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National and Global Petroleum Assessment

Assessment of Undiscovered Conventional Oil and Gas Resources of the Black Sea Area, 2023

Using a geology-based assessment methodology, the U.S. Geological Survey estimated undiscovered, technically recoverable mean resources of 2.3 billion barrels of oil and 105.5 trillion cubic feet of gas in the Black Sea area.

Introduction

The U.S. Geological Survey (USGS) assessed the potential for undiscovered, technically recoverable conventional oil and gas resources of the Black Sea area (fig. 1). The tectonic evolution of the present configuration of the Black Sea area began in the Triassic as the Neotethys oceanic slab subducted northwards under the continental crust of southern Eurasia. In the Late Jurassic, the oceanic slab began to roll back, possibly in response to the blocking effect brought about by the subduction of a thermally buoyant oceanic spreading center (Sosson and others, 2016). Asymmetric slab rollback during the Early Cretaceous, from the Barremian to Albian, and possibly later, resulted in complex oblique extension in the back-arc region of the Pontides volcanic arc (Hippolyte and others, 2018). The Western Black Sea Basin and the Karkinit Trough opened as the Western Pontides rifted to the southeast from the Moesian Platform (Robinson and others, 1996; Yegorova and others, 2013; Sosson and others, 2016). The Eastern Black Sea Basin opened as the Andrusov and Arkhangelsky ridges rifted and rotated clockwise from the Shatsky Ridge (Sosson and others, 2016; Boote, 2018; Hippolyte and others, 2018; Tari and Simmons, 2018). Rifting in both basins fragmented Upper Jurassic to Lower Cretaceous passive margin carbonate platforms. In the Late Cretaceous, from Coniacian to Santonian rifting may have formed hyperextended continental crust and later oceanic crust in parts of each basin (Yegorova and others, 2013; Nikishin and others, 2015a; Hippolyte and others, 2018). From the Late Cretaceous to the Eocene, the Western and Eastern Black Sea Basins accumulated several kilometers of clastic sediment (Tari and Simmons, 2018). In the Eocene, the Neotethys began to close, resulting in anoxic conditions and deposition of organic-rich mudstones of the Eocene Kuma Suite within the basins (Nikishin and others, 2015b; Boote, 2018; Vincent and Kaye, 2018). Renewed sedimentation from the late Eocene to the present included deposition of organic-rich mudstones of the Oligocene to Miocene Maykop Formation (Tari and Simmons, 2018). Subsequent burial resulted in the thermal maturation of most source rocks into the oil and gas thermal generation windows (Robinson and others, 1996; Mayer and others, 2018; Olaru and others, 2018). At present day most source rocks in the Western Black Sea and Eastern Black Sea Basins are within the thermal gas window (Olaru and others, 2018). From the Late Cretaceous (Coniacian) to the present, numerous base-level changes resulted in sediment bypassing the Black Sea shelves, leading to extensive sand deposition in shelf-edge delta, slope-channel, and basin-floor fan environments (Yegorova and others, 2013; Nikishin and others, 2015a). Sandstones in these depositional settings are considered the main reservoirs for this assessment. Final closure of the Neotethys in the Neogene resulted in the inversion of many extensional structures along the basin margins and ridges (Robinson and others, 1996; Nikishin and others, 2015b; Sosson and others, 2016; Hippolyte and others, 2018; Rees and others, 2018). Within the basins, most rift-related structures were not inverted and form structural and combination traps for hydrocarbons. This tectonic and petroleum-system summary, while generally accepted, could benefit from further research to constrain the timing of tectonic events, formation and extent of oceanic crust, and major extensional events within the greater Black Sea area (Simmons and others, 2018).

