

National Assessment of Oil and Gas Fact Sheet

Undiscovered Oil and Gas Resources Underlying the U.S. Portions of the Great Lakes, 2005

he U.S. Geological Survey recently completed allocations of oil and gas resources underlying the U.S. portions of the Great Lakes. These allocations were developed from the oil and gas assessments of the U.S. portions of the Appalachian Basin and the Michigan Basin. With the completion of the assessments of these two basins, the following quantities of undiscovered, technically recoverable oil and gas resources were allocated to the U.S. portions of the Great Lakes: (1) a mean value of 312 million barrels of oil, (2) a mean value of 5.2 trillion cubic feet of natural gas, and (3) a mean value of 122 million barrels of natural gas liquids.

Introduction

The U.S. Geological Survey (USGS) completed an assessment of the undiscovered oil and gas potential of the U.S. portions of the Appalachian Basin and the Michigan Basin in 2002 and 2004, respectively. Following the assessments of these two basins, oil and gas allocations were assigned to the U.S. portions of the Great Lakes (fig. 1) — Lake Superior (Michigan, Minnesota, and Wisconsin), Lake Michigan (Illinois, Indiana, Michigan, and Wisconsin), Lake Huron (Michigan), Lake Erie (Michigan, New York, Ohio, and Pennsylvania), and Lake Ontario (New York). Allocations for Lake St. Clair (Michigan) were included with those of Lake Erie.

The allocations are based on the geologic elements of each total petroleum system (TPS) defined in the region and the projected extent of those elements from onshore beneath each of the lakes. These geologic elements include the hydrocarbon source rocks, reservoir rocks, and traps. By using this geologic framework, the USGS defined 8 total petroleum systems and 21 assessment units (AUs) within the Great Lakes and estimated the quantity of undiscovered technically recoverable oil and gas resources within 16 of the 21 AUs in the Great Lakes (table 1).

Total Petroleum Systems

The eight total petroleum systems identified in the U.S. portions of the Great Lakes are the (1) Precambrian Nonesuch TPS, (2) Ordovician Foster TPS, (3) [Ordovician] Utica-Lower Paleozoic TPS, (4) Ordovician to Devonian Composite TPS, (5) Silurian Niagara/Salina TPS, (6) Devonian Antrim TPS, (7) Devonian Shale-Middle and Upper Paleozoic TPS, and (8) Pennsylvanian Saginaw TPS. Each TPS is named according to the petroleum source rock(s) of that system. For most of the systems, each TPS is associated with only one source rock. The Ordovician to Devonian Composite TPS, however, is a composite petroleum system having contributions from one or more of the following different source rocks: Ordovician Collingwood Shale, Devonian Detroit River Group, and Devonian Antrim Shale.



Figure 1. Map showing the allocated areas (U.S. portions) of the Great Lakes. Allocation areas do not include islands within the lakes.

Assessment Units

Of the AUs, 13 are characterized as conventional oil and gas accumulations, and 8 are characterized as continuous (unconventional) accumulations. The 13 conventional AUs (and associated basins) are as follows:

- 1. Devonian to Mississippian Berea/Michigan Sandstones AU (Michigan Basin);
- Middle Devonian Carbonates AU, which includes the Detroit River Group, Dundee Limestone, and Traverse Group (Michigan Basin);
- 3. [Devonian] Oriskany Sandstone-Stratigraphic AU (Appalachian Basin);
- 4. Devonian Sylvania Sandstone AU (Michigan Basin);
- 5. [Silurian] Lockport Dolomite AU (Appalachian Basin);
- 6. Silurian A-1 Carbonate AU (Michigan Basin);
- 7. Silurian Niagara AU (Michigan Basin);
- 8. Silurian Burnt Bluff AU (Michigan Basin);
- 9. [Ordovician] Black River-Trenton Hydrothermal Dolomite AU (Appalachian Basin);
- 10. Ordovician Trenton/Black River AU (Michigan Basin);
- 11. [Ordovician] Knox Unconformity AU (Appalachian Basin);
- Ordovician Sandstones and Carbonates AU, which includes the Prairie du Chien Group, St. Peter Sandstone, Glenwood Formation, and equivalent stratigraphic units (Michigan Basin); and
- 13. Precambrian Nonesuch AU (Michigan Basin).

