

## National and Global Petroleum Assessment

# Assessment of Undiscovered Conventional Oil and Gas Resources in Paleozoic Total Petroleum Systems of the Central European Basin System, 2019

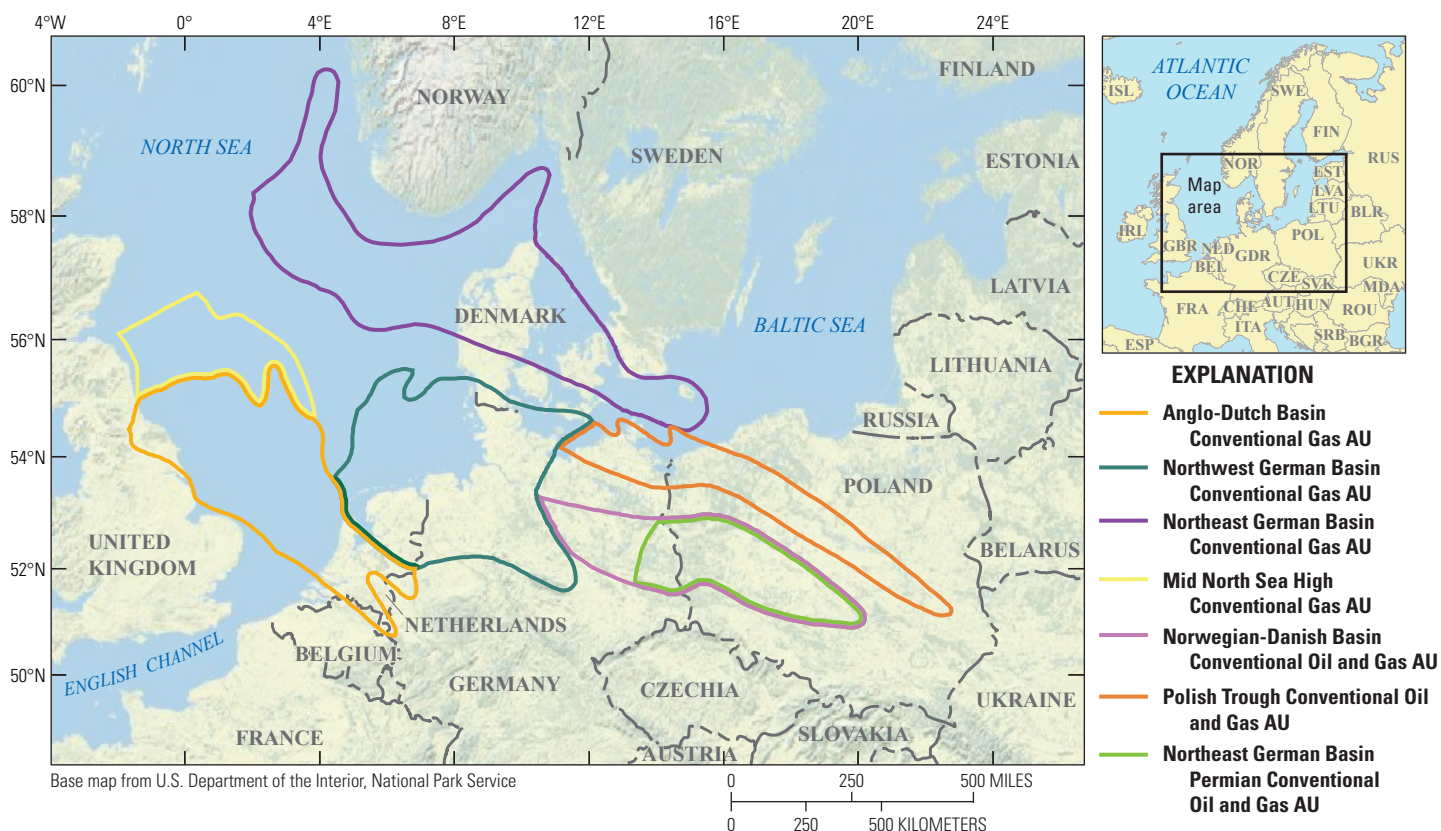
Using a geology-based assessment methodology, the U.S. Geological Survey estimated undiscovered, technically recoverable mean resources of 278 million barrels of oil and 25.7 trillion cubic feet of gas in Paleozoic total petroleum systems of the Central European Basin System.