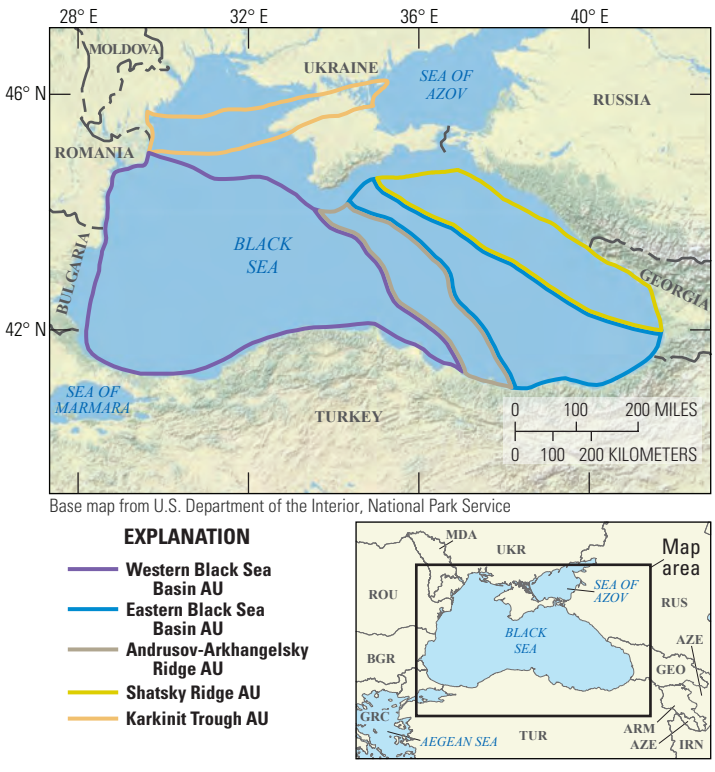

Figure 1. Maps showing location of five conventional assessment units (AUs) in the Black Sea area.

Total Petroleum System and Assessment Units

The Mesozoic–Cenozoic Composite Total Petroleum System (TPS) was defined to encompass several known or postulated petroleum source rocks. The most important source rocks within this composite TPS are organic-rich mudstones of the Eocene Kuma Formation and mudstones of the Oligocene–lower Miocene Maykop Formation. Mudstones of the Kuma Formation have total organic carbon (TOC) values as high as 12 weight percent, hydrogen index (HI) values as high as 600 milligrams of hydrocarbon per gram of TOC (mg HC/g TOC), and thicknesses of as much as 30 meters (m) (Nikishin and others, 2017; Sachsenhofer and others, 2018; Vincent and Kaye, 2018). Mudstones of the Maykop Formation have TOC values as much as 10 weight percent, HI values as much as 500 mg HC/g TOC, and thicknesses of as much as 200 m (Mayer and others, 2018; Olaru and others, 2018; Sachsenhofer and others, 2018; Vincent and Kaye, 2018). Both source rocks are interpreted to have generated thermogenic gas in the Black Sea Basins. Biogenic gas, possibly sourced from Pleistocene to Holocene organic matter, is present in several offshore Romanian fields (Olaru and others, 2018; Sachsenhofer and others, 2018). Other potential source rocks include Upper Jurassic, Cretaceous, and Eocene organic-rich marls deposited in anoxic basins adjacent to carbonate platforms (Nikishin and others, 2017). Although these marls may be significant sources of thermogenic gas in reservoirs within the deep basins and in carbonate reservoirs along the flanks of the ridges (Olaru and others, 2018; Tari and Simmons, 2018), geochemical data are not available to adequately characterize their source potential (Olaru and others, 2018). Organic-rich Miocene diatomite may be another potential petroleum source rock (Sachsenhofer and others, 2018).

The Western Black Sea Basin Assessment Unit (AU), Eastern Black Sea Basin AU, Andrusov-Arkhangelsky Ridge AU, Shatsky Ridge AU, and Karkinit Trough AU were defined within the Mesozoic–Cenozoic Composite TPS (fig. 1). The assessment input data for five conventional AUs are summarized in table 1 and in Schenk (2024). Reservoirs in the Black Sea Basins and Karkinit Trough are pre-rift carbonate platform margin reefs, dolomites, and karst zones; synrift fluvial-deltaic to marine shelf sandstones; and post-rift slope-channel to basin-floor fan sandstones resulting from sediment bypassing during base-level changes (Boote, 2018). Reservoirs within the Andrusov-Arkhangelsky Ridge AU and Shatsky Ridge AU are deep-marine sandstones onlapping ridge flanks, marine sandstones draping the carbonate horst blocks along the ridges, and pre- and post-rift carbonate platform-margin reservoirs (Robinson and others, 1996; Nikishin and others, 2015a).

Table 1. Key input data for five conventional oil and gas assessment units in the Black Sea area.

