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National and Global Petroleum Assessment

Assessment of Continuous Gas Resources in the Phosphoria Formation of the Wyoming Thrust Belt Province, Wyoming, Idaho, and Utah, 2017

Using a geology-based assessment methodology, the U.S. Geological Survey estimated mean undiscovered, technically recoverable resources of 198 billion cubic feet of continuous gas in the Phosphoria Formation of the Wyoming Thrust Belt Province, Wyoming, Idaho, and Utah.

Introduction

The U.S. Geological Survey (USGS) quantitatively assessed the potential for undiscovered, technically recoverable continuous gas resources in shales of the Lower Permian Phosphoria Formation within the Wyoming Thrust Belt Province (fig. 1). The Wyoming Thrust Belt developed by east-directed compression associated with steeply dipping subduction during the latest Jurassic to Late Cretaceous Sevier Orogeny (Lamerson, 1982; Webel, 1987). Compression resulted in a series of stacked thrust sheets that are progressively younger to the east. The major thrusts in the Wyoming Thrust Belt Province are the Paris-Willard, Meade, Crawford, Absaroka, Hogsback-Darby, and Prospect (fig. 1). The purpose of this assessment is to estimate potentially recoverable shale-gas resources remaining within Phosphoria Formation shales following structural deformation.

Total Petroleum System and Assessment Unit

The USGS defined the Phosphoria Total Petroleum System (TPS) and the Phosphoria Shale Gas Assessment Unit (AU) within this TPS. The Phosphoria TPS includes petroleum generated from organic-rich, Lower Permian Phosphoria Formation shales, specifically the Meade Peak Member and Retort Tongue. Organic-rich shales of the Phosphoria Formation contain marine Type IIS organic matter (Lillis and Selby, 2013) and have total organic carbon content averaging 4 weight percent and reaching a maximum of 13 weight percent (Claypool and others, 1978). Organic-rich shales of the Meade Peak Member are up to 60 meters thick, and the Retort Tongue is up to 30 meters thick (Maughan, 1984). Phosphoria Formation shales are largely in the dry-gas to postmature zone in terms of thermal maturity (Edman and Surdam, 1984; Burtner and Nigrini, 1994). In conventional accumulations in the Wyoming Thrust Belt Province, Phosphoria-sourced condensate is known from the Tip Top, Dry Piney, and Hogsback Fields (Edman and Cook, 1992). Gas is known to be present in the Phosphoria Formation at the Cave Creek (Utah), Whitney Canyon-Carter Creek (Wyoming), Yellow Creek (Wyoming), and Thomas Canyon (Wyoming) Fields (Ver Ploeg and De Bruin, 1982).

The assessment input data are summarized in table 1. Well drainage areas, success ratios, and estimated ultimate recoveries are taken from U.S. shale-gas analogs.

Geologic Model for Assessment

Organic-rich shales of the Lower Permian Phosphoria Formation are interpreted to have reached thermal maturity for oil generation through burial by Mesozoic sediments prior to the formation of most thrust structures related to the Sevier Orogeny (Warner, 1982; Burtner and Nigrini, 1994). Much of the oil from the Phosphoria Formation was generated prior to thrust development and migrated eastward into structural traps in what are now the Laramide basins in Wyoming, Montana, and Colorado (Sheldon, 1967; Lillis and Selby, 2013). Following migration, any oil retained within the Phosphoria Formation shales in the Wyoming Thrust Belt Province would have cracked to gas because of deeper burial from progressive thrust loading throughout the Sevier and Laramide deformations. Thrust loading has placed the Phosphoria Formation shales in the Wyoming Thrust Belt Province within the thermal window for dry gas or post-mature for gas generation (Edman and Surdam, 1984). Gas in these Phosphoria Formation shales may have high percentages of hydrogen sulfide. There is significant geologic uncertainty on the retention of oil in the Phosphoria Formation shales following migration and on the retention of gas within the shales during thrust displacement.

