USGS
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National and Global Petroleum Assessment

Assessment of Undiscovered Oil and Gas Resources in the Midlands Area, England, 2018

Using a geology-based assessment methodology, the U.S. Geological Survey estimated mean undiscovered, technically recoverable resources of 319 million barrels of oil and 8.3 trillion cubic feet of gas in the Midlands area of England.

Introduction

The U.S. Geological Survey (USGS) completed an assessment of undiscovered, technically recoverable continuous (unconventional) and conventional oil and gas resources in the Midlands area of England (figs. 1 and 2). The Midlands is a structurally complex area as a result of several regional tectonic events (Fraser and Gawthorpe, 1990; Corfield and others, 1996). Extension in the Late Devonian to Carboniferous led to deposition of synrift organic-rich shales of the lower part of the Bowland Shale Formation and Hodder Mudstone Formation within several grabens. Postrift regional thermal subsidence led to the deposition of organic-rich shales in the upper part of the Bowland Formation and fluvial-deltaic sandstones of the Millstone Grit Group. Shales in the upper and lower parts of the Bowland and in the Hodder represent the most viable petroleum source rocks in the Midlands (Gross and others, 2015; Raji and others, 2015; Yang and others, 2016; Fauchille and others, 2017; Hennissen and others, 2017; Whitelaw and others, 2017). Regional, north-directed compression in the late Carboniferous and Early Permian caused many of the extensional structures to be uplifted and inverted. Extension and subsidence in the Late Permian through Jurassic resulted in the deposition of several kilometers of sediment, which led to thermally mature organic matter in shales of the Bowland and Hodder Formations and to the generation and migration of oil and gas. Up to 4 kilometers of uplift and erosion in the Paleogene (Anell and others, 2009) may have resulted in the breaching of conventional traps and the loss of oil and gas resources from conventional and continuous reservoirs. This uplift and possible loss of oil and gas is the major source of geologic uncertainty in the assessment of conventional and continuous oil and gas resources in the Midlands area.

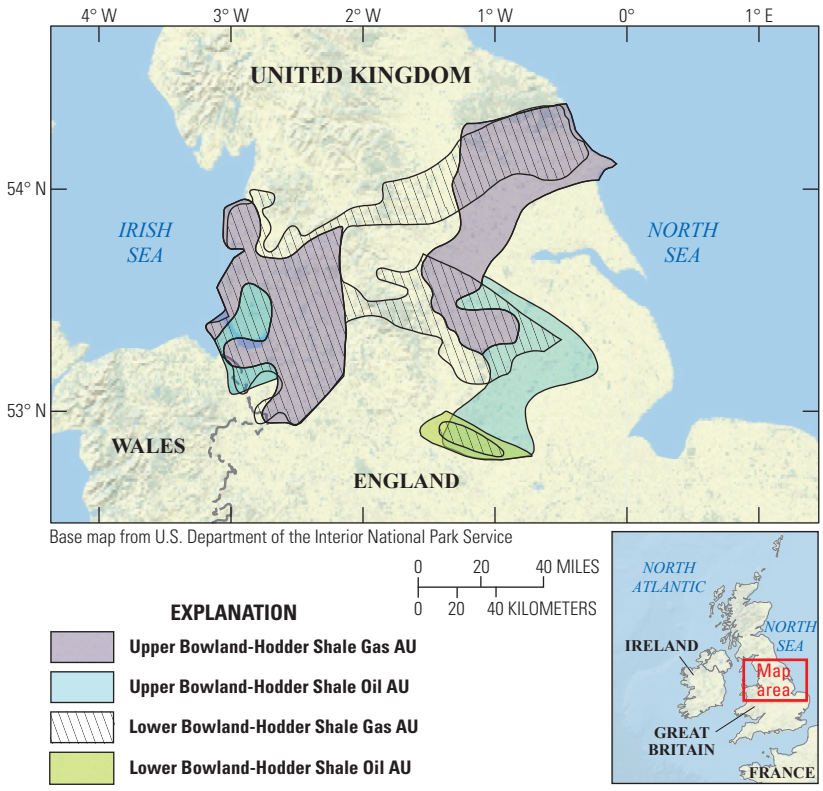

Figure 1. Location of four assessment units (AUs) in the Midlands area of England.

