

Assessment of Conventional and Continuous Oil and Gas Resources in the Lewis Shale in the Southwestern Wyoming Province, Wyoming and Colorado, 2023

Using a geology-based assessment methodology, the U.S. Geological Survey estimated undiscovered, technically recoverable mean conventional and continuous resources of 294 million barrels of oil and 11 trillion cubic feet of gas in the Lewis Shale in the Southwestern Wyoming Province, Wyoming and Colorado.

Introduction

The U.S. Geological Survey (USGS) assessed undiscovered, technically recoverable conventional and continuous (unconventional) oil and gas resources in the Late Cretaceous (Campanian-Maastrichtian) Lewis Shale in the eastern portion of the Southwestern Wyoming Province in Wyoming and Colorado (figs. 1–2). The Lewis Shale is part of

the Cretaceous–Cenozoic Composite Total Petroleum System (TPS), and it is bound to the north, south, and east by uplift, and to the west by depositional pinch-out (figs. 1–2).

The Lewis Shale was previously assessed by the USGS in 2005 (Hettinger and Roberts, 2005), and one conventional and one continuous assessment unit (AU) were defined at that time. One conventional and four continuous AUs were defined for this assessment of potential hydrocarbon resources in the

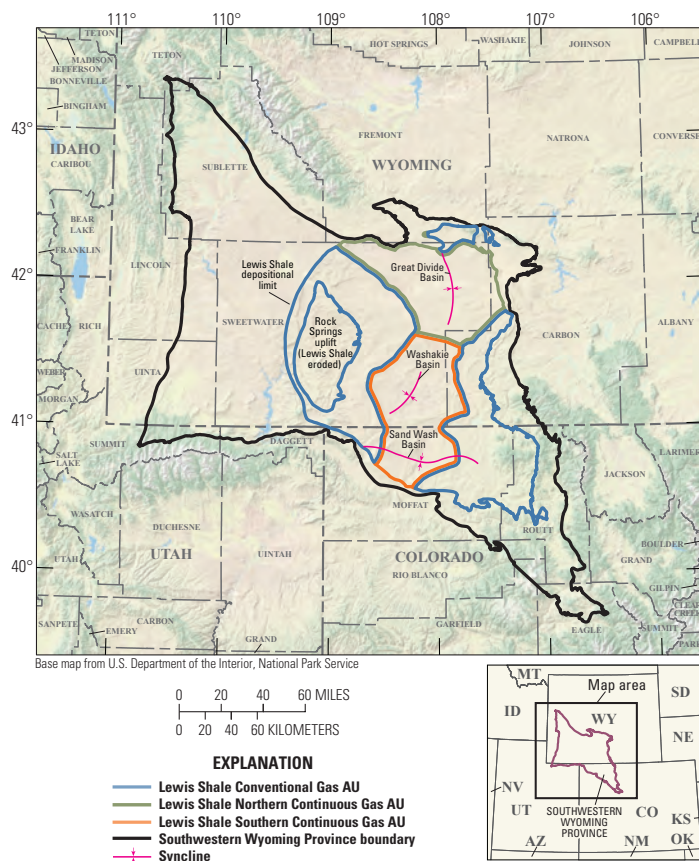


Figure 1. Map showing one conventional and two continuous assessment units (AUs) in the Lewis Shale within the Cretaceous–Cenozoic Composite Total Petroleum System of the Southwestern Wyoming Province.

