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National and Global Petroleum Assessment

Assessment of Undiscovered Conventional Oil and Gas Resources in Upper Paleozoic Reservoirs of the Wind River Basin, Bighorn Basin, and Powder River Basin Provinces, 2024

Using a geology-based assessment methodology, the U.S. Geological Survey estimated undiscovered, technically recoverable mean conventional resources of 47 million barrels of oil and 876 billion cubic feet of gas in upper Paleozoic reservoirs of the Wind River Basin, Bighorn Basin, and Powder River Basin Provinces.

Introduction

The U.S. Geological Survey (USGS) assessed the potential for undiscovered, technically recoverable conventional oil and gas resources within upper Paleozoic reservoirs of the Wind River Basin, Bighorn Basin, and Powder River Basin Provinces (fig. 1). These basins were formed during the Late Cretaceous to Paleogene Laramide orogeny that resulted in the fragmentation of the Sevier foreland by basement-involved deformation. This process formed intermontane basins, such as the Wind River, Bighorn, and Powder River Basins (Yeck and others, 2014; Yonkee and Weil, 2015). Exploration for oil in structural traps along the margins of these basins began in earnest in the 1920s because many of the contractional structures had obvious surface expression that focused exploration efforts. By the 1960s, most structural fields had been discovered. Since that time, exploration has focused on the pursuit of oil within complex stratigraphic and structural traps in eolian sandstones in the Permian upper part of the Pennsylvanian–Permian Minnelusa Formation in the north-central part of the Powder River Basin Province. The purpose of this report is to provide an assessment of the remaining oil and gas potential in upper Paleozoic reservoirs within structural and stratigraphic traps in these three geologic provinces.

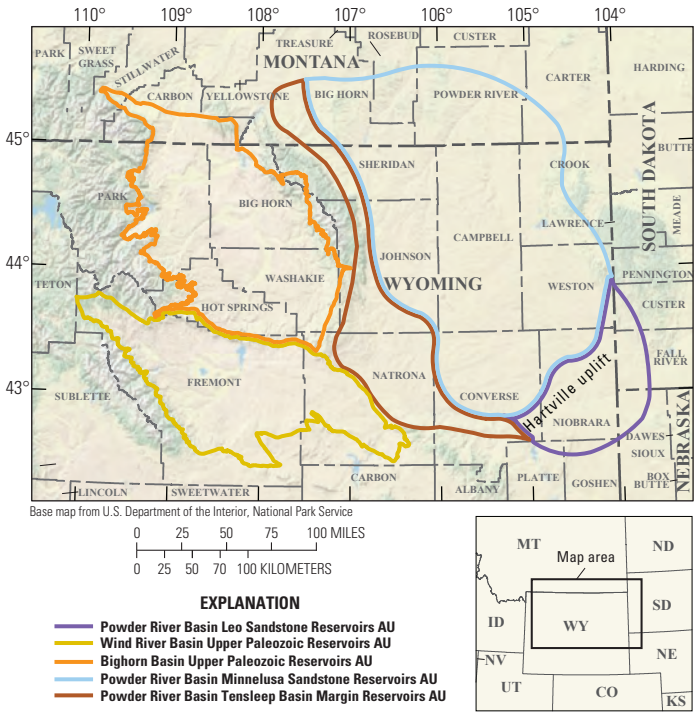

Figure 1. Maps showing the location of five conventional assessment units (AUs) in upper Paleozoic reservoirs of the Wind River Basin, Bighorn Basin, and Powder River Basin Provinces.

Total Petroleum Systems and Assessment Units

The USGS defined a Paleozoic–Mesozoic Composite Total Petroleum System (TPS) that encompasses oil generated and migrated from thermally mature Pennsylvanian and Cretaceous organic-rich shales. The geologic model for the Powder River Basin Leo Sandstone Reservoirs Assessment Unit (AU) is for oil generated from Pennsylvanian organic-rich shales and from Cretaceous shales (Clayton and Ryder, 1984) to have migrated into structural traps within the Hartville uplift. Reservoirs are predominantly eolian sandstones of the Pennsylvanian Leo Sandstone Member of the Minnelusa Formation (Tromp and others, 1981; Cardinal and Sherer, 1984; McBane, 1984).

The Phosphoria TPS was defined in the Wind River Basin and Bighorn Basin Provinces to encompass oil that may have been generated from thermally mature organic-rich shales of the Retort Tongue and Meade Peak Member of the Permian Phosphoria Formation in west-central Wyoming and eastern Idaho (Maughan, 1975). Phosphoria-generated oil was ultimately trapped in upper Paleozoic reservoirs in the Wind River Basin, Bighorn Basin, and Powder River Basin Provinces (Donohue and others, 2020), possibly as the result of long-distance eastward migration of oil (Sheldon, 1967; Stone, 1967; Maughan, 1975). Although several scenarios have been proposed for the regional distribution of oil generated from the Phosphoria Formation, the processes and timing of long-distance oil migration relative to ultimate trap formation are not well constrained (Burtner and Nigrini, 1994; Ellis and others, 2017; Kendall and others, 2023). The Wind River Basin Upper Paleozoic Reservoirs AU and the Bighorn Basin Upper Paleozoic Reservoirs AU were defined within the Phosphoria TPS (fig. 1). The geologic model for these two AUs is for Phosphoria-sourced oil to have ultimately migrated into eolian sandstone reservoirs in sandstones of the Pennsylvanian Amsden Formation and into the Pennsylvanian–Permian Tensleep Sandstone, and into carbonates of the Phosphoria Formation within Laramide-age structural and stratigraphic traps (Andrews and Higgins, 1984; Curry, 1984; Carr-Crabaugh and Dunn, 1996). Phosphoria-sourced gas is interpreted to have been generated at depth and trapped mainly within carbonate reservoirs of the Mississippian Madison Group, such as the hydrogen-sulfide-rich gas occurring within the dolomites of the Madison Group of the Madden Deep Field in the Wind River Basin Province (Hawkins and Baugh, 2006).

