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National and Global Petroleum Assessment

Assessment of Undiscovered Conventional Oil and Gas Resources of Oman, 2023

*U*sing a geology-based assessment methodology, the U.S. Geological Survey estimated undiscovered, technically recoverable mean conventional resources of 1.2 billion barrels of oil and 6.4 trillion cubic feet of gas in Oman.

Introduction

The U.S. Geological Survey (USGS) assessed the potential for undiscovered, technically recoverable conventional oil and gas resources within three salt basins, adjacent uplifts, and the foredeep of Oman (fig. 1). The tectonic evolution of Oman began with accretion of Neoproterozoic terranes that formed the Arabian plate. Accretion resulted in regional north-trending and northwest–southeast-trending complex fault and suture systems that form the basin boundaries (Al-Husseini, 2000; Ruban and others, 2007; Droste, 2014). A period of extension from late Neoproterozoic to Early Cambrian created a series of rift basins along the eastern margin of the Arabian plate (Al-Husseini, 2000); the Ghaba, Fahud, and South Oman Salt Basins formed at this time. The intermittent connection of the rift basins to the paleo-Tethys Ocean resulted in deposition of several kilometers of evaporites, carbonates, and clastics of the Neoproterozoic to Early Cambrian Huqf Supergroup (Grosjean and others, 2009). Within the Huqf Supergroup are Neoproterozoic petroleum source rocks, reservoirs, and thick salt deposits of the Ara Group (Amthor and others, 2005; Grosjean and others, 2009; Kowalewski and others, 2009). Thermal subsidence in the Cambrian and Ordovician resulted in accommodation space for several kilometers of fluvial to shallow-marine siliciclastics of the Haima Supergroup (Al-Barwani and McClay, 2008), which form oil and gas reservoirs throughout Oman (Al-Kindi and Richard, 2014). Burial by the Haima Supergroup resulted in progressive salt deformation and the formation of structures that are traps for oil and gas. Burial also resulted in the thermal maturation of Neoproterozoic source rocks (Al-Barwani and McClay, 2008) adequate for the generation of oil and gas. The Hercynian orogeny in the Carboniferous was a time of regional contraction, uplift, and erosion that removed most Silurian and Devonian rocks from Oman along a regional unconformity (Konert and others, 2001). The Hercynian orogeny was followed by regional glaciation in the late Carboniferous and early Permian and the deposition of fluvial and deltaic siliciclastics of the lower Permian Gharif Formation. The initial opening of the neo-Tethys Ocean in the late Permian resulted in a regional transgression across much of the Arabian plate and the formation of widespread east-facing carbonate platforms of the Khuff Formation and associated evaporites and intraplatform basinal source rocks (Droste, 2014). Triassic to Lower Jurassic progradation of a western-sourced clastic wedge produced a regional seal for much of Oman (Stewart and others, 2016). From the Upper Jurassic through Upper Cretaceous, extensive carbonate platforms, intraplatform basins, and source rocks were deposited, consisting of organic-rich marls of the Jurassic Tuwaiq Mountain Formation, Hanifa Formation, Shu'aiba Formation, and Cretaceous Natih Formation (Droste, 2014). Most of the Jurassic and Cretaceous source rocks and associated carbonate platforms are restricted to the extreme northwestern part of Oman adjacent to the Rub al Khali Basin (Droste, 2014). The initial closure of the neo-Tethys Ocean in the Late Cretaceous resulted in contraction across the eastern Arabian plate, forming the Oman thrust belt, foredeep, folds, and anticlines that are major traps for oil and gas. The final closure of the neo-Tethys Ocean in the Eocene resulted in uplift and erosion along the eastern Arabian plate.