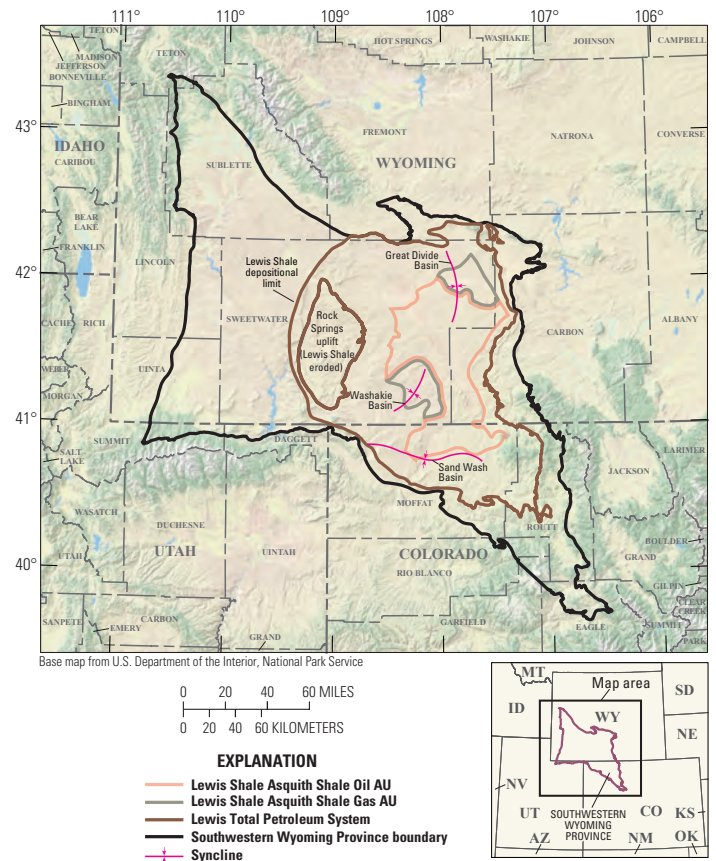


Figure 2. Map showing two continuous assessment units (AUs) for the Asquith marker in the Lewis Shale within the Cretaceous–Cenozoic Composite Total Petroleum System of the Southwestern Wyoming Province.

Lewis Shale (figs. 1–2): a Lewis Shale Conventional Gas AU, a Lewis Shale Northern Continuous Gas AU, a Lewis Shale Southern Continuous Gas AU, a Lewis Shale Asquith Shale Oil AU, and a Lewis Shale Asquith Shale Gas AU. Multiple criteria were used to define these AUs, including spatial and temporal lithologic variability and thickness, reservoir architecture, depositional environment, and thermal maturity.

Geologic Summary

The Lewis Shale comprises nearshore- to deep-marine sandstones, siltstones, and mudstones, and produces abundant natural gas and lesser amounts of oil from low porosity, low permeability clastic reservoirs. The Lewis overlies the marginal marine Almond Formation of the Mesaverde Group and is overlain by the shallow marine Fox Hills Sandstone. Regionally, the Lewis interfingers with both formations and represents time-equivalent, genetically related, marine strata.

The Lewis Shale is subdivided into three members herein, in ascending order (fig. 3): a mudstone-dominated, informal lower member; a sandstone-dominated, formally named, middle Dad Sandstone Member; and a silt- and mudstone-dominated, informal upper member (Gill and others, 1970; Pyles and Slatt, 2000). The top of the lower member is defined by a regionally extensive, high gamma ray zone that is informally known as the Asquith marker (fig. 3; Pasternack, 2005, after Asquith, 1970). The Asquith marker is an organic-rich, black shale that is interpreted as a third-order condensed section marking the maximum flooding surface of the Lewis (McMillen and Winn, 1991; Pyles and Slatt, 2000). This zone is greater than 30 feet (ft) thick in the east-central portion of the TPS (Hearon, 2023a) and total organic carbon content averages 3.2 weight percent. Along with coal beds in the underlying Almond Formation, the Asquith zone is likely a secondary source of hydrocarbons within the Lewis, yet this interval has had limited exploration as a self-sourced, continuous reservoir. For more detailed information on the regional geology of the Lewis Shale, refer to Hearon (2023b).

Total Petroleum System and Assessment Units

The USGS defined one conventional and four continuous AUs within the Cretaceous–Cenozoic Composite TPS (table 1). The outer boundaries of the Lewis Shale Conventional Gas AU are defined by either uplift or depositional pinchout of the Lewis Shale (figs. 1–2). The inner boundaries are defined by the 0.8 percent modeled vitrinite reflectance (R_o) thermal maturity line for gas. An R_o value of 0.8 percent was used to define the AUs because coal beds within the Almond Formation are the likely primary gas source. In general, Lewis fields within the Lewis Shale Conventional Gas AU have normal reservoir pressures, average porosities greater than 10 percent, average permeabilities greater than 0.1 millidarcies, and distinct gas-water contacts. In contrast, the Lewis Shale Northern and Southern Continuous Gas AUs are defined by the area where R_o is greater than 0.8 percent thermal maturity. In general, fields in the continuous AUs have overpressured reservoirs, average porosities less than 10 percent, average permeabilities less than 0.1 millidarcies, and no defined gas-water contacts.

