

National and Global Petroleum Assessment

Assessment of Undiscovered Conventional Oil and Gas Resources of the Montana Thrust Belt Province, 2021

Using a geology-based assessment methodology, the U.S. Geological Survey estimated means of 783 million barrels of conventional oil and 17,606 billion (17.6 trillion) cubic feet of conventional gas in the Montana Thrust Belt Province.

Introduction

The U.S. Geological Survey (USGS) quantitatively assessed the potential for undiscovered, technically recoverable conventional oil and gas resources in two total petroleum systems (TPSs) within the Montana Thrust Belt Province (fig. 1). The Montana Thrust Belt forms a segment of the Cordilleran orogenic belt that extends from Alaska to Mexico along the western margin of cratonic North America (Fuentes and others, 2012; Beranek and others, 2016). Regional extension along the Mesoproterozoic margin resulted in the deposition of several kilometers of mainly clastic sediments of the Belt Supergroup; the Helena salient has been interpreted as a failed Mesoproterozoic rift which contains several kilometers of Belt Supergroup strata. The lower Paleozoic was dominated by passive margin carbonate deposition. Subduction during the Late Devonian and Mississippian Antler orogeny accentuated the existing structure of the Williston and Sappington basins (Schultz and Hofmann, 2021), within which organic-rich marine shales of the Bakken Formation and the stratigraphically equivalent Sappington Formation were deposited coeval with adjacent carbonate platforms. Renewed subduction during the Jurassic led to the progressive eastward-directed thrusts of the Sevier fold and thrust belt that formed an extensive foreland basin to the east, which persisted through the Paleogene. The Sevier thrusts complexly deformed the Paleozoic–earliest Cenozoic sediments. The progressive imbrication of thrust sheets, including the emplacement of the several-kilometer-thick Mesoproterozoic Lewis Thrust sheet during the Laramide orogeny resulted in the thermal maturity necessary to generate oil and gas from shales of the Upper Devonian–Lower Mississippian Sappington Formation and Cenomanian–Santonian Marias River Shale (Clayton and others, 1982; Dolson and others, 1993). Late Eocene to Miocene basin-and-range extension formed regional west-facing normal faults and half grabens, which filled with up to five kilometers of clastic sediments, including organic-rich lacustrine shales.

Total Petroleum Systems and Assessment Units

The USGS defined two TPSs and six conventional oil and gas assessment units (AUs) in the Montana Thrust Belt Province. The Paleozoic–Mesozoic Composite TPS was defined to include the Main Thrust Belt Structures Conventional Oil and Gas AU, the Sawtooth Structures Conventional Oil and Gas AU, the Foothills Structures Conventional Oil and Gas AU, and the Greater Helena Salient Structures Conventional Oil and Gas AU. The geologic model for these four AUs is similar; oil and gas were generated from shales of the Sappington Formation (Bakken Formation equivalent) and the Cenomanian–Turonian Marias River Shale as these rocks entered the thermal-generative windows for oil and gas during Laramide thrust loading (Clayton and others, 1982; Dolson and others, 1993; Di Pasquo and others, 2019; Browne and others, 2020; Schultz and Hofmann, 2021). Generated and expelled oil and gas migrated into fractured carbonate and karst reservoirs of the Madison Group and other Paleozoic carbonates and Mesozoic clastic reservoirs within complexly faulted and fractured structural traps. Multiple phases of deformation and extensive fracturing may have hindered the retention of oil and gas within structurally trapped reservoirs.

The Oligocene Lacustrine TPS was defined on the presence and thermal maturity of lacustrine source rocks and encompasses the Northern and Southern Cenozoic Basins Conventional Oil and Gas AUs (Fields and others, 1985; Curiale and others, 1988). The geologic model for the Oligocene Lacustrine TPS is for oil and gas generated from organic matter-rich lacustrine shales to have migrated into sandstone and conglomerate reservoirs within stratigraphic and structural traps. Coal beds within the Cenozoic section may be an additional source of gas in this TPS. The presence of volcanoclastic detritus within the Cenozoic sediments suggests reservoir quality could be compromised. The assessment input data for six conventional AUs are summarized in table 1 and in Schenk (2022).

