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National and Global Petroleum Assessment

Assessment of Shale-Oil Resources of the Sirte Basin Province, Libya, 2019

Using a geology-based assessment methodology, the U.S. Geological Survey estimated undiscovered, technically recoverable mean resources of 23.7 billion barrels of shale oil and 23 trillion cubic feet of associated gas in the onshore part of the Sirte Basin Province of Libya.

Introduction

The U.S. Geological Survey (USGS) quantitatively assessed the potential for undiscovered, technically recoverable continuous oil and gas resources in the onshore part of the Sirte Basin Province of Libya (fig. 1). The Sirte Basin Province encompasses a series of northwest–southeast trending horsts and grabens (or troughs) that resulted from multiple phases of rifting and subsidence beginning in the Triassic and continuing into the Neogene (Montgomery, 1994; Abadi and others, 2008; Badalini and others, 2009). Rifting and subsidence in the Sirte Basin Province were the result of the diachronous opening of the Atlantic and Tethys Oceans, differential movement of the African and Apulian plates, and transtensional and transpressional motion along the regional strike-slip faults in northernmost Africa (Fiduk, 2009; Hassan and Kendall, 2014). Major petroleum source rocks include the Lower Cretaceous Nubian shale and the Upper Cretaceous Sirte, Rachmat, and Etel Shales (Hassan and Kendall, 2014; Abualkhir, 2016). Subsidence in the Paleogene generally resulted in burial sufficient to thermally mature all source rocks into the oil-generation window (Gumati and Schamel, 1988; Futyan and Jawzi, 1996). All petroleum source rocks were interpreted to be of sufficient thickness and quality for each to be a potential target for horizontal drilling and were assessed separately. Lack of data prevented the delineation of shale-gas assessment units, although gas is present in a limited area of the basin (Hassan and Kendall, 2014).

Total Petroleum Systems and Assessment Units

The USGS defined four total petroleum systems (TPSs) and four assessment units (AUs) within these systems: (1) Sirte Shale TPS with the Sirte Shale Oil AU, (2) Rachmat Shale TPS with the Rachmat Shale Oil AU, (3) Etel Shale TPS with the Etel Shale Oil AU, and (4) Nubian Shale TPS with the Nubian Shale Oil AU. The Sirte shale is present and best developed as a petroleum source rock in all major troughs (Hassan and Kendall, 2014); the Rachmat and Etel Shales are in the Maradah, Ajdābiyā, and Hameimat troughs, and the Nubian shale is in the Zallah and Hameimat troughs (fig. 1). The assessment unit areas could change as more information becomes available on the geochemistry of each petroleum source rock. Assessment input data are summarized in table 1.

The geologic model for these four TPSs is for oil to have been generated from each of the organic-rich shales in the Paleogene with peak oil generation possibly in the late Paleogene to Neogene (Hassan and Kendall, 2014). Some portion of the oil was partially retained within each of the shales following migration into conventional traps. The Sirte Shale contains Type II marine organic matter, has total organic carbon (TOC) contents of as much as 8 weight percent, hydrogen indices as high as 600 milligrams of hydrocarbon per gram of TOC, and shale thickness of as much as 600 meters (m; Hassan and Kendall, 2014). The Rachmat Shale contains Type II marine organic matter, has TOC contents of as much as 4 weight percent, and shale thickness of as much as 700 m. The Etel Shale contains Type II marine organic matter, has TOC contents of as much as 6.5 weight percent, and has shale thickness of as much as 300 m. The Lower Cretaceous Nubian shale is a lacustrine shale with Type I organic matter, has TOC contents of as much as 9 weight percent, and is as much as 500 m thick (Hassan and Kendall, 2014). Shales of the Cenomanian–Turonian Eagle Ford Group were used as a partial production analog for the Sirte, Rachmat, and Etel Shales (Whidden and others, 2018), and lacustrine shale of the Uteland Butte member of the Green River Formation (nomenclature from Osmond, 1992) was used as a partial analog for the Nubian shale (Johnson and others, 2015).

Undiscovered Resources Summary

The USGS quantitatively assessed undiscovered continuous oil and gas resources in four assessment units (table 2) in the Sirte Basin Province of Libya. For undiscovered, technically recoverable shale-oil and associated gas resources, the mean totals are 23,706 million barrels of oil (MMBO), or 23.7 billion barrels of oil, with an F95–F5 fractile range from 5,505 to 50,652 MMBO; 23,033 billion cubic feet of associated gas (BCFG), or 23 trillion cubic feet of gas, with an F95–F5 fractile range from 5,000 to 51,464 BCFG; and 332 million barrels of natural gas liquids (MMBNGL) with an F95–F5 fractile range from 71 to 756 MMBNGL.