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

Assessment input data—Conventional AUs	Western Black Sea Basin AU				Eastern Black Sea Basin AU			
	Minimum	Median	Maximum	Calculated mean	Minimum	Median	Maximum	Calculated mean
Number of oil fields	1	20	80	22.1	1	10	40	11.0
Number of gas fields	1	70	280	77.2	1	30	120	33.1
Size of oil fields (MMBO)	5	8	6,000	50.5	5	8	2,000	28.0
Size of gas fields (BCFG)	30	48	160,000	793.8	30	48	160,000	793.8
AU probability	1.0				1.0			
Assessment input data—Conventional AUs	**Andrusov-Arkhangelsky Ridge AU**				**Shatsky Ridge AU**			
	Minimum	Median	Maximum	Calculated mean	Minimum	Median	Maximum	Calculated mean
Number of oil fields	1	10	40	11.0	1	20	60	21.3
Number of gas fields	1	10	40	11.0	1	20	60	21.3
Size of oil fields (MMBO)	5	8	2,000	28.0	5	8	2,000	28.0
Size of gas fields (BCFG)	30	48	40,000	322.5	30	48	40,000	322.5
AU probability	1.0				1.0			
Assessment input data—Conventional AUs	**Karkinit Trough AU**							
	Minimum	Median	Maximum	Calculated mean				
Number of oil fields	1	2	6	2.1				
Number of gas fields	1	8	24	8.5				
Size of oil fields (MMBO)	5	8	20	8.4				
Size of gas fields (BCFG)	30	48	40,000	322.5				
AU probability	1.0							

Reservoir quality of some sandstones may be inadequate to form an oil and gas accumulation (Olaru and others, 2018; Rees and others, 2018; Tari and Simmons, 2018). Traps in the Western Black Sea Basin AU, Eastern Black Sea Basin AU, and Karkinit Trough AU are pre-rift and syn-rift faults, sandstone drapes over extensional structures, combination and stratigraphic traps associated with shelf-edge deltas, and slope-channel and basin-floor sandstones encased in mudstones. Traps in the Andrusov-Arkhangelsky Ridge AU and Shatsky Ridge AU are stratigraphic traps along carbonate platform margins, karst zones along unconformities, sandstone drapes over horst blocks, and sandstone pinch-outs along ridge flanks, and anticlines and folds within inverted structures. Most seals within this total petroleum system are intraformational mudstones.

Undiscovered Resources Summary

The USGS quantitatively assessed undiscovered conventional oil and gas resources in five AUs in the Black Sea area (table 2). The total estimated mean resources are 2,349 million barrels of oil (MMBO), or 2.3 billion barrels, with an F95–F5 range from 427 to 7,036 MMBO; 105,525 billion cubic feet of gas (BCFG), or 105.5 trillion cubic feet, with an F95–F5 range from 14,100 to 328,685 BCFG; and 2,172 million barrels of natural gas liquids (MMBNGL), or 2.2 billion barrels, with an F95–F5 range from 288 to 6,806 MMBNGL. The ranges of estimated undiscovered resources reflect the geologic uncertainty in the elements of the composite petroleum system of the Black Sea area, particularly in the deep basins.

Table 2. Results for five conventional oil and gas assessment units in the Black Sea area.

[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
Mesozoic–Cenozoic Composite Total Petroleum System														
Western Black Sea Basin AU	1.0	Oil	157	712	3,574	1,116	315	1,423	7,151	2,231	5	24	121	38
		Gas					9,213	43,826	172,613	61,251	184	876	3,445	1,225
Eastern Black Sea Basin AU	1.0	Oil	55	201	942	308	109	403	1,885	616	2	7	32	10
		Gas					2,324	14,479	96,546	26,453	47	290	1,927	529
Andrusov-Arkhangelsky Ridge AU	1.0	Oil	54	203	951	310	108	406	1,899	620	2	7	32	11
		Gas					351	1,773	13,225	3,571	7	35	264	71
Shatsky Ridge AU	1.0	Oil	153	459	1,539	597	305	917	3,079	1,194	5	16	52	20
		Gas					1,084	4,332	21,998	6,858	22	87	439	137
Karkinit Trough AU	1.0	Oil	8	17	30	18	2	4	8	5	0	0	0	0
		Gas					289	1,267	10,281	2,726	14	61	494	131
Total undiscovered conventional resources			**427**	**1,592**	**7,036**	**2,349**	**14,100**	**68,830**	**328,685**	**105,525**	**288**	**1,403**	**6,806**	**2,172**

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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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