The Pennsylvanian–Permian Composite TPS was defined within the Powder River Basin Province to encompass oil and gas generated and migrated from organic-rich shales of the Phosphoria Formation (Donohue and others, 2020) and oil possibly generated from organic-rich shales of the Pennsylvanian middle part of the Minnelusa Formation (Clayton and Ryder, 1984; Desmond and others, 1984). The Powder River Basin Minnelusa Sandstone Reservoirs AU and the Powder River Basin Tensleep Basin Margin Reservoirs AU were defined within this composite TPS (fig. 1). The geologic model for the Powder River Basin Minnelusa Sandstone Reservoirs AU is for oil from the Phosphoria Formation and from thin, organic-rich shales of the middle part of the Minnelusa Formation to have migrated into Wolfcamp-age eolian sandstones within a spectrum of stratigraphic and structural traps (Fryberger, 1984; George, 1984; Trotter, 1984; Sheppy, 1986; Jorgensen and James, 1988). The potential for oil in the eolian sandstone reservoirs of the middle part of the Minnelusa Formation (Desmond and others, 1984) and for oil and gas in the carbonate reservoirs of the Madison Group are included in this AU. The geologic model for the Powder River Basin Tensleep Basin Margin Reservoirs AU is for oil to have migrated from the Powder River Basin into structural traps along the western and southern margins of the basin. Reservoirs within the basin-margin structures are eolian sandstones of the Tensleep Sandstone and possibly carbonates of the Madison Group. The assessment input data for five conventional AUs are summarized in table 1 and in Schenk (2025).

Table 1. Key input data for five conventional assessment units in upper Paleozoic reservoirs of the Wind River Basin, Bighorn Basin, and Powder River Basin Provinces.

[Gray shading indicates not applicable. AU, assessment unit; MMBO, million barrels of oil; BCFG, billion cubic feet of gas]

Assessment input data—Conventional AUs	Powder River Basin Leo Sandstone Reservoirs AU				Wind River Basin Upper Paleozoic Reservoirs AU			
	Minimum	Median	Maximum	Calculated mean	Minimum	Median	Maximum	Calculated mean
Number of oil fields	1	2	4	2.1	1	4	12	4.3
Number of gas fields					1	12	48	13.2
Size of oil fields (MMBO)	0.5	0.8	6	1.0	0.5	0.8	10	1.0
Size of gas fields (BCFG)					3	18	1,500	46.0
AU probability	0.95				1.0			

Assessment input data—Conventional AUs	Bighorn Basin Upper Paleozoic Reservoirs AU				Powder River Basin Minnelusa Sandstone Reservoirs AU			
	Minimum	Median	Maximum	Calculated mean	Minimum	Median	Maximum	Calculated mean
Number of oil fields	1	20	40	20.5	1	15	30	15.4
Number of gas fields	1	6	24	6.6	1	2	8	2.2
Size of oil fields (MMBO)	0.5	0.8	12	1.1	0.5	0.8	6	1.0
Size of gas fields (BCFG)	3	12	1,000	30.1	3	12	360	20.8
AU probability	1.0				1.0			

Assessment input data—Conventional AUs	Powder River Basin Tensleep Basin Margin Reservoirs AU			
	Minimum	Median	Maximum	Calculated mean
Number of oil fields	1	4	8	4.1
Number of gas fields				
Size of oil fields (MMBO)	0.5	0.8	6	1.0
Size of gas fields (BCFG)				
AU probability	0.95			

Undiscovered Resources Summary

The USGS quantitatively assessed undiscovered conventional oil and gas resources in upper Paleozoic reservoirs in five AUs in the Wind River Basin, Bighorn Basin, and Powder River Basin Provinces (table 2). The estimated mean undiscovered resources are 47 million barrels of oil (MMBO), with an F95–F5 range from 24 to 76 MMBO; 876 billion cubic feet of gas (BCFG), or 0.9 trillion cubic feet of gas, with an F95–F5 range from 198 to 2,186 BCFG; and 20 million barrels of natural gas liquids (MMBNGL), with an F95–F5 range from 4 to 50 MMBNGL.

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Table 2. Results for five conventional assessment units in upper Paleozoic reservoirs of the Wind River Basin, Bighorn Basin, and Powder River Basin Provinces.

[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 systems 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
Paleozoic–Mesozoic Composite Total Petroleum System														
Powder River Basin Leo Sandstone Reservoirs AU	0.95	Oil	0	2	4	2	0	1	3	1	0	0	0	0
		Gas												
Phosphoria Total Petroleum System														
Wind River Basin Upper Paleozoic Reservoirs AU	1.0	Oil	2	4	9	4	2	4	8	4	0	0	0	0
		Gas					142	497	1,468	610	3	11	34	14
Bighorn Basin Upper Paleozoic Reservoirs AU	1.0	Oil	13	22	34	22	7	12	19	12	0	1	1	1
		Gas					37	145	554	200	1	3	9	3
Pennsylvanian–Permian Composite Total Petroleum System														
Powder River Basin Minnelusa Sandstone Reservoirs AU	1.0	Oil	9	14	22	15	1	1	1	1	0	0	0	0
		Gas					9	33	132	47	0	2	6	2
Powder River Basin Tensleep Basin Margin Reservoirs AU	0.95	Oil	0	4	7	4	0	1	1	1	0	0	0	0
		Gas												
Total undiscovered conventional oil and gas resources			**24**	**46**	**76**	**47**	**198**	**694**	**2,186**	**876**	**4**	**17**	**50**	**20**

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For More Information

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

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