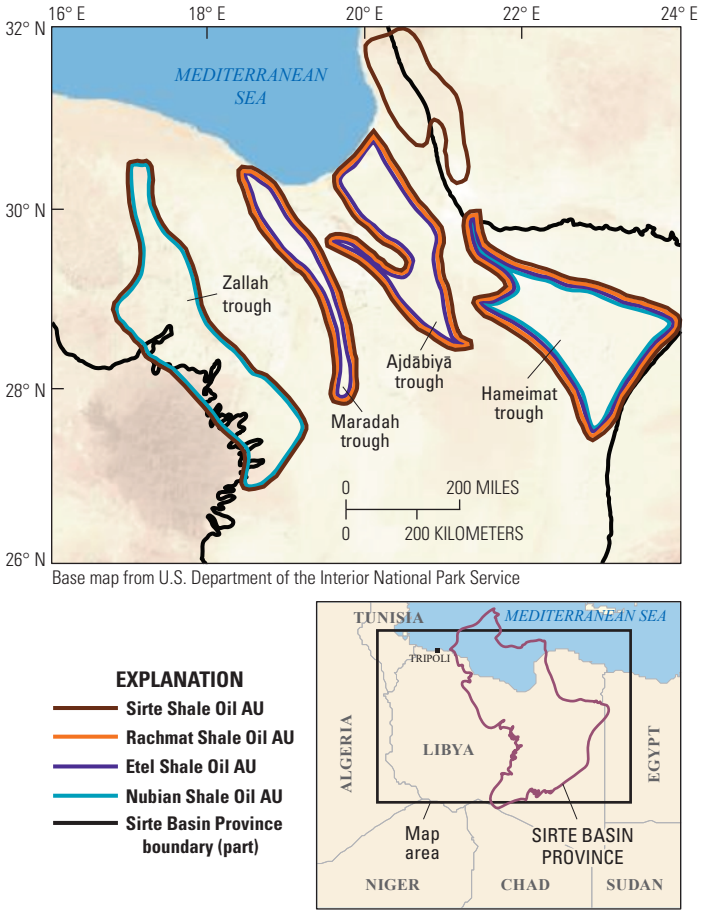

Figure 1. Map showing four continuous assessment units (AUs) in the Sirte Basin Province of Libya.

Table 1. Key input data for four continuous assessment units in the Sirte Basin Province of Libya.

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

Assessment input data—Continuous AUs	Sirte Shale Oil AU				Rachmat Shale Oil AU			
	Minimum	Mode	Maximum	Calculated mean	Minimum	Mode	Maximum	Calculated mean
Potential production area of AU (acres)	1,000	9,500,000	24,987,000	11,496,000	1,000	7,272,500	14,545,000	7,272,833
Average drainage area of wells (acres)	60	100	140	100	60	100	140	100
Area untested in AU (%)	100	100	100	100	100	100	100	100
Success ratio (%)	10	50	90	50	10	50	90	50
Average EUR (MMBO)	0.06	0.15	0.28	0.155	0.06	0.15	0.28	0.155
AU probability	1.0				1.0			
Assessment input data—Continuous AUs	**Etel Shale Oil AU**				**Nubian Shale Oil AU**			
	Minimum	Mode	Maximum	Calculated mean	Minimum	Mode	Maximum	Calculated mean
Potential production area of AU (acres)	1,000	7,272,500	14,545,000	7,272,833	1,000	7,419,500	14,839,000	7,419,833
Average drainage area of wells (acres)	60	100	140	100	60	100	140	100
Area untested in AU (%)	100	100	100	100	100	100	100	100
Success ratio (%)	10	50	90	50	10	50	90	50
Average EUR (MMBO)	0.06	0.15	0.28	0.155	0.06	0.085	0.15	0.088
AU probability	1.0				1.0			

Table 2. Results for four continuous assessment units in the Sirte Basin Province of Libya.

[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. 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
Sirte Shale Total Petroleum System														
Sirte Shale Oil AU	1.0	Oil	2,026	7,914	19,681	9,009	1,893	7,724	20,457	8,994	28	114	312	135
Rachmat Shale Total Petroleum System														
Rachmat Shale Oil AU	1.0	Oil	1,327	5,090	12,057	5,680	1,235	4,937	12,617	5,675	18	73	192	85
Etel Shale Total Petroleum System														
Etel Shale Oil AU	1.0	Oil	1,357	5,132	12,034	5,707	1,276	4,999	12,609	5,714	19	74	192	86
Nubian Shale Total Petroleum System														
Nubian Shale Oil AU	1.0	Oil	795	3,010	6,880	3,310	596	2,336	5,781	2,650	6	23	60	26
Total undiscovered continuous resources			**5,505**	**21,146**	**50,652**	**23,706**	**5,000**	**19,996**	**51,464**	**23,033**	**71**	**284**	**756**	**332**

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Differences in the spelling of the Sirte (Sirt) Basin reflect the individual author's usage.

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For More Information

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

ISSN 2327-6916 (print) ISSN 2327-6932 (online) https://doi.org/10.3133/fs20193028