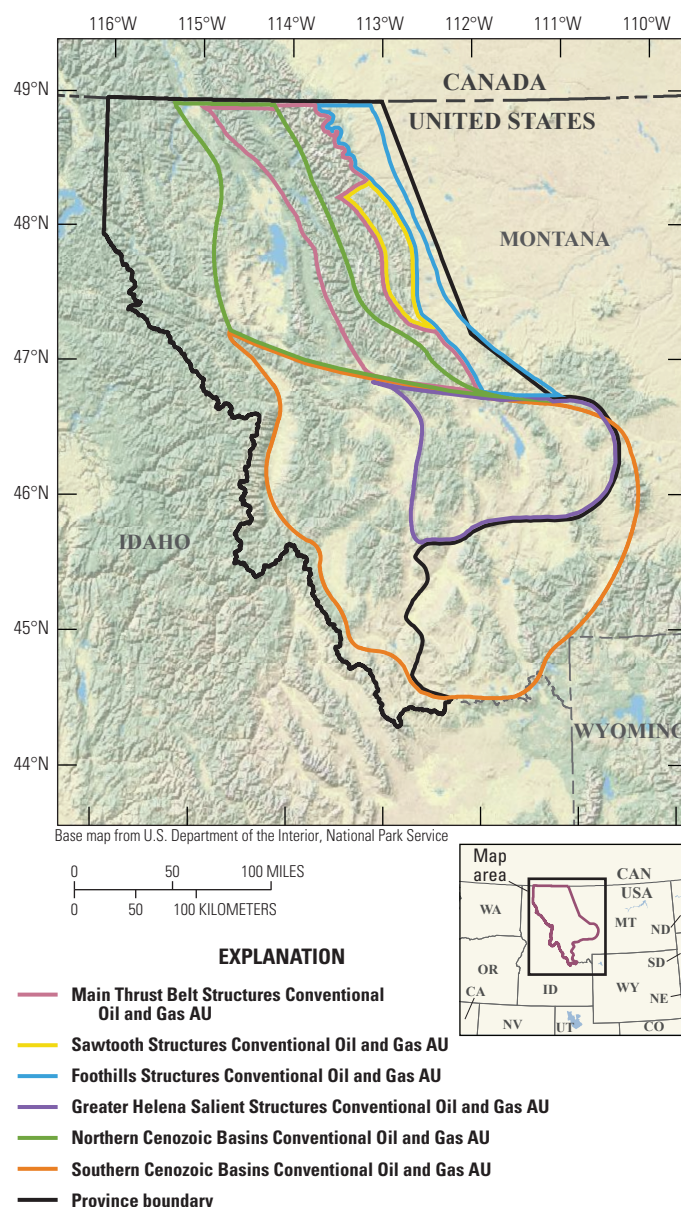


Figure 1. Map showing location of six conventional oil and gas assessment units (AUs) in the Montana Thrust Belt Province (Province boundary from U.S. Geological Survey and Minerals Management Service, 1988).

Undiscovered Resources Summary

The USGS quantitatively assessed undiscovered continuous oil and gas resources within six conventional assessment units in the Montana Thrust Belt Province (table 2). The estimated mean totals for conventional

resources are 783 million barrels of oil (MMBO), or 0.8 billion barrels with an F95–F5 range from 103 to 2,269 MMBO; 17,606 billion cubic feet of gas (BCFG), or 17.6 trillion cubic feet, with an F95–F5 range from 4,713 to 39,227 BCFG; and 812 million barrels of natural gas liquids (MMBNGL), or 0.8 billion barrels, with an F95–F5 range from 231 to 1,752 MMBNGL.

