

Assessment of Continuous Oil and Gas Resources in the Bakken Formation of Northwest Montana, 2022

Using a geology-based assessment methodology, the U.S. Geological Survey estimated means of 220 million barrels of continuous oil and 1 trillion cubic feet of continuous gas in the Bakken Formation of northwest Montana.

Introduction

The U.S. Geological Survey (USGS) assessed the potential for undiscovered, technically recoverable continuous oil and gas resources in the Bakken Formation of northwest Montana (fig. 1). In the Late Devonian and Early Mississippian, contractional deformation of crust associated with east-dipping subduction (Antler orogeny) formed a north-south trending foredeep, slope, and platform collectively called the Antler foreland in the United States and the Prophet trough in Canada (Fuentes and others, 2012; Beranek and others, 2016). An extensive west-dipping carbonate ramp formed along the eastern part of the foreland platform and organic-rich transgressive mudstones of the Bakken Formation and Exshaw Formation were deposited to the west along the slope and foredeep (Smith and Bustin, 2000). Renewed subduction along the western cratonic margin of North America during the Jurassic led to the progressive eastward-directed thrusts of the Sevier fold and thrust belt which persisted through the Paleogene. The progressive imbrication of eastward-directed thrust sheets of the Montana thrust belt, including the emplacement of the several-kilometer-thick Lewis thrust sheet during the Laramide orogeny, resulted in burial and levels of thermal maturity adequate to generate oil and gas from organic-rich mudstones of the Bakken Formation in the United States and Exshaw Formation in Canada (Clayton and others, 1982; Dolson and others, 1993).

Total Petroleum System and Assessment Units

The USGS defined the Bakken Formation Total Petroleum System (TPS) which includes the NW Montana Bakken Formation Continuous Oil Assessment Unit (AU) and the NW Montana Bakken Formation Continuous Gas AU (fig. 1). Both AUs are bounded to the north by the international border with Canada and to the south by the Scapegoat-Ballantyne structural trend (Dolson and others, 1993). The Bakken Continuous Oil AU is bounded to the east by the 0.5 percent vitrinite reflectance contour and to the west by the 1.3 percent vitrinite reflectance contour (Dolson and others, 1993). The adjacent Bakken Continuous Gas AU is bounded to the east by the 1.3 percent vitrinite reflectance contour, and to the west by the footwall of the frontal thrust of the Montana Thrust Belt. South of the Scapegoat-Ballantyne structural trend, the term Sappington Formation is used in place of Bakken Formation (Pasquo and others, 2019; Browne and others, 2020; Schultz and Hofmann, 2021). The stratigraphy and lithology of the Bakken Formation (Pasquo and others, 2019) in northwest Montana is like the Bakken Formation in the Williston Basin and the Exshaw Formation in Alberta, Canada (Smith and Bustin, 2000), with an informal lower organic-rich black shale unit, a middle siliciclastic unit, and an upper organic-rich black shale unit (Smith and Bustin, 2000). The lower black shale unit has total organic carbon (TOC) values as high as 20 weight percent, hydrogen index (HI) values up to 906 milligrams hydrocarbon per gram of TOC (mg HC/g TOC), and a maximum thickness of 20 meters (m; Smith and others, 1995; Smith

and Bustin, 2000). The middle siliciclastic unit is up to 13 m thick (Smith and others, 1995). The upper black shale unit has TOC values up to 14 weight percent, HI values as high as 1,060 mg HC/g TOC and is up to 7 m thick (Smith and others, 1995; Smith and Bustin, 2000). Mudstones of the Bakken Formation in northwest Montana achieved adequate thermal maturity for oil and gas generation during Laramide thrust loading and burial (Clayton and others, 1982; Dolson and others, 1993). Upon generation, oil and gas migrated into conventional fractured carbonate and karst reservoirs of the Mississippian Madison Group and other Paleozoic carbonates, and Mesozoic clastic reservoirs within structural and stratigraphic traps, as shown by the oil and gas accumulations of Cutbank Field and other fields (Dolson and others, 1993). The geologic model for this assessment of continuous oil and gas resources is for some portion of the oil and gas to have been retained within the Bakken Formation as a continuous resource following migration. Shows of oil during production tests in the Bakken Formation indicate that movable oil does exist within part of the Bakken Continuous Oil AU (Just and others, 2014). However, with proximity to the thrust belt, fracturing may become more pervasive to the west and may have caused increased migration or loss of oil and gas in the absence of an adequate top seal. The assessment input data for two continuous AUs are summarized in table 1 and in Schenk (2023).

