

Assessment of Undiscovered Continuous Oil and Gas Resources in the Heath Formation, Central Montana and Western North Dakota, 2016

Using a geology-based assessment methodology, the U.S. Geological Survey estimated undiscovered, technically recoverable mean resources of 884 million barrels of oil and 106 billion cubic feet of gas in the North-Central Montana and Williston Basin Provinces of central Montana and western North Dakota.

Introduction

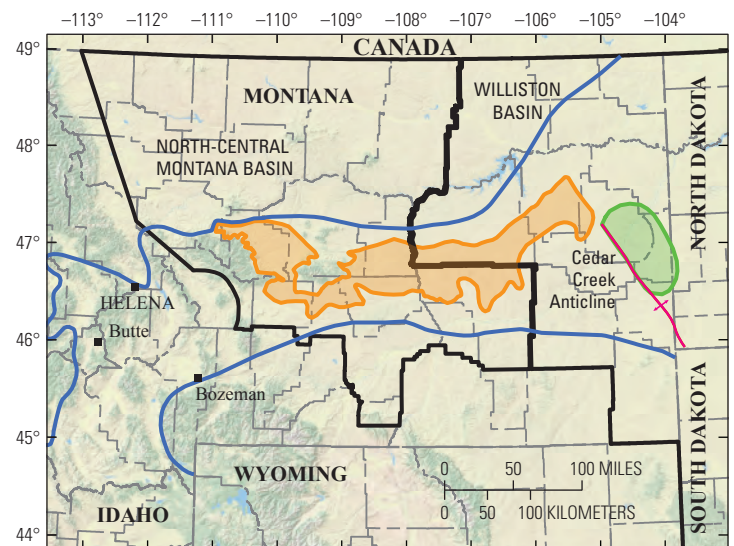
The U.S. Geological Survey (USGS) completed a geology-based assessment of the continuous (unconventional) oil and gas resources in the Big Snowy Trough area of central Montana and western North Dakota (fig. 1). The Big Snowy Trough was an east-west depression during Meramec time, and the north and south boundaries of the trough were later enhanced by faulting and erosion (Maughan and Roberts, 1967). The Heath Formation of the Big Snowy Group is confined to the Big Snowy Trough. This assessment is based on the geologic concepts and criteria of a total petroleum system (TPS) and includes information on the hydrocarbon source rocks, reservoir rocks, and hydrocarbon traps. In this study, we defined the Heath TPS and two assessment units (AUs) that contain similar structural, stratigraphic, and petroleum-charge histories. The assessment input data for each AU are shown in table 1.

Total Petroleum System

The Heath TPS is limited to the Heath Formation, which consists of a heterogeneous mix of lithologies that includes black shales, limestone, sandstone, anhydrite, and coal. The primary petroleum source rock is the Cox Ranch shale member in the middle of the Heath Formation. The Heath TPS is self-sourced with total organic carbon ranging from 0.5 to 26 weight percent and averaging 9 weight percent (McClave, 2012). Additional minor sources of petroleum may include the less organic-rich shale units in the upper and lower Heath Formation. Evidence suggests that some petroleum has migrated from the Heath Formation, and much of it has been produced from the overlying Tyler Formation; however, the primary resource potential is within the Heath Formation.

Assessment Units

Two AUs are identified in this assessment: the North-Central Montana Heath Continuous Oil AU and the Williston Heath Continuous Oil AU. The North-Central Montana Heath Continuous Oil AU lies within the Big Snowy Trough of central and eastern Montana and covers a maximum area of 5,255,000 acres (fig. 1). The potential resource AUs include the areas where the Heath Formation is thermally mature and not near the surface. Oil has been produced from the Heath Formation since 1919 when it was discovered in the Devil's Basin oil field on the Central Montana Uplift (IHS Markit™, 2016). The Heath Formation is the source