Total Petroleum Systems and Assessment Units

In the Midlands area, the USGS defined the Bowland-Hodder Total Petroleum System (TPS), the Carboniferous TPS, and the Carboniferous Coal TPS. The Bowland-Hodder TPS encompasses oil or gas retained within shales of the Bowland and Hodder Formations in the (1) Upper Bowland-Hodder Shale Gas Assessment Unit (AU), (2) Upper Bowland-Hodder Shale Oil AU, (3) Lower Bowland-Hodder Shale Gas AU, and (4) Lower Bowland-Hodder Shale Oil AU. Boundaries of potential shale-gas areas are modified from Andrews (2013). Shales in the lower part of the Bowland are as much as 3,000 meters (m) thick and contain both Type II and Type III kerogen. Shales in the upper part of the Bowland are as much as 900 m thick and contain predominantly Type II kerogen. Thermal maturity ranges upward to gas-generation levels in both shales (greater than 1.3 percent vitrinite reflectance), so present-day values of total organic carbon and hydrogen index are variable as these values are affected by maturation. The geologic model for potential shale-oil and shale-gas resources in the Bowland–Hodder TPS is for some portion of the oil or gas to have been retained within shales of the Bowland and Hodder Formations following Paleogene uplift and erosion.

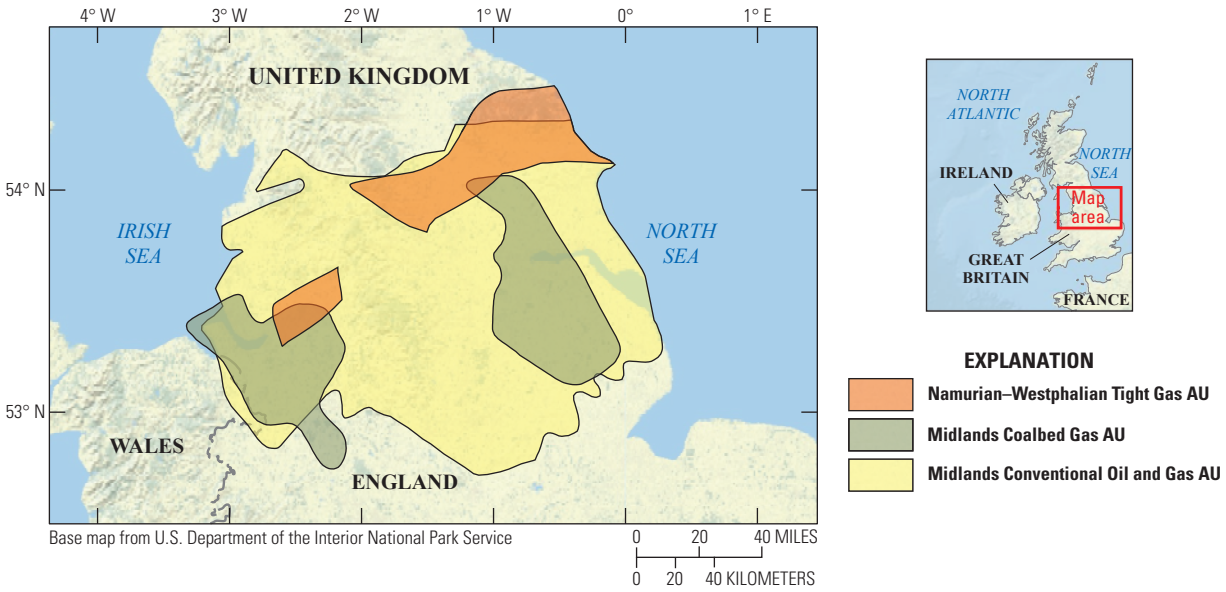

Figure 2. Location of three assessment units (AUs) in the Midlands area of England.

Table 1. Key input data for seven assessment units in the Midlands area of England.