All these conventional AUs were assessed quantitatively, except for the Precambrian Nonesuch AU, which lacked sufficient data to assess quantitatively.

assumption			n peuoreum ayaw	111. AU 15 43505		III. Ulay s		arcs not ap		Total	undiscov	ered resou	Irces				
Resource	Total petroleum svstems	Assessment	Lake	State	Field		0il (M	(MBO)			Gas (I	BCFG)			NGL (MMI	SNGL)	
adda	allanche	2			adda	F95	F50	55	Mean	F95	F50	£	Mean	F95	F50	E	Mean
	Devonian Shale-	Oriskany Sandstone-	-Lake Erie	Ohio	0il	0.00	0.00	0.00	00.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Middle and	Stratigraphic AU	I aba Ettia	Dannewlwania	Gas	000	000	000	000	9.31	31.89	77.29	36.06	0.07	0.00	0.00	0.29
	Upper Paleozoic			r currey ryanna	Gas Gas	0.00	0.0	00.0	00.0	0.00	14.55	34.71	0.00	0.03	0.11	0.20	0.00
	Silurian Niagara/	Devonian Svlvania	Lake Erie	Michigan	liC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	00.0	0.00	0.00	0.00
	Salina TPS	Sandstone AU		0	Gas					0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Silurian Niagara AU	l Lake Erie	Michigan	Oil	0.28	3.34	11.09	4.21	0.54	6.66	23.60	8.65	0.04	0.50	1.90	0.68
					Gas	1000	00 10			0.84	10.21	33.78	12.80	0.05	0.63	2.23	0.82
			Lake Michigan	Michigan	Ū.	38.86	90.59	163.97	94.74	72.90	181.49	362.23	194.89	5.20	13.78	30.16	15.22
			Lake Michigan	Wisconsin	Dil	0.01	0.17	0.56	0.2.1	0.03	2/3.60	2C./UC	287.74 0.44	0.00	0.03	010	0.03
			C		Gas					0.04	0.51	1.70	0.64	0.00	0.03	0.11	0.04
			Lake Huron	Michigan	Oil	32.31	75.55	144.54	80.23	60.77	151.61	315.02	165.05	4.35	11.54	26.09	12.89
					Gas					96.95	228.66	445.25	243.90	5.71	14.25	30.17	15.61
	Ordovician to	Devonian to	Lake Erie	Michigan	ii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Devonian	Mississippian			Gas					0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Composite TPS	Berea/Michigan	Lake Huron	Michigan		1.88	4.76	9.33	5.01	0.85	2.28	4.96	2.50	0.03	0.09	0.21	0.10
		Sandstones AU			Gas	000	000	000	000	10.80	30.06	63.47	32.75	0.40	1.18	2.68	1.31
		Conhomotor AII	Lake Erie	Michigan	10	00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			Lake Michigan	Illinois	Oil	0.00	0.02	0.08	0.03	0.00	0.01	0.04	0.01	0.00	0.00	0.00	0.00
					Gas					0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			Lake Michigan	Indiana	E I	0.00	0.07	0.32	0.10	0.00	0.03	0.16	0.05	0.00	0.00	0.01	0.00
					Gas	6	1001	00 50	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			Lake Michigan	Michigan	55	07.7	10.91	5 / .08	14.13	0.00	0.00	18.90	CU./	0.00	0.42	00.0	00.0
			Lake Michigan	Wisconsin	Dil	0.04	0.68	3.16	1.02	0.02	0.33	1.60	0.51	0.00	0.03	0.13	0.04
					Gas					0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			Lake Huron	Michigan	iii	6.03	26.17	69.62	30.51	2.84	12.71	36.08	15.21	0.21	0.99	3.00	1.22
		Cilurian A_1	I aka Huron	Michigan	Cas Dil	000	0.00	000	000	0.00	00.0	00.0	00.0	00.0	0.00	0.00	0000
		Carbonate AU	TUNIT AND	ImStituti	Gas	0.0	00.0	0.0	00.0	1.36	6.89	26.03	9.37	0.03	0.13	0.53	0.19
		Silurian Burnt Bluff	Lake Michigan	Illinois	Oil	0.00	0.00	0.00	00.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
s		AU			Gas					0.00	0.05	0.22	0.08	0.00	0.00	0.00	0.00
ເລວ			Lake Michigan	Michigan	lio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
oın					Gas	000	0000	000		3.86	13.32	35.21	15.60	0.07	0.26	0.73	0.31
os			Lake Michigan	WISCONSIN	3,	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1. L			I also Human	Michicon	Cas			0000	000	0.12	1.61	0.04	2.24	0.00	0.03	0.13	0.04
ST				MUCHIGAII	55	0.00	0.00	0.00	0.00	1.67	16.24	15.00	10.00	00.0	0.00	0.00	0.00
25		Ordovician Trenton/	'Lake Erie	Ohio	C IIC	0.79	11.41	47.98	16.16	1.52	22.12	98.61	32.38	0.10	1.50	26-0 80.7	2.27
pu		Black River AU			Gas					0.58	8.41	38.31	12.51	0.01	0.16	0.79	0.25
e l			Lake Erie	Michigan	Oil	0.78	11.35	48.54	16.18	1.51	22.09	99.21	32.38	0.10	1.51	7.08	2.27
io					Gas					0.58	8.38	37.99	12.42	0.01	0.16	0.78	0.25
lai			Lake Michigan	Illinois	, Oil	0.03	0.51	2.13	0.72	0.07	0.09	4.40	1.45	0.00	0.07	0.31	0.10
uo			Lake Michioan	Indiana	Dil I	0.03	0.51	2 15	0 72	0.07	00 0	4 40	CC.U 144	000	10.0	0 37	0.10
itu			meditivity wind	nimmin	Gas	22.2	1220	2412		0.02	0.38	1.70	0.55	0.00	0.01	0.04	0.01