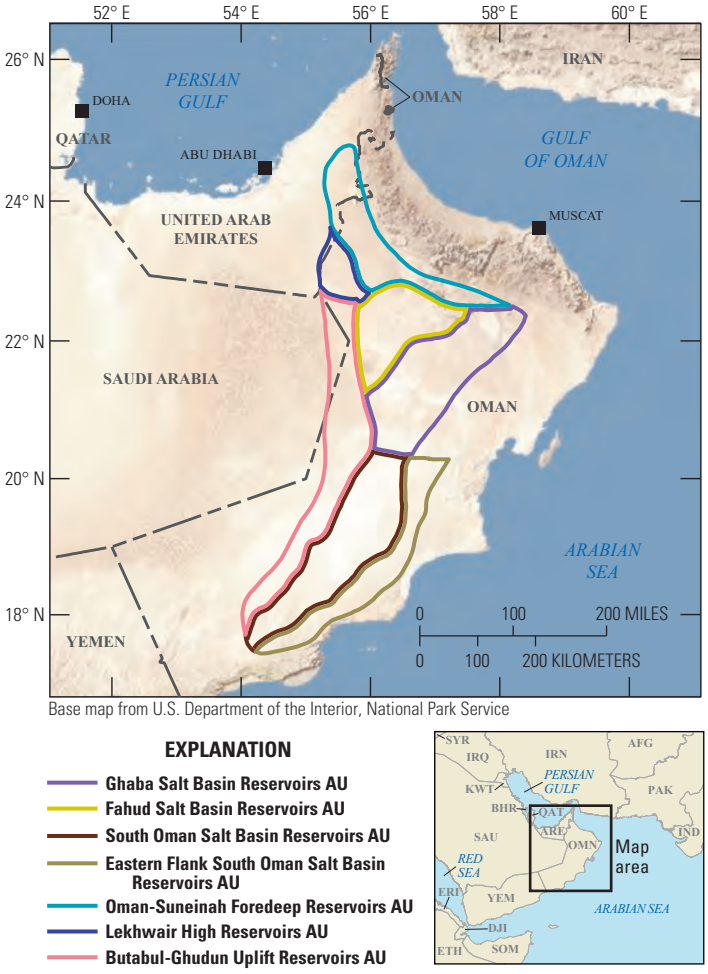

Figure 1. Map showing seven conventional assessment units (AUs) in Oman.

Total Petroleum System and Assessment Units

The USGS defined a Neoproterozoic–Mesozoic Composite Total Petroleum System (TPS) encompassing petroleum generated from several source rocks. Neoproterozoic source rocks underlie, overlie, and are within salt of the Ara Group. Organic-rich marls of the underlying presalt Nafun Group have total organic carbon (TOC) values as much as 5 weight percent (wt. pct.), have hydrogen index (HI) values as much as 700 milligrams (mg) of hydrocarbon per gram of TOC (mg HC/g TOC), and are as much as 50 meters (m) thick (Grosjean and others, 2009). Within the deformed salt of the Ara Group are unusual "silicilite" source (and reservoir) rocks that have TOC values as much as 7 wt. pct., have HI values as much as 900 mg HC/g TOC, and are as much as 400 m thick (Terken and others, 2001; Amthor and others, 2005). Associated with the silicilites are organic-bearing carbonate "stringers" that may also contribute as source rocks (Al-Siyabi, 2005). Within the Ara Group, overlying the salt are shales of the Dhahaban Formation, which have TOC values as much as 8 wt. pct., have HI values as much as 600 mg HC/g TOC, and are as much as 500 m thick (Terken and Frewin, 2000; Terken and others, 2001; Grosjean and others, 2009). Within the Ghaba, Fahud, and South Oman Salt Basins, Neoproterozoic source rocks have generated most of the oil and gas. Organic-rich graptolitic shales of the Silurian Qusaiba Formation are source rocks in northwestern Oman adjacent to the Rub al Khali Basin. In northwesternmost Oman, marls of the Jurassic Tuwaiq Mountain Formation, Hanifa Formation, and Shu'aiba Formation are source rocks (Boote and Mou, 2003; Grosjean and others, 2009; Droste, 2014). The Jurassic source rocks have TOC values as much as 5 wt. pct. and HI values as much as 500 mg HC/g TOC. Shales of the Cretaceous Natih Formation are source rocks in the Oman-Suneinah foredeep adjacent to the Oman thrust belt (Pollastro, 1999). Shales of the Natih Formation have TOC values as much as 15 wt. pct., have HI values as much as 800 mg HC/g TOC, and are as much as 50 m thick (Terken, 1999). Reservoirs within the salt basins are primarily the Neoproterozoic silicilites, carbonate stringers, and sandstones of the Cambrian to Ordovician Haima Supergroup.

Assessment units (AUs) defined within the composite TPS consist of the Ghaba Salt Basin Reservoirs AU, Fahud Salt Basin Reservoirs AU, South Oman Salt Basin Reservoirs AU, Eastern Flank South Oman Salt Basin Reservoirs AU, Oman-Suneinah Foredeep Reservoirs AU, Lekhwair High Reservoirs AU, and Butabul-Ghudun Uplift Reservoirs AU. Each of the AUs was assessed for undiscovered conventional oil and gas resources. The assessment input data for seven conventional AUs are summarized in table 1 and in Schenk (2025).