## Introduction

The U.S. Geological Survey (USGS) quantitatively assessed the potential for undiscovered, technically recoverable conventional oil and gas resources in Paleozoic total petroleum systems (TPSS) in the Central European Basin System (CEBS), which spans east–west from Poland to the United Kingdom and north–south from Scandinavia to Germany (Maystrenko and others, 2012). The CEBS encompasses superimposed basins with various areal extents and origins resulting from complex deformation that began during the Devonian (Glennie, 1986; Maynard and others, 1997; Van Wees and others, 2000; McCann and

others, 2006; Hübscher and others, 2010; Pharaoh and others, 2010). Important to this study are the Carboniferous-sourced gas and minor oil in the Anglo-Dutch Basin, Northwest German Basin, Northeast German Basin, and Mid North Sea High; as well as the Paleozoic-sourced oil and gas in the Norwegian-Danish Basin and Polish Trough, and the Permian-sourced oil and gas in the Northeast German Basin (Gerard and others, 1993; Pedersen and others, 2006; Schwarzer and Littke, 2007) (fig. 1).

Intensive exploration over the past 70 years has resulted in the discovery of more than 250 trillion of cubic feet of gas sourced from the Carboniferous TPS, whereas volumes of discovered oil (about 1 billion barrels) are minor in comparison to gas. The



**Figure 1.** Map showing seven conventional assessment units (AUs) defined within Paleozoic total petroleum systems of the Central European Basin System.

purpose of this study was to assess the potential for remaining undiscovered conventional oil and gas resources in Paleozoic TPSs in the CEBS given what is known of conventional oil and gas trapping configurations (fig. 2).

## Total Petroleum Systems and Assessment Units

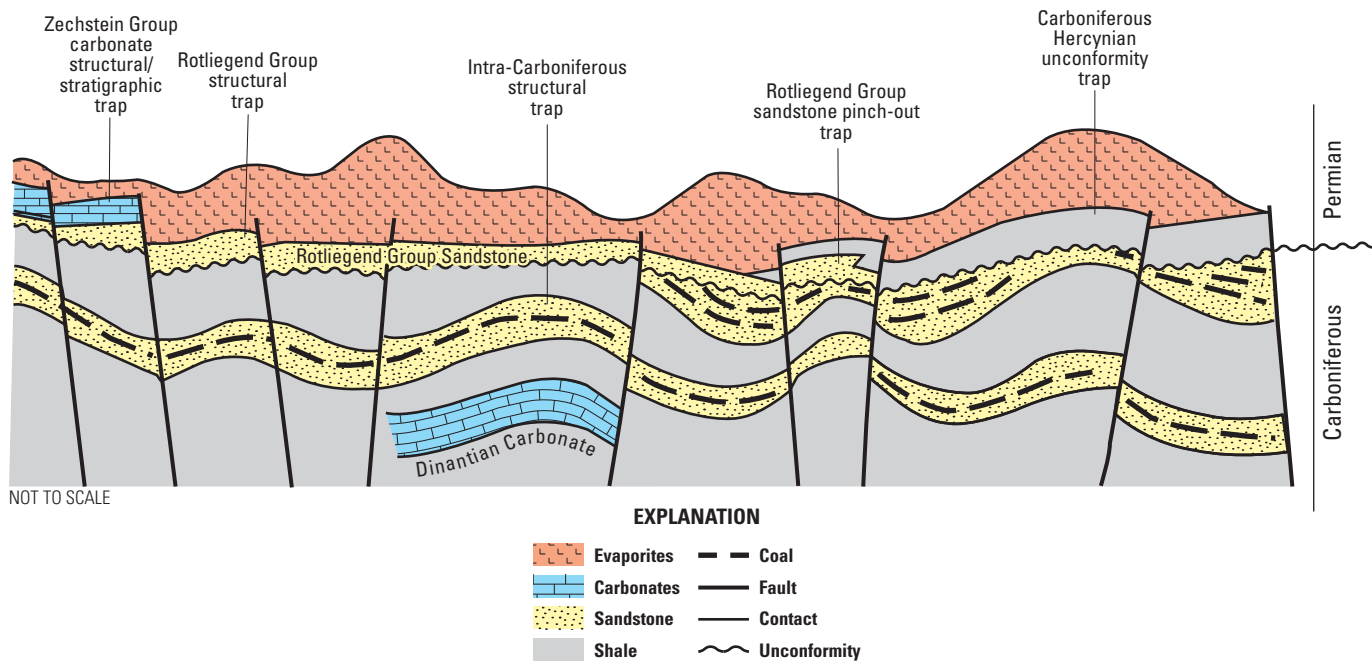
The Permian TPS was defined to encompass oil and gas generated mainly from the Permian Kupferschiefer Shale and equivalent organic-rich shales within the Northeast German Basin Permian Conventional Oil and Gas AU (Gerard and others, 1993; Pedersen and others, 2006).

