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National and Global Petroleum Assessment

Assessment of Undiscovered Oil and Gas Resources in the Pennsylvanian Tyler Formation of the Williston Basin Province, 2020

Using a geology-based assessment methodology, the U.S. Geological Survey estimated undiscovered, technically recoverable mean resources of 161 million barrels of oil and 93 billion cubic feet of gas in the Tyler Formation of the Williston Basin Province, North Dakota.

Introduction

The U.S. Geological Survey (USGS) quantitatively assessed the potential for undiscovered, technically recoverable conventional and continuous, or unconventional, oil and gas resources in the Pennsylvanian Tyler Formation of the Williston Basin Province (fig. 1), North Dakota. Three assessment units (AUs) were defined within the Tyler Formation, and each was assessed for undiscovered oil, gas, and natural gas liquids.

The Tyler Formation formed during the Pennsylvanian when glacially modulated sea-level fluctuations led to the deposition of several thin, transgressive-regressive, mudstone-limestone cycles that included potential petroleum source rocks (Nordeng and Nesheim, 2012; Monahan, 2014; Nesheim and Nordeng, 2016). During this time, the western margin of the Williston Basin was connected to the Panthalassa Ocean by way of the Big Snowy Trough, which was oriented east to west across Montana (Bottjer and others, 2020). As sea level rose to initiate each cycle, marine water transgressed from west to east through the Big Snowy Trough and eventually reached the shallow Williston Basin.

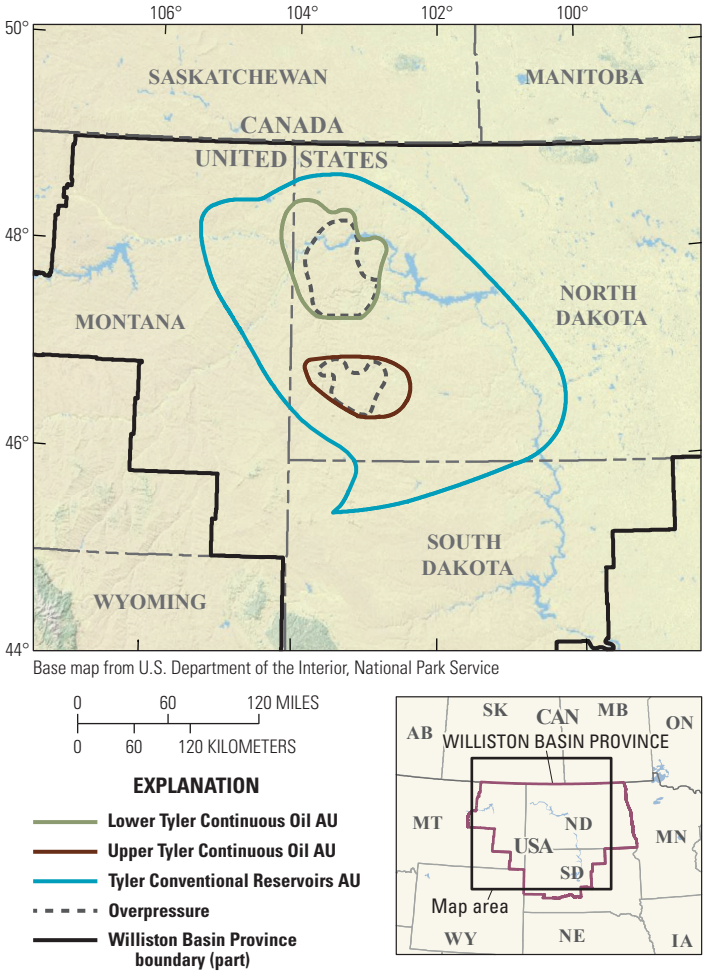

Figure 1. Map showing the location of three assessment units (AUs) in the Tyler Formation in the Williston Basin Province, North Dakota.

The Tyler Formation contains two geographically distinct areas of thermally mature source rock: one in the north (Lower Tyler) and one in the south (Upper Tyler) (fig. 1; Nesheim and Nordeng, 2016). In the northern area of source rock, the lower part of the Tyler Formation contains several cycles of subtidal shale that show a change from organic-rich shale to organic-lean, bioturbated shale as bottom waters became progressively more oxic. The organic-rich shales have as much as 4 weight percent total organic carbon (TOC) and hydrogen index (HI) values as much as 400 milligrams hydrocarbon per gram (mg HC/g) of TOC. In the southern area of source rock, the upper part of the Tyler Formation is a sequence of shales and limestones that were deposited in mainly brackish water conditions. The shales have as much as 6 weight percent TOC and HI values as much as 800 mg HC/g TOC. Oils from the upper part of the Tyler Formation largely originated from Type I organic matter and are likely derived from lacustrine shales (Nesheim and Nordeng, 2012, 2016; Stevanovic and others, 2014).