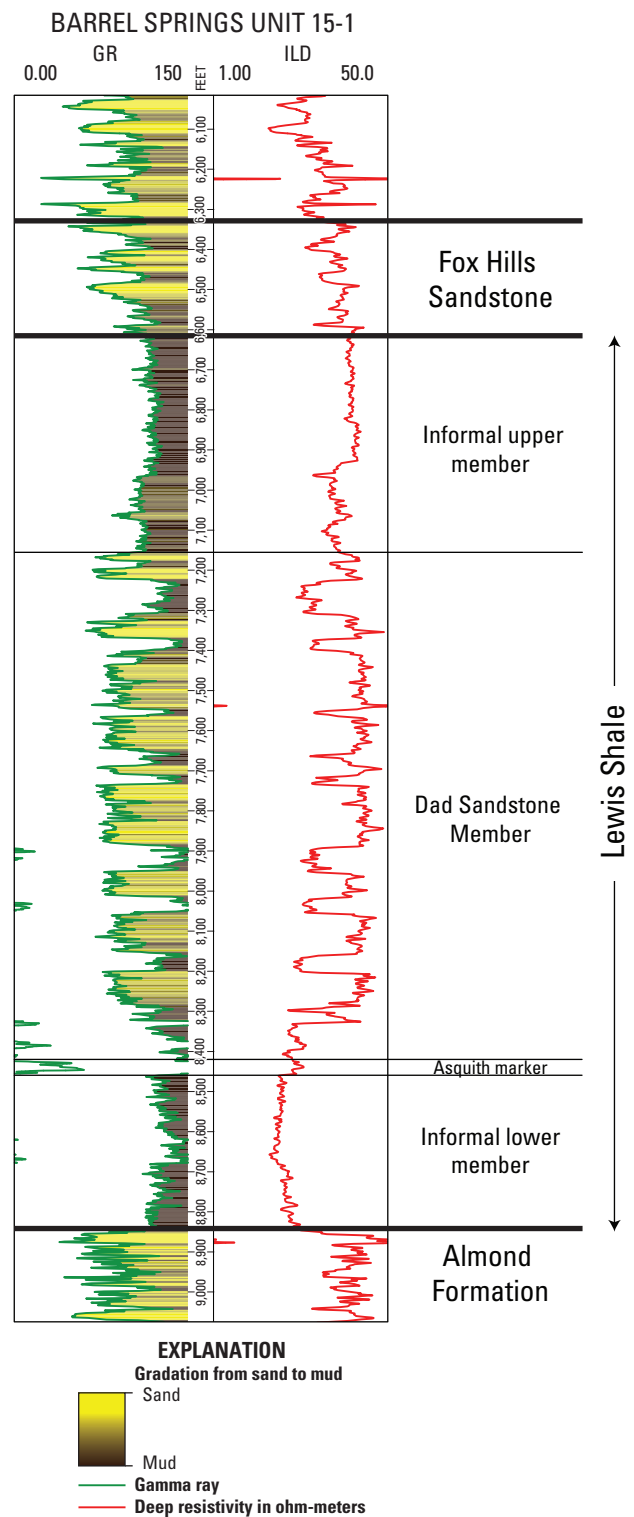


Figure 3. Type log image of the Barrel Spring Unit 15-1 well (S15, T16N, R93W), which highlights the stratigraphy of the Lewis Shale and associated formations. GR, gamma ray in American Petroleum Institute (API) units; ILD, deep resistivity in ohm-meters.

The Lewis Shale Northern and Southern Continuous Gas AUs are delineated in the north and south by uplift, respectively, and in the west and east by the modeled 0.8 percent R_o thermal maturity line for gas. These two

continuous gas AUs are separated by a change in the interpreted depositional environment and architecture of the clastic reservoirs. Specifically, the boundary between these AUs is defined where there is an inferred paleo-shelf break. Sand bodies in the Lewis Shale Northern Continuous Gas AU are relatively smaller (less than 100 ft thick), widely distributed, and are interpreted as shelf, delta front, and (or) prodelta deposits. Conversely, sand bodies in the Lewis Shale Southern Continuous Gas AU are relatively larger (greater than 100 ft thick), are successively stacked on one another, and are interpreted as basin-floor fan deposits. Additionally, the Asquith marker markedly thins toward the boundary between the Lewis Shale Northern and Southern Continuous Gas AUs (Hearon, 2023a). Collectively, these data indicate a distinct change in stratigraphic architecture and depositional environments at this boundary.

The Lewis Shale Asquith Shale Oil AU is defined in the east by the modeled 0.6 percent R_o thermal maturity line for oil, in the south, west, and northwest by a 10-foot thickness minimum, and

in the southwest and north by the 1.3 percent R_o thermal maturity line for gas. The Lewis Shale Asquith Shale Gas AU is split between a northern and southern area, representing locations in the Great Divide Basin and Washakie Basin, respectively. Both areas are bounded by either the 1.3 percent R_o thermal maturity line for gas or by a 10-foot thickness minimum.