Table 1. Key input data for six conventional oil and gas assessment units in the Montana Thrust Belt Province.

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

Assessment input data— Conventional AUs	Main Thrust Belt Structures Conventional Oil and Gas AU				Sawtooth Structures Conventional Oil and Gas AU			
	Minimum	Median	Maximum	Calculated mean	Minimum	Median	Maximum	Calculated mean
Number of oil fields	1	5	20	5.5	1	5	20	5.5
Number of gas fields	1	60	180	63.8	1	5	20	5.5
Size of oil fields (MMBO)	5	8	400	14.8	5	8	100	10.5
Size of gas fields (BCFG)	30	48	12,000	168.0	30	48	2,000	83.8
AU probability	1.0				0.9			
Assessment input data— Conventional AUs	Foothills Structures Conventional Oil and Gas AU				Greater Helena Salient Structures Conventional Oil and Gas AU			
	Minimum	Median	Maximum	Calculated mean	Minimum	Median	Maximum	Calculated mean
Number of oil fields	1	15	45	16.0	1	5	15	5.3
Number of gas fields	1	15	45	16.0	1	20	60	21.3
Size of oil fields (MMBO)	5	8	100	10.5	5	8	400	14.8
Size of gas fields (BCFG)	30	48	3,000	95.3	30	48	7,000	131.5
AU probability	1.0				0.85			
Assessment input data— Conventional AUs	Northern Cenozoic Basins Conventional Oil and Gas AU				Southern Cenozoic Basins Conventional Oil and Gas AU			
	Minimum	Median	Maximum	Calculated mean	Minimum	Median	Maximum	Calculated mean
Number of oil fields	1	5	20	5.5	1	10	40	11.0
Number of gas fields	1	2	8	2.2	1	4	16	4.4
Size of oil fields (MMBO)	5	8	2,000	28.0	5	8	2,500	31.3
Size of gas fields (BCFG)	30	48	6,000	123.3	30	48	6,000	123.3
AU probability	0.9				0.8			

Table 2. Results for six conventional oil and gas assessment units in the Montana Thrust Belt Province.

[Results shown are fully risked estimates. F95 represents a 95-percent chance of at least the amount tabulated; other fractiles are defined similarly. 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
Paleozoic–Mesozoic Composite Total Petroleum System														
Main Thrust Belt Structures Conventional Oil and Gas AU	1.0	Oil	23	62	209	82	90	250	836	327	5	13	42	16
		Gas					3,754	9,512	21,700	10,725	196	494	1,128	558
Sawtooth Structures Conventional Oil and Gas AU	0.9	Oil	0	47	115	52	0	189	461	208	0	10	23	10
		Gas					0	332	1,088	416	0	8	27	10
Foothills Structures Conventional Oil and Gas AU	1.0	Oil	80	156	295	168	321	625	1,178	670	16	31	59	34
		Gas					548	1,309	3,216	1,515	14	33	80	38
Greater Helena Salient Structures Conventional Oil and Gas AU	0.85	Oil	0	54	181	67	0	214	724	268	0	11	36	13
		Gas					0	2,013	6,215	2,382	0	105	323	124
Oligocene Lacustrine Total Petroleum System														
Northern Cenozoic Basins Conventional Oil and Gas AU	0.9	Oil	0	73	486	139	0	73	489	139	0	1	4	1
		Gas					0	124	846	245	0	1	8	2
Southern Cenozoic Basins Conventional Oil and Gas AU	0.8	Oil	0	161	983	275	0	161	980	275	0	1	8	2
		Gas					0	258	1,494	436	0	2	14	4
Total undiscovered conventional resources			103	553	2,269	783	4,713	15,060	39,227	17,606	231	710	1,752	812

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For More Information

Assessment results are also available at the U.S. Geological Survey Energy website, <https://www.usgs.gov/programs/energy-resources-program>.