

National and Global Petroleum Assessment

Assessment of Undiscovered Shale Gas and Shale Oil Resources in the Mississippian Barnett Shale, Bend Arch–Fort Worth Basin Province, North-Central Texas

Using a geology-based assessment methodology, the U.S. Geological Survey estimated mean volumes of 53 trillion cubic feet of shale gas, 172 million barrels of shale oil, and 176 million barrels of natural gas liquids in the Barnett Shale of the Bend Arch–Fort Worth Basin Province of Texas.

Introduction

The U.S. Geological Survey (USGS) completed a geology-based assessment of continuous (unconventional) oil and gas resources of the Mississippian Barnett Shale within the Bend Arch–Fort Worth Basin Province of north-central Texas (fig. 1). The Barnett Shale was last assessed in this region by the USGS in 2003, and that assessment was based solely on vertical drilling development (Pollastro and others, 2004). Since 2003, horizontal drilling has taken precedence, with more than 16,000 horizontal wells and 4,700 vertical wells drilled into the Barnett Shale since exploitation of the formation began. More than 15 trillion cubic feet of gas (TCFG) and 59 million barrels of oil (MMBO) have been produced from the Barnett Shale since the 2003 assessment (IHS Energy Group, 2015).

Geologic Summary

The Barnett Shale was deposited during the Late Mississippian within a narrow, restricted seaway during the initial formation of the Bend Arch–Fort Worth Basin. The shale is mainly composed of siliceous and calcareous mudstone, with a total organic carbon content ranging from 2 to 6 weight percent (Bruner and Smosna, 2011). The formation is thickest (greater than 1,000 feet) in the structurally deepest part of the basin, southwest of the Muenster arch (fig. 1; Pollastro and others, 2007). The Barnett Shale is divided into upper and lower units where the Forestburg limestone is present; however, the Barnett Shale is considered undifferentiated beyond the lateral extent of this unit. The underlying Viola-Simpson Group and overlying Marble Falls Formation may serve as fracture barriers where present, but they do not preclude drilling outside their extents (Pollastro and others, 2007).

The Barnett Shale serves as the primary source rock and as a reservoir in the Bend Arch–Fort Worth Basin. Hydrocarbons generated from the Barnett have also migrated into overlying conventional reservoirs, forming the Barnett-Paleozoic Total Petroleum System (TPS). Production from the Barnett Shale is contingent on thermal maturity, which has been primarily based on vitrinite reflectance studies and on formation parameters such as porosity and thickness (Browning and others, 2013; Fu and others, 2015). For this assessment, thermal maturity is based on the hydrogen index (HI); where, based on recent

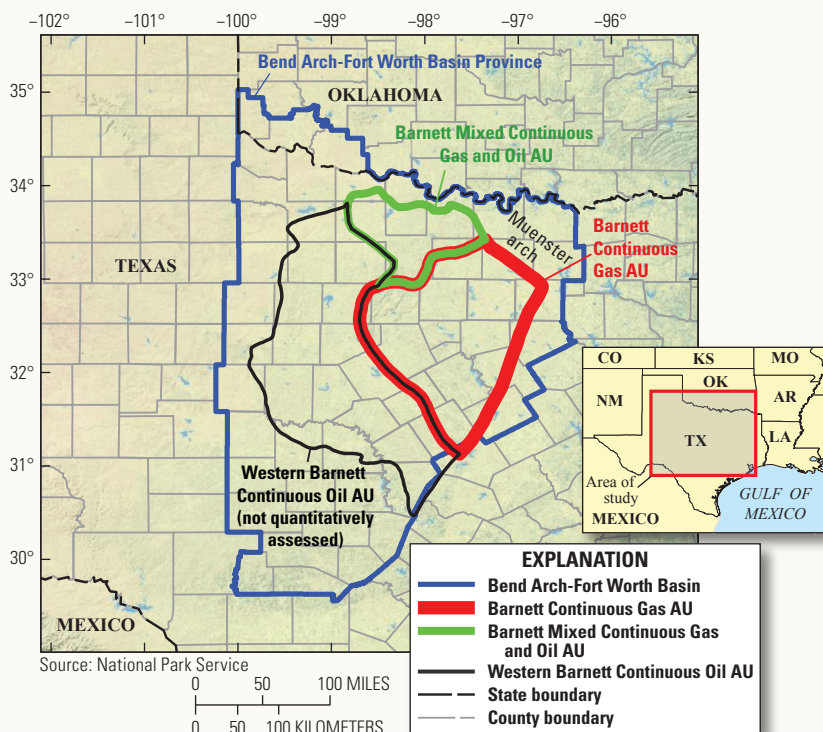


Figure 1. Map of the Bend Arch–Fort Worth Basin Province (blue outline) and three Barnett Shale assessment units.

USGS research, HI less than 100 represents primary and secondary gas generation (with secondary gas predominant at HI less than 50), and HI greater than 100 represents primarily oil generation.