Assessment input data are summarized in table 1 and in Hearon (2024). Only two wells within the Cretaceous–Cenozoic Composite TPS have targeted the Asquith marker within the Lewis Shale Asquith Shale Oil AU, and none have targeted the Asquith marker within the Lewis Shale Asquith Shale Gas AU (IHS Markit, 2022). As a result, there were insufficient production data to calculate estimated ultimate recoveries. Because of robust similarities in total organic carbon content, hydrogen index, oxygen index, low carbonate content, age, and location, data from the Mowry Shale in the Powder River Basin were used as analogs for the assessment of continuous resources in the Lewis Shale Asquith Shale Oil and Shale Gas AUs.

Table 1. Key input data for five assessment units in the Lewis Shale, Southwestern Wyoming Province.

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

Assessment input data— Conventional AUs	Lewis Shale Conventional Gas AU							
	Minimum	Mode	Maximum	Calculated mean				
Number of oil fields								
Number of gas fields	1	4	8	4.1				
Size of oil fields (MMBO)								
Size of gas fields (BCFG)	3	6	10	6.1				
AU probability	1.0							
Assessment input data— Continuous AUs	Lewis Shale Northern Continuous Gas AU				Lewis Shale Southern Continuous Gas AU			
	Minimum	Mode	Maximum	Calculated mean	Minimum	Mode	Maximum	Calculated mean
Potential production area (acres)	1,000	950,000	1,506,000	819,000	1,000	785,000	1,542,370	776,123
Average drainage area (acres)	140	160	180	160	140	160	180	160
Success ratio (%)	50	70	90	70	30	60	90	60
Untested area (%)	90	93	95	92.7	97	98	99	98
Average EUR (MMBO, oil; BCFG, gas)	1.5	2	2.5	2.017	0.8	1	1.2	1.007
AU probability	1.0				1.0			
Assessment input data— Continuous AUs	Lewis Shale Asquith Shale Oil AU				Lewis Shale Asquith Shale Gas AU			
	Minimum	Mode	Maximum	Calculated mean	Minimum	Mode	Maximum	Calculated mean
Potential production area (acres)	1,000	771,000	1,709,000	827,000	1,000	92,833	444,487	179,440
Average drainage area (acres)	100	120	140	120	100	120	140	120
Success ratio (%)	30	60	90	60	30	60	90	60
Untested area (%)	100	100	100	100	100	100	100	100
Average EUR (MMBO, oil; BCFG, gas)	0.05	0.07	0.1	0.071	0.7	0.8	0.9	0.803
AU probability	1.0				1.0			

Undiscovered Resources Summary

The USGS quantitatively assessed oil and gas resources in one conventional and four continuous AUs in the Lewis Shale in the Southwestern Wyoming Province (table 2). The fully risked,

estimated mean totals are 294 million barrels of oil (MMBO) with an F95–F5 fracture range from 83 to 556 MMBO; 11,207 billion cubic feet of gas (BCFG) with an F95–F5 range from 3,444 to 19,705 BCFG; and 338 million barrels of natural gas liquids (MMBNGL) with an F95–F5 range from 103 to 591 MMBNGL.

Table 2. Results for five assessment units of the Lewis Shale, Southwestern Wyoming Province.

[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. 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
Cretaceous–Cenozoic Composite Total Petroleum System														
Lewis Shale Conventional Gas AU	1.0	Oil												
		Gas					17	25	36	25	1	1	1	1
Total undiscovered conventional resources							17	25	36	25	1	1	1	1
Lewis Shale Northern Continuous Gas AU	1.0	Oil												
		Gas					2,143	6,737	11,144	6,691	64	202	334	201
Lewis Shale Southern Continuous Gas AU	1.0	Oil												
		Gas					870	2777	5,285	2,885	26	83	159	87
Lewis Shale Asquith Shale Oil AU	1.0	Oil	83	280	556	294	243	829	1,710	884	7	25	51	27
		Gas												
Lewis Shale Asquith Shale Gas AU	1.0	Oil												
		Gas					171	644	1,530	722	5	19	46	22
Total undiscovered continuous resources			83	280	556	294	3,427	10,987	19,669	11,182	102	329	590	337
Total undiscovered resources			83	280	556	294	3,444	11,012	19,705	11,207	103	330	591	338

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For More Information

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

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