The USGS defined a Carboniferous TPS and four assessment units (AU) within this system (table 1): Anglo-Dutch Basin Conventional Gas AU, Northwest German Basin Conventional Gas AU, Northeast German Basin Conventional Gas AU, and the Mid North Sea High Conventional Gas AU. The primary source rocks for this petroleum system are coals of Westphalian age (or older Carboniferous coals for the Mid North Sea High AU; Kombrink and others, 2010; Monaghan and others, 2017; Booth and others, 2018). The geologic model for the Carboniferous TPS is for gas generated from coals to have migrated into fluvial-deltaic sandstones of the Carboniferous, eolian sandstones of the Permian Rotliegend Group, and carbonate reservoirs of the Permian Zechstein Group, mainly within salt-influenced structural traps that have been sealed by evaporites (Glennie and Provan, 1990; Maystrenko and others, 2012; Harding and Huuse, 2015).

The Paleozoic Composite TPS was defined to encompass gas generated from the organic-rich Cambrian–Lower Ordovician Alum Shale (Pletsch and others, 2010; Gautier and others, 2013) and gas trapped within lower Paleozoic reservoirs and structures in the Norwegian-Danish Basin Conventional Oil and Gas AU (Gerard and others, 1993; Pedersen and others, 2006). This TPS was also defined to include oil and gas generated from Paleozoic source rocks within the Polish Trough Conventional Oil and Gas AU. Preservation of oil and gas may be an issue in the Polish Trough Conventional Oil and Gas AU given the history of uplift and erosion. Assessment input data are summarized in table 1 and in Schenk (2022).

## Undiscovered Resources Summary

The USGS quantitatively assessed undiscovered conventional oil and gas resources in seven AUs (table 2). For undiscovered, technically recoverable conventional oil and gas resources, the mean totals are 278 million barrels of oil (MMBO) with an F95–F5 fractile range from 173 to 410 MMBO; 25,692 billion cubic feet of gas (BCFG), or 25.7 trillion cubic feet of gas, with an F95–F5 fractile range from 15,158 to 40,027 BCFG; and 227 million barrels of natural gas liquids (MMBNGL), with an F95–F5 fractile range from 122 to 381 MMBNGL. Approximately 70 percent of the undiscovered conventional gas resources is estimated to be in the Carboniferous TPS.



