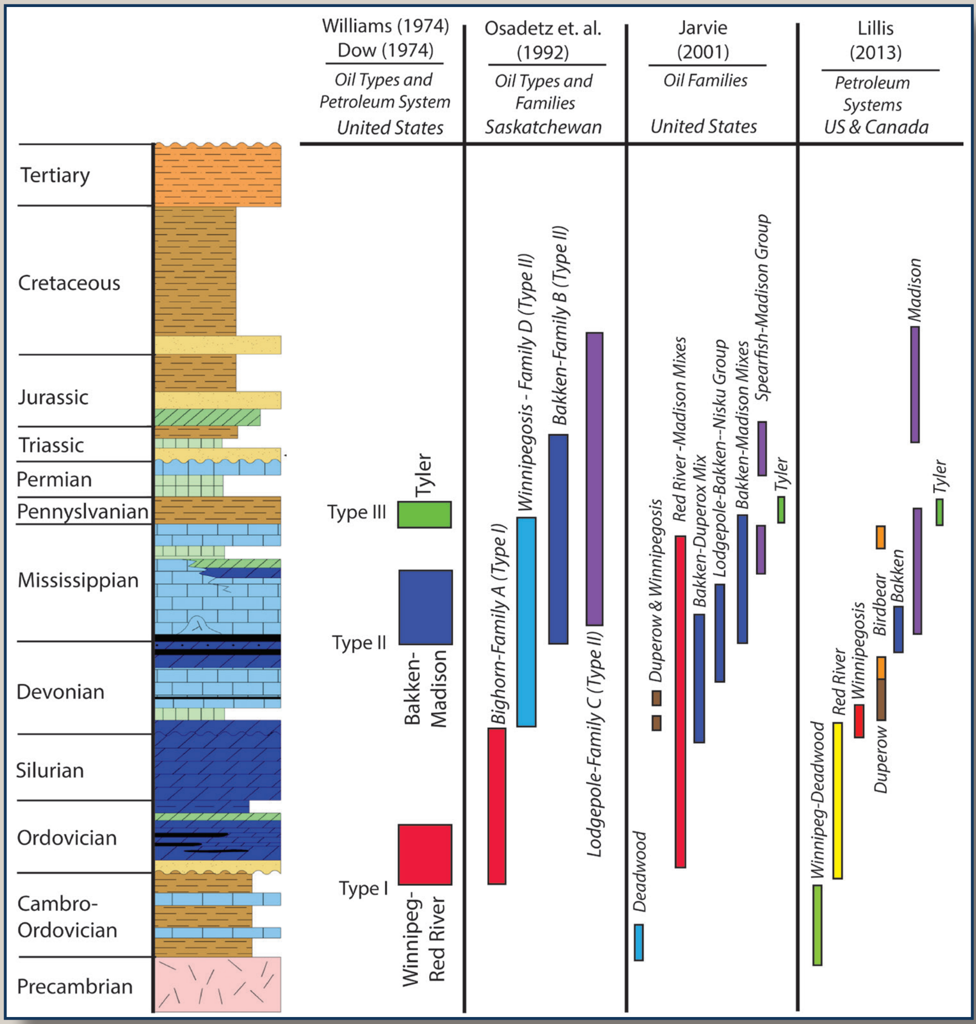

Figure 1. Oil families and petroleum systems of the Williston Basin from the literature. The distribution of the fluids and source rocks are tied to the stratigraphic column on the left. Diagram includes oils that are not linked to a specific source rock.

In a companion paper, Dow (1974) places the oils in the context of geology of the Williston Basin. He combines the source rocks, regional geology (carrier beds, reservoirs, and seals), and geological history of the basin into a petroleum system that models the pathway and migration leading to an understanding of the distribution of the oil deposits.

Osadetz and others (1992) proposed four regionally significant oil families based on source rocks from the Canadian Williston Basin. Family A oils are derived from a Type I source, in this case, from the kukersites of the Bighorn Group (Red River-Stonewall) (fig. 1). Family B oils are derived from Type II shales in the Bakken Formation. Family D oils are derived from Type II source beds found in the Winnipegosis Formation. Family C oils are from source beds within the Lodgepole Formation. They did not examine the Type III oils in this study.

Price and LeFever (1994) analyzed oils from conventional reservoirs in the middle of the Madison Group on the U.S. side of the Williston Basin. These analyses suggest that oils found in the Bakken and mid-Madison oil are from two distinct families and from different source rocks. The data also suggested that multiple source beds with slightly different compositions exist within the Madison.