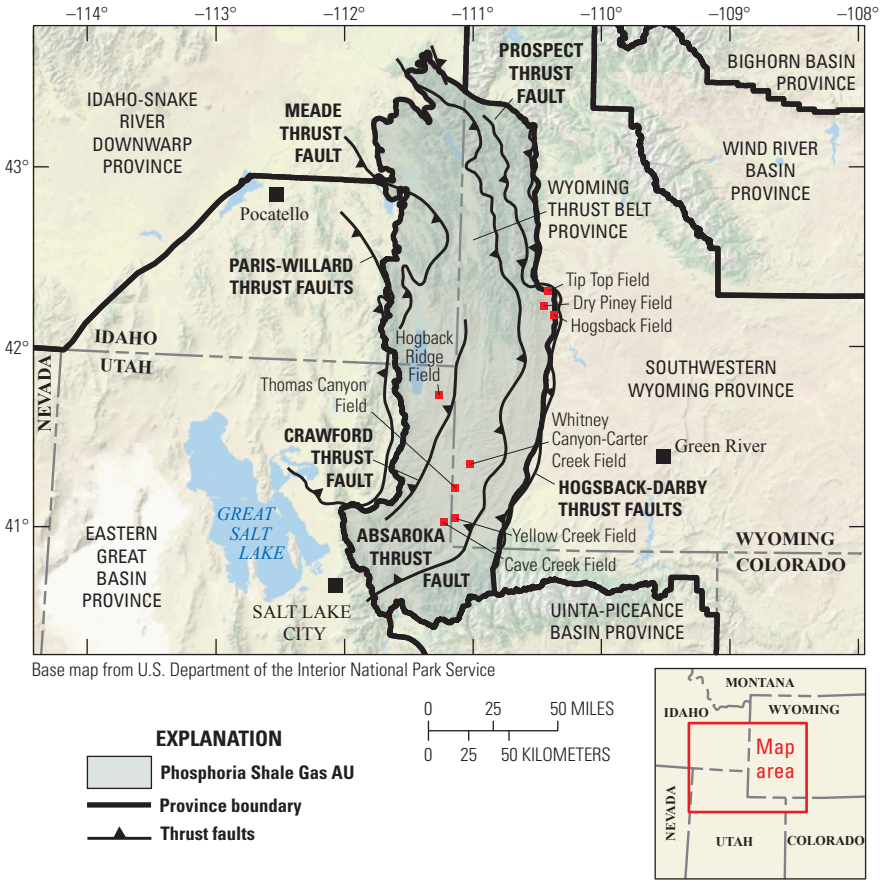

Figure 1. Map showing the location of the Phosphoria Shale Gas Assessment Unit (AU) in the Wyoming Thrust Belt Province, Wyoming, Idaho, and Utah.

Table 1. Key input data for one continuous assessment unit in the Phosphoria Formation, Wyoming Thrust Belt Province, Wyoming, Idaho, and Utah.

[AU, assessment unit; %, percent; EUR, estimated ultimate recovery per well; BCFG, billion cubic feet of gas. Well drainage area, success ratio, and EUR are from U.S. shale-gas analogs. The average EUR input is the minimum, median, maximum, and calculated mean. Shading indicates not applicable]

Assessment input data—Continuous AU	Phosphoria Shale Gas AU			
	Minimum	Mode	Maximum	Calculated mean
Potential production area of AU (acres)	1,000	2,000,000	8,000,000	3,333,667
Average drainage area of wells (acres)	80	120	200	133
Success ratio (%)	5	15	35	18
Average EUR (BCFG)	0.04	0.07	0.1	0.071
AU probability	0.6			

Undiscovered Resources Summary

The USGS quantitatively assessed the potential for continuous gas resources within the organic-rich shales of the Phosphoria Formation in the Wyoming Thrust Belt Province (table 2). The estimated mean total for undiscovered shale gas resource is 198 billion cubic feet of gas (BCFG) with an F95–F5 range from 0 to 669 BCFG and 2 million barrels of natural gas liquids (MMBNGL) with an F95–F5 range from 0 to 7 MMBNGL. Values of 0 at the F95 fractiles reflect geologic risk for the retention of gas within shales of the Phosphoria Formation.

Table 2. Results for one continuous assessment unit in the Phosphoria Formation, Wyoming Thrust Belt Province, Wyoming, Idaho, and Utah.

[AU, assessment unit; 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 NGL 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 unit (AU)	AU probability	Accumulation type	Total undiscovered resources							
			Gas (BCFG)				NGL (MMBNGL)			
			F95	F50	F5	Mean	F95	F50	F5	Mean
Phosphoria Total Petroleum System										
Phosphoria Shale Gas AU	0.6	Gas	0	130	669	198	0	1	7	2
Total undiscovered continuous resources			**0**	**130**	**669**	**198**	**0**	**1**	**7**	**2**

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For More Information

Assessment results are also available at the USGS Energy Resources Program website at https://energy.usgs.gov.

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