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National and Global Petroleum Assessment

Assessment of Undiscovered Oil and Gas Resources in the Tindouf Basin Province, North Africa, 2018

Using a geology-based assessment methodology, the U.S. Geological Survey estimated undiscovered, technically recoverable mean resources of 2.6 billion barrels of oil and 123.9 trillion cubic feet of gas in the Tindouf Basin Province of North Africa.

Introduction

The U.S. Geological Survey (USGS) completed an assessment of undiscovered, technically recoverable conventional and unconventional (continuous) oil and gas resources within the Tindouf Basin Province of Algeria, Mauritania, Morocco, and Western Sahara (fig. 1). The Tindouf Basin is the westernmost of a series of Paleozoic intracontinental basins that are present across much of northern Africa (Boote and others, 1998; Badalini and others, 2002; Dixon and others, 2017). North Africa was a passive margin in the lower Paleozoic with fluvial systems flowing northwards towards the ocean. Glaciation across North Africa waned in the Ordovician, with meltwater forming a series of north-trending incised valleys that were filled with organic-rich sediments during a major south-directed transgression in the Silurian (Lüning and others, 2000; Le Heron and Craig, 2008). Another major transgression in the Late Devonian led to deposition of a second layer of organic-rich shale (Lüning and others, 2003). These two potential petroleum source rocks form the foundation of the total petroleum systems and assessment units defined and assessed in this study.

Total Petroleum Systems and Assessment Units

The USGS defined three total petroleum systems (TPS) in the Tindouf Basin Province. The Silurian TPS contains three assessment units (AUs): (1) Tindouf Silurian Shale Gas AU, (2) Tindouf Ordovician Tight Gas AU, and (3) Tindouf Silurian Shale Oil AU. The Devonian TPS contains the (1) Tindouf Devonian Shale Gas AU and (2) Tindouf Devonian Shale Oil AU. The Silurian–Devonian Composite TPS contains the Tindouf Conventional Oil and Gas AU (fig. 1). Silurian shales contain as much as 10 weight percent total organic carbon (TOC), hydrogen index (HI) values as much as 380 milligrams of hydrocarbon per gram of total organic carbon (mg HC/g TOC), and shale thickness is as much as 100 meters (El Diasty and others, 2017). Devonian shales contain as much as 14 weight percent TOC, HI values are as much as 580 mg HC/g TOC, and shale thickness is as much as 200 meters (Lüning and others, 2003; Chaouche, 2013).

The geologic model for the Silurian TPS is for oil to have been generated from organic-rich shales possibly as early as the Carboniferous (Lüning and others, 2000), and some of this oil was partially retained within the shales in the southern part of the basin. In the northern part of the basin, oil within the shales cracked to gas during maturation, and some of the gas was retained within the shales. Gas may have migrated locally to accumulate into subjacent tight Ordovician sandstones, forming a potential tight-gas accumulation. The geologic model for the Devonian TPS is similar in that oil as well as gas from thermal cracking of oil was partially retained within Devonian shales following migration. The geologic model for the Silurian–Devonian Composite TPS is for oil and gas from both source rocks to have migrated into conventional traps along the structurally complex northern margin of the basin and into stratigraphic traps within the basin.

Key assessment input data are shown in table 1. Well drainage areas, success ratios, and estimated ultimate recoveries are taken from U.S. shale-oil and shale-gas analogs. For continuous oil and gas accumulations, zeros at F95 reflect the interpretation of geologic risk (AU probability less than 1.0) on the potential occurrence of one well of minimum estimated ultimate recoveries in the AU.

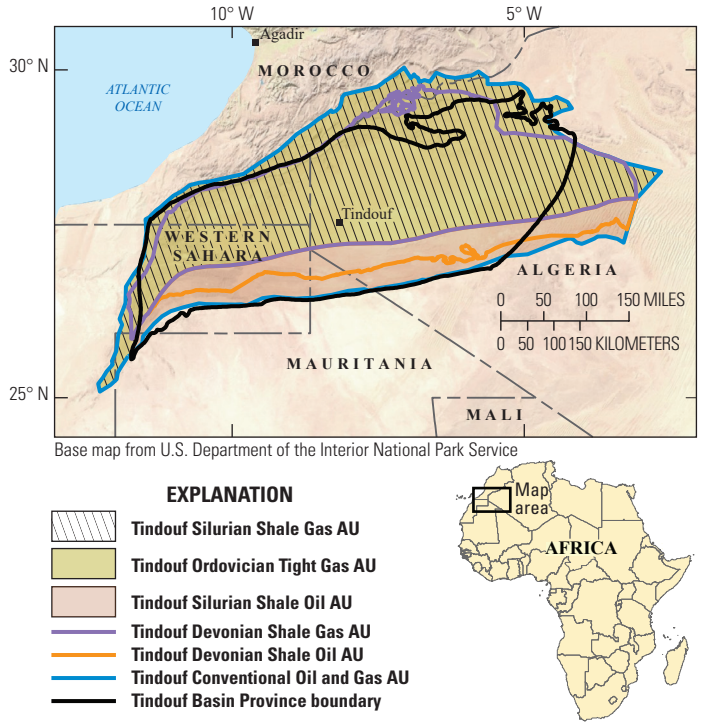

Figure 1. Location of the Tindouf Basin Province, North Africa, and the six assessment units (AUs) defined in this study.