Table 1. Key input data for seven conventional assessment units in Oman.

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

Assessment input data—Conventional AUs	Ghaba Salt Basin Reservoirs AU				Fahud Salt Basin Reservoirs AU			
	Minimum	Median	Maximum	Calculated mean	Minimum	Median	Maximum	Calculated mean
Number of oil fields	1	25	50	25.6	1	30	60	30.7
Number of gas fields	1	25	50	25.6	1	15	30	15.4
Size of oil fields (MMBO)	1	3	600	10.8	1	2	20	2.6
Size of gas fields (BCFG)	6	18	4,000	68.3	6	12	60	13.7
AU probability	1.0				1.0			
Assessment input data—Conventional AUs	**South Oman Salt Basin Reservoirs AU**				**Eastern Flank South Oman Salt Basin Reservoirs AU**			
	Minimum	Median	Maximum	Calculated mean	Minimum	Median	Maximum	Calculated mean
Number of oil fields	1	30	60	30.7	1	15	30	15.4
Number of gas fields	1	15	30	15.4				
Size of oil fields (MMBO)	1	3	100	5.3	1	2	40	3.0
Size of gas fields (BCFG)	6	18	2,500	54.8				
AU probability	1.0				1.0			
Assessment input data—Conventional AUs	**Oman-Suneinah Foredeep Reservoirs AU**				**Lekhwair High Reservoirs AU**			
	Minimum	Minimum	Median	Calculated mean	Minimum	Median	Maximum	Calculated mean
Number of oil fields	1	20	40	20.5	1	10	20	10.3
Number of gas fields	1	10	20	10.3	1	10	30	10.6
Size of oil fields (MMBO)	1	2	10	2.3	0.5	2	100	4.1
Size of gas fields (BCFG)	6	12	250	18.0	3	12	200	17.6
AU probability	1.0				1.0			
Assessment input data—Conventional AUs	**Butabul-Ghudun Uplift Reservoirs AU**							
	Minimum	Minimum	Median	Calculated mean				
Number of oil fields	1	40	120	42.5				
Number of gas fields	1	20	60	21.3				
Size of oil fields (MMBO)	1	3	1,000	14.0				
Size of gas fields (BCFG)	6	18	8,000	98.1				
AU probability	1.0							

Undiscovered Resources Summary

The USGS quantitatively assessed undiscovered conventional oil and gas resources in seven AUs in Oman (table 2). The estimated mean resources are 1,248 million barrels of oil (MMBO), or 1.2 billion barrels of oil, with an F95–F5 range from 477 to 2,536 MMBO; 6,352 billion cubic feet of gas (BCFG), or 6.4 trillion cubic feet of gas, with an F95–F5 range from 1,977 to 14,897 BCFG; and 291 million barrels of natural gas liquids (MMBNGL), or 0.3 billion barrels, with an F95–F5 range from 87 to 704 MMBNGL.

Table 2. Results for seven conventional assessment units in Oman.

[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
Neoproterozoic–Mesozoic Composite Total Petroleum System														
Ghaba Salt Basin Reservoirs AU	1.0	Oil	97	235	607	277	87	211	549	249	1	2	6	3
		Gas					591	1,468	3,932	1,753	24	59	157	70
Fahud Salt Basin Reservoirs AU	1.0	Oil	49	76	115	79	34	53	81	55	1	1	1	1
		Gas					135	205	304	210	4	5	8	5
South Oman Salt Basin Reservoirs AU	1.0	Oil	88	155	262	162	61	108	184	114	5	8	14	9
		Gas					269	690	1,965	842	18	46	131	56
Eastern Flank South Oman Salt Basin Reservoirs AU	1.0	Oil	25	43	75	46	5	9	15	9	0	0	0	0
		Gas												
Oman-Suneinah Foredeep Reservoirs AU	1.0	Oil	30	46	67	47	39	59	88	61	2	3	5	3
		Gas					94	171	321	184	5	10	19	11
Lekhwair High Reservoirs AU	1.0	Oil	16	37	89	42	11	26	62	30	0	0	0	0
		Gas					76	171	352	186	0	1	2	1
Butabul-Ghudun Uplift Reservoirs AU	1.0	Oil	172	506	1,321	595	164	480	1,254	565	2	5	13	6
		Gas					411	1,532	5,790	2,094	25	92	348	126
Total undiscovered conventional resources			**477**	**1,098**	**2,536**	**1,248**	**1,977**	**5,183**	**14,897**	**6,352**	**87**	**232**	**704**	**291**

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For More Information

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

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