Jarvie's (2001) analysis of oil samples from fields scattered throughout the Williston Basin demonstrates the presence of a number of oil families (fig. 1). He states that mixing is not extensive through the basin, and that many of the oils are distinct families of variable size. The dominant families are the Bakken, Madison, and Red River with additional sourcing from the Deadwood, Winnipegosis, and Tyler. Lillis's (2013) review of the available data adds one more petroleum family to Jarvie's list. The Birdbear Formation is added to the list of possible source beds based on work performed in Canada.

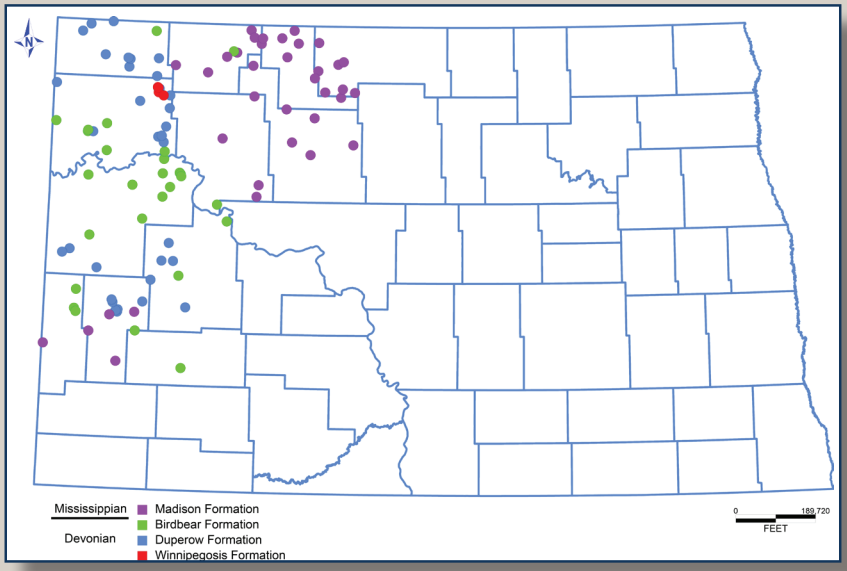

Figure 2. Map showing the distribution of samples collected from the Devonian and Mississippian rocks.

Current Study

The preceding discussion reflects the change in data through time. As more information is gathered, our understanding of the petroleum systems is changing. A reconnaissance program designed to further our understanding of source beds that are present in selected Devonian and Mississippian rocks is in progress within the North Dakota Geological Survey. This program is focusing on the formations where distinctive oils have been found and the necessary source rock has not been discovered. Samples have been collected for the Devonian Winnipegosis, Duperow, and Birdbear Formations and the Mississippian Madison Group, specifically Mission Canyon Formation (fig. 2). Based on visual inspection of cores, prospective organic-rich zones have been and will continue to be sampled for total organic carbon (TOCs). Samples with an elevated TOC (table 1) will then undergo RockEval analyses to help determine source potential.

This is just the start of the assessment process of source beds in the Williston Basin. High TOC values do not necessarily indicate that the bed will be a good source. TOCs used in combination with the indicator of hydrogen-richness (total S2) derived from the RockEval data will give an idea as to the amount of associated hydrogen (Dembicki, 2009). Higher TOC ranges with higher S2 values will generate more hydrocarbons. Source rock maturity also enters into the equation: the more mature a source rock is, the less it looks like a source rock. Also, variation in source rock richness and kerogen type, both horizontal and vertical, as well as thickness and areal extent must be taken into account in the overall assessment. The final question to be answered is, Are the amounts of potentially generated hydrocarbon great enough to source the reservoir?

Total Organic Carbon (TOC) value (weight percent)		
TOC in Shales	Source Rating	%TOC in Carbonate
0.00-0.50	Poor	0.00-0.12
0.50-1.00	Fair	0.12-0.25
1.00-2.00	Good	.0.25-0.50
2.00-4.00	Very Good	0.50-1.00
4.00 and greater	Excellent	1.00 and greater
S2 Value (mg hydrocarbon/gm of rock)		
Less than 2.00	Poor	
2.00-5.00	Fair	
Greater than 5.00	Good	

Table 1. Criteria for rating potential source rocks (Osadetz and Snowdon, 1986).

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