Source: U.S. Department of the Interior National Park Service

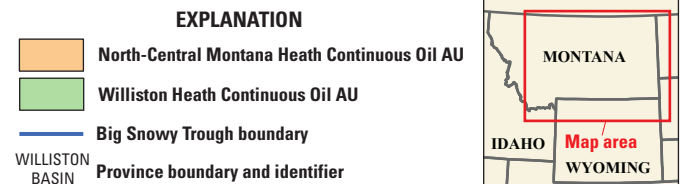


Figure 1. Location of the North-Central Montana and Williston Basin Provinces with continuous assessment unit (AU) boundaries. Cedar Creek Structure modified from Maughan (1966) and Gaswirth and others (2013). Big Snowy Trough outline modified from Derkey and others (1985).

of more than 95 million barrels of oil (MMBO) produced from the overlying Tyler Formation (Bottjer, 2014).

The Williston Heath Continuous Oil AU is along the eastern side of the Cedar Creek anticlinal structure in the southwestern portion of the Williston Basin (fig. 1). The Heath Formation is present only in a limited area (Maughan, 1966; Clement, 1986) and is thickest along the Cedar Creek anticline (greater than 300 feet according to Clement, 1986). The Heath Formation eroded during the Early Pennsylvanian on the west side of the Cedar Creek structure and only extends a short distance east from the structure (Maughan, 1966).

Undiscovered Resources Summary

Using the USGS continuous resource methodology for assessing petroleum resources (Charpentier and Cook, 2011), we quantitatively assessed oil and gas resources in two continuous (unconventional) AUs in the North-Central Montana and Williston Basin Provinces (table 2). The overall total mean resources in the Heath Formation AUs are 884 million barrels of oil (MMBO) with an F95–F5 range from 154 MMBO to 1,965 MMBO and 106 billion cubic feet of gas (BCFG) with an F95–F5 range from 17 BCFG to 246 BCFG.

Table 1. Key assessment input data for two continuous assessment units in the Heath Formation, Montana and North Dakota.

[AU, assessment unit; %, percent; EUR, estimated ultimate recovery per well; MMBO, million barrels of oil. EUR, well drainage area, and success ratios are partly from U.S. shale-oil analogs. The average EUR input is the minimum, median, maximum, and calculated mean. Shading indicates not applicable]

Assessment input data	North-Central Montana Heath Continuous Oil AU				Williston Heath Continuous Oil AU			
	Minimum	Mode	Maximum	Calculated mean	Minimum	Mode	Maximum	Calculated mean
Potential production area of AU (acres)	1,200	1,437,000	5,255,000	2,231,067	600	1,309,000	2,600,000	1,303,200
Average drainage area of wells (acres)	60	120	180	120	60	120	180	120
Success ratios (%)	40	70	80	63.3	10	40	90	46.7
Average EUR (MMBO, oil)	0.02	0.05	0.12	0.053	0.02	0.05	0.12	0.053
AU probability	1.0				0.9			

Table 2. Assessment results for two continuous assessment units in the Heath Formation, Montana and North Dakota.

[MMBO, million barrels of oil; BCFG, billion cubic feet of gas; NGL, natural gas liquids; MMBNGL, million barrels of natural gas liquids. Results shown are fully risked estimates. For gas accumulations, all liquids are included in the natural gas liquids category. F95 represents a 95-percent chance of at least the amount tabulated; other fractiles are defined similarly. Fractiles are additive under the assumption of perfect positive correlation. Shading indicates not applicable]

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
Heath Total Petroleum System														
North-Central Montana Heath Continuous Oil AU	1.0	Oil	154	563	1,371	637	17	66	172	76	0	0	1	0
Williston Heath Continuous Oil AU	0.9	Oil	0	216	594	247	0	25	74	30	0	0	0	0
Total undiscovered continuous resources			154	779	1,965	884	17	91	246	106	0	0	1	0

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For More Information

Assessment results are available at the USGS Energy Resources Science Center website at <https://energy.usgs.gov>.