Assessment Units

The three Barnett Shale assessment units (AUs) that were defined for the Barnett-Paleozoic TPS are as follows: (1) Barnett Continuous Gas AU, (2) Barnett Mixed Continuous Gas and Oil AU, and (3) Western Barnett Continuous Oil AU (fig. 1). The Barnett Continuous Gas AU is bounded by the eastern extent of the Barnett Shale and contained within the area where HI is less than 100. In the Barnett Continuous Gas AU, the geologic “sweet spot” is defined by HI less than 50. The Barnett Mixed Continuous Gas and Oil AU is adjacent to the Barnett Continuous Gas AU, where HI is equal to 100 delineates the boundary between the Barnett Mixed Continuous Gas and Oil AU and the Barnett Continuous Gas AU. The HI values within the Barnett Mixed Continuous Gas and Oil AU are therefore greater than 100. The northeastern extent of the Barnett Mixed Continuous Gas and Oil AU is limited to the extent of the Barnett Shale, and the AU covers an area where the formation thickness exceeds 100 feet in this region of the Bend Arch–Fort Worth Basin. The 100 foot isopach contour delineates the western edge of the Barnett Mixed Continuous Gas and Oil AU. The Western Barnett Continuous Oil AU is adjacent to both the Barnett Continuous Gas and Barnett Mixed Continuous Gas and Oil AUs, where formation thickness is less than 100 feet in the northern area of the AU (limit of the Barnett Mixed

Continuous Gas and Oil AU) and where HI is greater than 100 (limit of the Barnett Continuous Gas AU). The western boundary of the Western Barnett Continuous Oil AU is defined by the western extent of the Barnett Shale. No sweet spots were defined for the Barnett Mixed Continuous Gas and Oil and Western Barnett Continuous Oil AUs, and the latter was not quantitatively assessed because of minimal drilling within the AU. Key input data used to assess the continuous AUs are listed in table 1.

Resource Summary

The USGS assessed technically recoverable continuous (unconventional) resources for two AUs defined in the Barnett Shale, resulting in total estimated means of 53 trillion cubic feet of natural gas (TCFG), 172 million barrels of oil (MMBO), and 176 million barrels of natural gas liquids (MMBNGL; table 2). These total estimated means include mean estimated natural gas resources of 48.3 TCFG within the Barnett Continuous Gas AU (with a mean of 61 MMBNGL) and of 3.3 TCFG within the Barnett Mixed Continuous Gas and Oil AU. In addition, means of 172 MMBO, 1.4 TCFG, and 115 million barrels of natural gas liquids were estimated for the Barnett Mixed Continuous Gas and Oil AU (table 2).

Table 1. Key assessment input data for two continuous assessment units in Barnett Shale of the Bend Arch–Fort Worth Basin Province.

[EUR, estimated ultimate recovery per well; MMBO, million barrels of oil; BCFG, billion cubic feet of gas; AU, assessment unit; %, percent. The average EUR input is the minimum, median, maximum, and calculated mean]

Assessment input data—Continuous AU	Barnett Continuous Gas			
	Minimum	Mode	Maximum	Calculated mean
Potential production area of AU (acres)	6,000,000	6,419,000	7,000,000	6,473,000
Average drainage area of wells (acres)	60	100	140	100
Percentage of total AU area that is untested (%)	65	73	80	73
Percentage of untested AU area in sweet spots (%)	15	30	40	28
Success ratio (%) in sweet spots	85	90	92	89
Average EUR (BCFG) in sweet spots	1.0	2.0	3.0	2.034
Success ratio (%) in non-sweet spots	60	75	85	73
Average EUR (BCFG) in non-sweet spots	0.5	0.9	2.0	0.956
AU probability	1.0			
Assessment input data—Continuous AU	Barnett Mixed Continuous Gas and Oil			
	Minimum	Mode	Maximum	Calculated mean
Potential production area of AU (acres)	1,700,000	2,057,000	2,300,000	2,019,000
Average drainage area of wells (acres)	60	100	140	100
Percentage of total AU area that is untested (%)	75	85	92	84
Percentage of untested wells that are oil wells (%)	40	65	75	60
Success ratio of oil wells (%)	30	45	65	47
Average EUR of oil wells (MMBO)	0.02	0.035	0.05	0.036
Success ratio of gas wells (%)	30	45	65	47
Average EUR of gas wells (BCFG)	0.5	1.0	1.5	1.017
AU probability	1.0			

Table 2. Assessment results for continuous oil and gas resources in Barnett Shale of the Bend Arch–Fort Worth Basin Province.

[MMBO, million barrels of oil; BCFG, billion cubic feet of gas; MMBNGL, million barrels of natural gas liquids; TPS, total petroleum system; AU, assessment unit. Results shown are fully risked estimates. For gas accumulations, all liquids are included under NGL (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 assumption of perfect positive correlation. Gray shading indicates not applicable]

Total Petroleum System (TPS) 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
Barnett-Paleozoic TPS														
Barnett Continuous Gas AU	1.0	Gas					36,929	47,666	61,978	48,313	34	60	92	61
Barnett Mixed Continuous Gas and Oil AU	1.0	Oil	107	166	254	172	873	1,358	2,080	1,401	22	40	68	42
	1.0	Gas					1,916	3,132	5,099	3,271	40	69	118	73
Western Barnett Continuous Oil AU	Not quantitatively assessed													
Total undiscovered unconventional resources			107	166	254	172	39,718	52,156	69,157	52,985	96	169	278	176

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For Additional Information

Supporting geologic studies of the Barnett Shale and the methodology used in this assessment are in progress. Assessment information can be accessed at the USGS Energy Resources program web site (<http://energy.usgs.gov>).