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

Assessment input data—Continuous AUs	Upper Bowland-Hodder Shale Gas AU				Upper Bowland-Hodder Shale Oil AU			
	Minimum	Mode	Maximum	Calculated mean	Minimum	Mode	Maximum	Calculated mean
Potential production area of AU (acres)	560	1,125,500	2,251,000	1,125,687	560	1,007,000	2,000,000	1,002,520
Average drainage area of wells (acres)	100	140	180	140	80	140	200	140
Success ratio (%)	10	50	90	50	10	50	90	50
Average EUR (BCFG, gas; MMBO, oil)	0.1	0.4	1.3	0.447	0.04	0.08	0.2	0.086
AU probability	1.0				0.9			
Assessment input data—Continuous AUs	**Lower Bowland-Hodder Shale Gas AU**				**Lower Bowland-Hodder Shale Oil AU**			
	Minimum	Mode	Maximum	Calculated mean	Minimum	Mode	Maximum	Calculated mean
Potential production area of AU (acres)	600	1,470,500	2,941,000	1,470,700	500	101,000	300,000	133,833
Average drainage area of wells (acres)	60	120	180	120	60	80	140	93.3
Success ratio (%)	10	50	90	50	10	50	90	50
Average EUR (BCFG, gas; MMBO, oil)	0.1	0.4	1.3	0.447	0.01	0.04	0.15	0.046
AU probability	0.9				0.9			
Assessment input data—Continuous AUs	**Namurian–Westphalian Tight Gas AU**				**Midlands Coalbed Gas AU**			
	Minimum	Mode	Maximum	Calculated mean	Minimum	Mode	Maximum	Calculated mean
Potential production area of AU (acres)	480	800,000	1,206,000	668,827	400	950,000	1,908,000	952,800
Average drainage area of wells (acres)	40	80	120	80	40	80	120	80
Success ratio (%)	10	50	90	50	10	50	90	50
Average EUR (BCFG)	0.08	0.4	1.2	0.44	0.08	0.25	1.0	0.29
AU probability	1.0				1.0			

Assessment input data—Conventional AU	Midlands Conventional Oil and Gas AU			
	Minimum	Median	Maximum	Calculated mean
Number of oil fields	1	5	15	5.3
Number of gas fields	1	20	60	21.3
Size of oil fields (MMBO)	0.5	1.5	20	2.1
Size of gas fields (BCFG)	3	9	80	11.3
AU probability	1.0			

The Carboniferous TPS is defined by oil and gas sourced from shales of the Bowland and Hodder Formations and possibly from coals of Westphalian age. Within this TPS are the Namurian–Westphalian Tight Gas AU and Midlands Conventional Oil and Gas AU. The geologic model for conventional accumulations in this AU is for oil and gas to have migrated into inversion structures that contain possible clastic and carbonate reservoirs. The geologic model for the continuous Namurian–Westphalian Tight Gas AU is for gas, generated from organic matter in shales of the Bowland and Hodder Formations and possibly from the Westphalian coals, to have migrated locally into and to have been trapped within low permeability, nonmarine to shallow-marine sandstones and siltstones of Namurian and Westphalian age. The AU area encompasses the Carboniferous Cleveland and Cheshire subbasins.

The Carboniferous Coal TPS is defined to encompass potential coalbed gas resources within Westphalian coals in two main areas of the Midlands, as mapped by the Department of Energy and Climate Change, United Kingdom (2013). In unmined areas, net coal thickness is as much as 40 m, and coal rank is variable but ranges upward to anthracite. The Midlands Coalbed Gas AU does not include areas of current coal mines, mined areas, or areas that produce coal-mine gas.

Assessment input data for seven assessment units are shown in table 1. For continuous assessment units, well drainage areas, success ratios, and estimated ultimate recoveries are guided by geologic analogs from the United States.

Undiscovered Resources Summary

The USGS quantitatively assessed undiscovered continuous and conventional oil and gas resources within the Midlands area of England (table 2). For undiscovered resources, the estimated mean totals are 319 million barrels of oil (MMBO), with an F95–F5 range from 4 to 753 MMBO; 8,254 billion cubic feet of gas (BCFG), or 8.3 trillion cubic feet of gas, with an F95–F5 range from 1,235 to 19,696 BCFG; and 54 million barrels of natural gas liquids (MMBNGL) with an F95–F5 range from 6 to 133 MMBNGL. Of the total mean oil resources of 319 MMBO, about 97 percent, or 308 MMBO, is potential shale-oil resources; and of the mean total gas resources of 8,254 BCFG, about 97 percent, or 8,006 BCFG, are shale gas (54 percent), tight gas (22 percent), and coalbed gas (21 percent) resources.

Table 2. Results for seven assessment units in the Midlands area of England.