Undiscovered Resources Summary

The USGS quantitatively assessed undiscovered, technically recoverable oil and gas resources within six assessment units in the Tindouf Basin Province (table 2). The estimated total mean resources are 2,575 million barrels of oil (MMBO), or 2.6 billion barrels of oil, with an F95 to F5 range from 34 to 7,176 MMBO; 123,959 billion cubic feet of gas (BCFG), or 123.9 trillion cubic feet of gas, with an F95 to F5 range from 2,963 to 316,809 BCFG; and 534 million barrels of natural gas liquids (MMBNGL) with an F95 to F5 range from 17 to 1,480 MMBNGL. Of the mean of 2,575 MMBO, 95 percent, or 2,447 MMBO, is continuous oil, and of the mean undiscovered gas resources of 123,959 BCFG, 93 percent, or 114,928 BCFG, is continuous gas.

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Table 1. Key input data for six assessment units (AUs) in the Tindouf Basin Province, North Africa.

[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-oil and shale-gas analogs. The average EUR input is the minimum, median, maximum, and calculated mean. Shading indicates not applicable]

Assessment input data—Continuous AUs	Tindouf Silurian Shale Gas AU				Tindouf Ordovician Tight Gas AU			
	Minimum	Mode	Maximum	Calculated mean	Minimum	Mode	Maximum	Calculated mean
Potential production area of AU (acres)	1,000	20,341,000	40,681,000	20,341,000	1,000	20,341,000	40,681,000	20,341,000
Average drainage area of wells (acres)	80	120	160	120	40	80	120	80
Area untested in AU (%)	100	100	100	100	100	100	100	100
Success ratio (%)	10	50	90	50	10	50	90	50
Average EUR (BCFG)	0.1	0.4	1.3	0.447	0.08	0.4	1.5	0.459
AU probability	0.9				0.9			

Assessment input data—Continuous AUs	Tindouf Silurian Shale Oil AU				Tindouf Devonian Shale Gas AU			
	Minimum	Mode	Maximum	Calculated mean	Minimum	Mode	Maximum	Calculated mean
Potential production area of AU (acres)	1,000	6,804,000	13,508,000	6,771,000	1,000	16,440,000	32,880,000	16,440,333
Average drainage area of wells (acres)	60	100	120	93.3	80	120	160	120
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, oil; BCFG, gas)	0.01	0.04	0.2	0.049	0.1	0.4	1.3	0.447
AU probability	0.9				0.9			

Assessment input data—Continuous AU	Tindouf Devonian Shale Oil AU			
	Minimum	Mode	Maximum	Calculated mean
Potential production area of AU (acres)	1,000	3,870,000	7,732,000	3,867,667
Average drainage area of wells (acres)	60	100	120	93.3
Area untested in AU (%)	100	100	100	100
Success ratio (%)	10	50	90	50
Average EUR (MMBO)	0.01	0.04	0.2	0.049
AU probability	0.9			

Assessment input data—Conventional AU	Tindouf Conventional Oil and Gas AU			
	Minimum	Mode	Maximum	Calculated mean
Number of oil fields	1	6	24	6.62
Number of gas fields	1	50	200	55.13
Size of oil fields (MMBO)	5	10	500	19.29
Size of gas fields (BCFG)	30	60	7,000	158.99
AU probability	1.0			

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For More Information

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

Table 2. Results for six assessment units (AUs) in the Tindouf Basin Province, North Africa.

[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
Silurian Total Petroleum System														
Tindouf Silurian Shale Gas AU	0.9	Gas					0	28,316	86,048	33,700	0	103	377	135
Tindouf Ordovician Tight Gas AU	0.9	Gas					0	42,846	138,115	52,334	0	156	606	209
Tindouf Silurian Shale Oil AU	0.9	Oil	0	1,197	4,329	1,554	0	698	2,650	932	0	11	43	15
Devonian Total Petroleum System														
Tindouf Devonian Shale Gas AU	0.9	Gas					0	23,027	69,694	27,425	0	84	307	110
Tindouf Devonian Shale Oil AU	0.9	Oil	0	682	2,528	893	0	399	1,554	537	0	6	26	9
Total undiscovered continuous resources			**0**	**1,879**	**6,857**	**2,447**	**0**	**95,286**	**298,061**	**114,928**	**0**	**360**	**1,359**	**478**
Silurian–Devonian Composite Total Petroleum System														
Tindouf Conventional Oil and Gas AU	1.0	Oil	34	100	319	128	62	197	655	256	1	2	7	3
		Gas					2,901	7,757	18,093	8,775	16	45	114	53
Total undiscovered conventional resources			**34**	**100**	**319**	**128**	**2,963**	**7,954**	**18,748**	**9,031**	**17**	**47**	**121**	**56**
Total undiscovered resources			**34**	**1,979**	**7,176**	**2,575**	**2,963**	**103,240**	**316,809**	**123,959**	**17**	**407**	**1,480**	**534**

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