**Figure 2.** Five conceptual traps for Carboniferous and Permian reservoirs (modified from Gérard and others, 1993).

**Table 1.** Key input data for seven conventional assessment units in Paleozoic total petroleum systems of the Central European Basin System.

[Gray shading indicates not applicable. AU, assessment unit; MMBO, million barrels of oil; BCFG, billion cubic feet of gas]

Assessment input data— Conventional AUs	Northeast German Basin Permian Conventional Oil and Gas AU							
	Minimum	Median	Maximum	Calculated mean				
Number of oil fields	1	70	150	72.1				
Number of gas fields	1	140	250	142.4				
Size of oil fields (MMBO)	1	2	20	2.6				
Size of gas fields (BCFG)	6	12	60	13.7				
AU probability	1.0							
Assessment input data— Conventional AUs	Anglo-Dutch Basin Conventional Gas AU				Northwest German Basin Conventional Gas AU			
	Minimum	Median	Maximum	Calculated mean	Minimum	Median	Maximum	Calculated mean
Number of gas fields	1	240	480	245.9	1	200	400	204.9
Size of gas fields (BCFG)	6	24	300	32.7	6	18	300	26.1
AU probability	1.0				1.0			
Assessment input data— Conventional AUs	Northeast German Basin Conventional Gas AU				Mid North Sea High Conventional Gas AU			
	Minimum	Median	Maximum	Calculated mean	Minimum	Median	Maximum	Calculated mean
Number of gas fields	1	100	200	102.4	1	40	120	42.5
Size of gas fields (BCFG)	6	12	80	14.3	30	60	1,000	85.1
AU probability	1.0				1.0			
Assessment input data— Conventional AUs	Norwegian-Danish Basin Conventional Oil and Gas AU				Polish Trough Conventional Oil and Gas AU			
	Minimum	Median	Maximum	Calculated mean	Minimum	Median	Maximum	Calculated mean
Number of oil fields	1	10	20	10.3	1	2	4	2.1
Number of gas fields	1	40	120	42.5	1	3	6	3.1
Size of oil fields (MMBO)	5	8	30	8.8	1	2	10	2.3
Size of gas fields (BCFG)	30	48	5,000	114.6	6	12	40	13.0
AU probability	1.0				0.9			

**Table 2.** Results for seven conventional assessment units in Paleozoic total petroleum systems of the Central European Basin System.

[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 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
Permian Total Petroleum System														
Northeast German Basin Permian Conventional Oil and Gas AU	1.0	Oil	116	179	272	184	173	268	409	276	3	5	7	5
		Gas					1,393	1,912	2,610	1,944	28	38	53	39
Carboniferous Total Petroleum System														
Anglo-Dutch Basin Conventional Gas AU	1.0	Gas					5,358	7,852	11,424	8,052	32	47	70	48
Northwest German Basin Conventional Gas AU	1.0	Gas					3,548	5,222	7,593	5,351	10	16	24	16
Northeast German Basin Conventional Gas AU	1.0	Gas					974	1,427	2,075	1,462	4	6	8	6
Mid North Sea High Conventional Gas AU	1.0	Gas					1,784	3,389	6,199	3,613	7	14	25	14
Paleozoic Composite Total Petroleum System														
Norwegian-Danish Basin Conventional Oil and Gas AU	1.0	Oil	57	88	130	90	35	52	79	54	0	1	1	1
		Gas					1,893	4,411	9,565	4,898	38	88	192	98
Polish Trough Conventional Oil and Gas AU	0.9	Oil	0	4	8	4	0	6	12	6	0	0	0	0
		Gas					0	37	61	36	0	0	1	0
Total undiscovered conventional resources			173	271	410	278	15,158	24,576	40,027	25,692	122	215	381	227

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## For More Information

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

## Central European Basin System Assessment Team

Christopher J. Schenk, Tracey J. Mercier, Cheryl A. Woodall, Heidi M. Leathers-Miller, Phuong A. Le, Ronald M. Drake II, and Michael E. Brownfield