Assessment Units

The extent of the thermally mature shale and overpressure data defines the boundaries of the Lower Tyler Continuous Oil AU and the Upper Tyler Continuous Oil AU in this study (fig. 1). The geologic model for both of the continuous AUs is for oil to have been generated within these pods of source rock, and the oil was partially retained within the shales following expulsion and migration. The Tyler Conventional Reservoirs AU was defined to include Tyler-sourced oil that migrated from marine shales in the Tyler and was retained within fluvial-deltaic to shelf sandstone reservoirs within conventional structural and stratigraphic traps. Key assessment input data for the three AUs within the Tyler Formation are shown in table 1.

Undiscovered Resources Summary

The USGS quantitatively assessed undiscovered conventional and continuous oil, gas, and natural gas liquid resources within three AUs of the Tyler Formation (table 2) in the Williston Basin Province, North Dakota. The estimated mean totals for the Tyler Formation are 161 million barrels of oil (MMBO) with an F95–F5 fractile range from 41 to 369 MMBO, 93 billion cubic feet of gas (BCFG) with an

F95–F5 fractile range from 21 to 224 BCFG, and 5 million barrels of natural gas liquids (MMBNGL) with an F95–F5 fractile range from 1 to 11 MMBNGL. Estimated mean totals for the two continuous AUs are 125 MMBO (78 percent of total), 82 BCFG (88 percent of total), and 4 MMBNGL (80 percent of total). Given the assessment mean input data (table 1), we estimate that a mean of approximately 21,000 wells would be necessary to develop this potential continuous oil resource in the Tyler Formation.

Table 1. Key input data for three assessment units in the Tyler Formation of the Williston Basin Province, North Dakota.

[Well drainage area, success ratio, and estimated ultimate recovery are defined using U.S. shale-oil analogs. The average EUR input is the minimum, median, maximum, and calculated mean. Gray shading indicates not applicable. AU, assessment unit; MMBO, million barrels of oil]

Assessment input data—Continuous AUs	Lower Tyler Continuous Oil AU				Upper Tyler Continuous Oil AU			
	Minimum	Mode	Maximum	Calculated mean	Minimum	Mode	Maximum	Calculated mean
Potential productive area of AU (acres)	1,000	1,414,000	2,525,000	1,313,333	1,000	650,000	1,586,000	745,667
Average drainage area of wells (acres)	60	100	140	100	60	100	140	100
Success ratio (%)	5	35	80	40	10	50	90	50
Average EUR (MMBO)	0.005	0.01	0.05	0.012	0.006	0.015	0.05	0.017
AU probability	1.0				1.0			

Assessment input data—Conventional AUs	Tyler Conventional Reservoirs AU			
	Minimum	Median	Maximum	Calculated mean
Number of oil fields	1	30	90	31.9
Size of oil fields (MMBO)	0.5	0.7	24	1.1
AU probability	1.0			

Table 2. Results for three assessment units in the Tyler Formation of the Williston Basin Province, North Dakota.

[Results shown are fully risked estimates. F95 represents a 95-percent chance of at least the amount tabulated; other fractiles are defined similarly. Gray shading indicates not applicable. MMBO, million barrels of oil; BCFG, billion cubic feet of gas; NGL, natural gas liquids; MMBNGL, million barrels of natural gas liquids]

Total petroleum system and assessment units (AUs)	AU probability	Accumulation type	Total undiscovered resources											
			Oil (MMBO)				Gas (BCFG)				NGL (MMBNGL)			
			F95	F50	F5	Mean	F95	F50	F5	Mean	F95	F50	F5	Mean
Pennsylvanian Tyler Total Petroleum System														
Lower Tyler Continuous Oil AU	1.0	Oil	12	50	159	63	12	50	159	63	1	3	8	3
Upper Tyler Continuous Oil AU	1.0	Oil	13	53	146	62	4	16	45	19	0	1	2	1
Total undiscovered continuous resources			**25**	**103**	**305**	**125**	**16**	**66**	**204**	**82**	**1**	**4**	**10**	**4**
Tyler Conventional Reservoirs AU	1.0	Oil	16	33	64	36	5	10	20	11	0	1	1	1
Total undiscovered conventional resources			**16**	**33**	**64**	**36**	**5**	**10**	**20**	**11**	**0**	**1**	**1**	**1**
Total undiscovered resources			**41**	**136**	**369**	**161**	**21**	**76**	**224**	**93**	**1**	**5**	**11**	**5**

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For More Information

Assessment results are also available at the USGS Energy Resources Program website at https://www.usgs.gov/energy-and-minerals/energy-resources-program/.

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