[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 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 systems 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
Bowland-Hodder Total Petroleum System														
Upper Bowland-Hodder Shale Gas AU	1.0	Gas					368	1,486	4,209	1,779	3	12	35	14
Upper Bowland-Hodder Shale Oil AU	0.9	Oil	0	250	653	279	0	148	400	167	0	0	1	1
Lower Bowland-Hodder Shale Gas AU	0.9	Gas					0	2,076	6,252	2,465	0	25	76	30
Lower Bowland-Hodder Shale Oil AU	0.9	Oil	0	23	78	29	0	14	48	17	0	0	0	0
Carboniferous Total Petroleum System														
Namurian–Westphalian Tight Gas AU	1.0	Gas					403	1,590	4,179	1,850	2	6	17	7
Carboniferous Coal Total Petroleum System														
Midlands Coalbed Gas AU	1.0	Gas					343	1,411	4,179	1,728	0	0	0	0
Total undiscovered continuous resources			**0**	**273**	**731**	**308**	**1,114**	**6,725**	**19,267**	**8,006**	**5**	**43**	**129**	**52**
Carboniferous Total Petroleum System														
Midlands Conventional Oil and Gas AU	1.0	Oil	4	10	22	11	3	6	13	7	0	0	0	0
		Gas					118	226	416	241	1	2	4	2
Total undiscovered conventional resources			**4**	**10**	**22**	**11**	**121**	**232**	**429**	**248**	**1**	**2**	**4**	**2**
Total undiscovered resources			**4**	**283**	**753**	**319**	**1,235**	**6,957**	**19,696**	**8,254**	**6**	**45**	**133**	**54**

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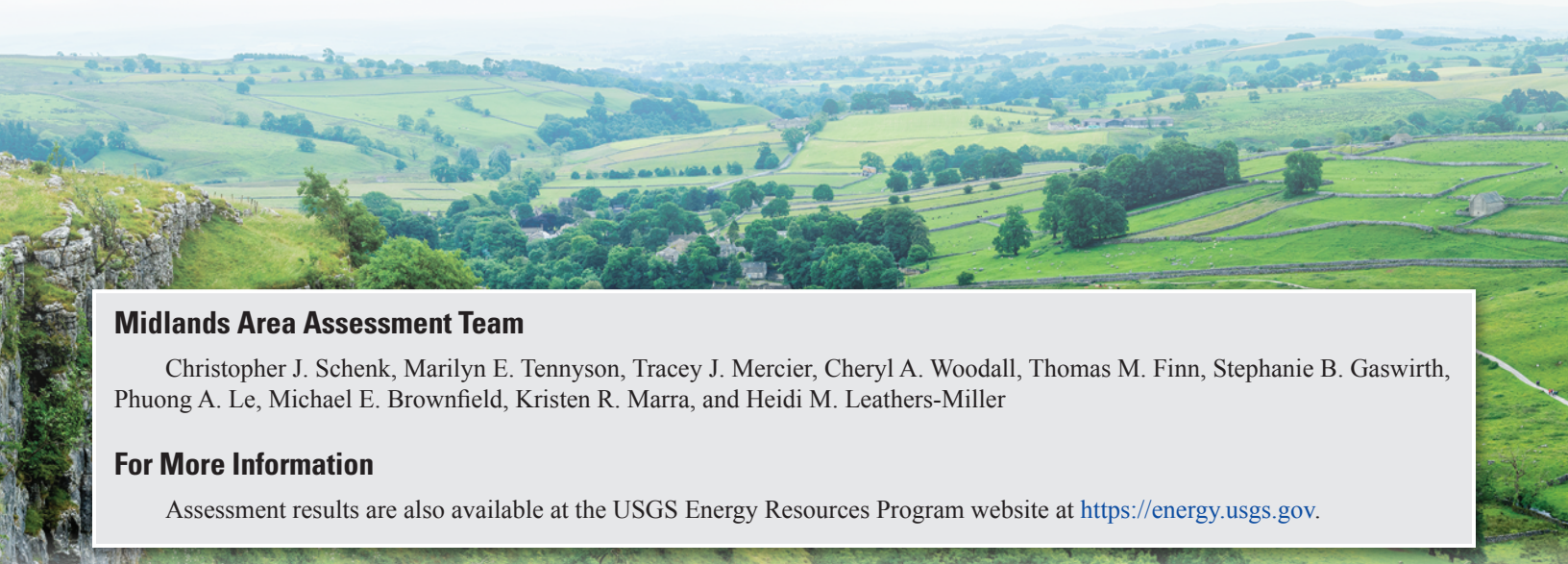

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For More Information

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

Image within the Midlands area. Photograph by Tony Hill, accessed June 22, 2018, at https://pixabay.com/en/malham-cove-yorkshire-pano-panorama-2451405/.

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