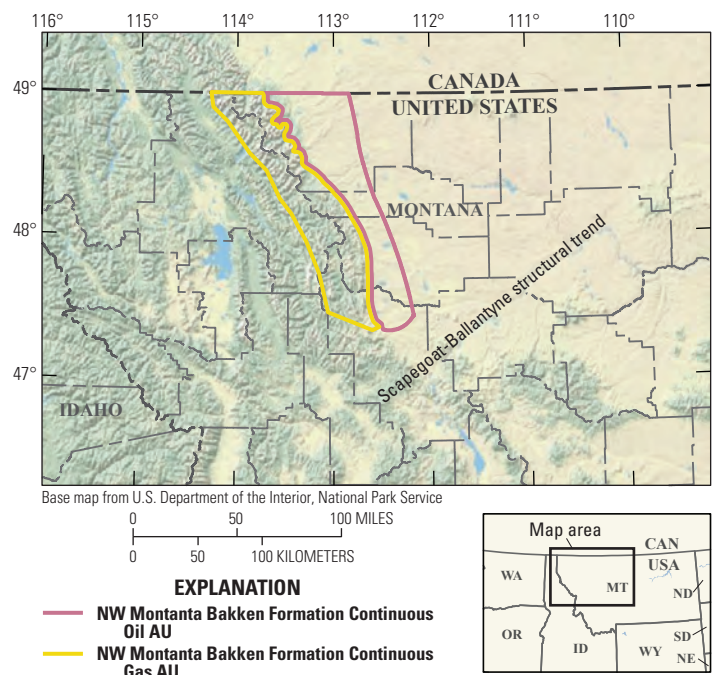


Figure 1. Map showing location of two continuous oil and gas assessment units (AUs) in the Bakken Formation of northwest Montana.

Table 1. Key input data for two continuous oil and gas assessment units in the Bakken Formation of northwest Montana.

[AU, assessment unit; NW, northwest; %, percent; EUR, estimated ultimate recovery; MMBO, million barrels of oil. The average EUR input is the minimum, median, maximum, and calculated mean. Gray shading indicates not applicable]

Assessment input data— Continuous AUs	NW Montana Bakken Formation Continuous Oil				NW Montana Bakken Formation Continuous Gas			
	Minimum	Mode	Maximum	Calculated mean	Minimum	Mode	Maximum	Calculated mean
Potential production area of AU (acres)	1,000	834,500	1,669,000	834,833	1,000	815,000	1,630,000	815,333
Average drainage area of wells (acres)	240	280	320	280	120	160	200	160.0
Success ratio (%)	30	60	90	60	10	30	50	30
Untested area (%)	99.7	99.8	99.9	99.8	100	100	100	100.0
Average EUR (MMBO)	0.04	0.12	0.22	0.124	0.2	0.5	0.8	0.510
AU probability	1.0				1.0			

Undiscovered Resources Summary

The USGS quantitatively assessed undiscovered oil and gas resources within two continuous assessment units in the Bakken Formation of northwest Montana (table 2). The estimated mean totals for continuous resources are 220 million barrels of oil (MMBO), or

0.2 billion barrels of oil, with an F95–F5 range from 62 to 431 MMBO; 1,030 billion cubic feet of gas (BCFG), or 1 trillion cubic feet of gas, with an F95–F5 range from 274 to 2,056 BCFG; and 24 million barrels of natural gas liquids (MMBNGL), or 0.02 billion barrels, with an F95–F5 range from 7 to 48 MMBNGL.

Table 2. Results for two continuous assessment units in the Bakken Formation of northwest Montana.

[AU, Assessment units; MMBO, million barrels of oil; BCFG, billion cubic feet of gas; NGL, natural gas liquids; MMBNGL, million barrels of natural gas liquids; NW, northwest. 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]

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
Bakken Total Petroleum System														
NW Montana Bakken Formation Continuous Oil AU	1.0	Oil	62	205	431	220	69	230	498	250	6	20	42	21
NW Montana Bakken Formation Continuous Gas AU	1.0	Gas					205	721	1,558	780	1	3	6	3
Total undiscovered continuous oil and gas resources			62	205	431	220	274	951	2,056	1,030	7	23	48	24

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For More Information

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

Northwest Montana Bakken Assessment Team

Christopher J. Schenk, Michael H. Gardner, Tracey J. Mercier, Cheryl A. Woodall, Phuong A. Le, Andrea D. Cicero, Ronald M. Drake II, Geoffrey S. Ellis, Thomas M. Finn, Sarah E. Gelman, Jane S. Hearon, Benjamin G. Johnson, Jenny H. Lagesse, Heidi M. Leathers-Miller, Kristen R. Marra, Kira K. Timm, and Scott S. Young.