Table 1. Great Lakes oil and gas resource allocations by total petroleum system and assessment unit.

10.01	1.71	0.10	0.01	3.55	0.39	0.00	0.10	0.00	00.0	0.00	0.00	0.55	0.32	0.92	0.00	0.18	0.00	1.10	0.00	0.06	0.15	0.00	0.04	0.00	0.02	0.00	0.02	0.00	0.02	0.00	00.0	0.07	0.00	6.85	92.35	0.21	0.58	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.44	18.08	5.75	29.32			Mean	121.68	
0.04	5.28	0.31	0.04	11.03	1.21	0.00	0.28	0.00	5.39	0.00	0.00	1 56	0.87	2.46	0.00	0.51	0.00	2.95	0.00	0.18	0.35	0.00	0.12	0.00	0.06	0.00	0.07	0.00	0.07	0.00	0.00	0.01	0.00	17.88	204.35	0.50	1.43	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.61	29.20	9.88	50.26		MBNGL)	F5	254.61	
10.01	1.14	0.07	0.01	2.37	0.25	0.00	0.08	0.00	1.3/	0.00	0.00	0.00	0.25	0.70	0.00	0.13	0.00	0.83	0.00	0.05	0.13	0.00	0.03	0.00	0.02	0.00	0.02	0.00	0.02	0.00	C7.0	0.05	0.00	5.30	79.16	0.17	0.47	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.98	17.43	5.42	27.69		NGL (M	F50	106.86	
0.00	0.08	0.00	0.00	0.16	0.02	0.00	0.02	0.00	0.40	0.00	0.0	0.05	0.05	0.15	0.00	0.02	0.00	0.16	0.00	0.01	0.03	cn.n	0.01	0.00	0.00	00.0	0.00	0.00	0.00	0.00	0.00	0000	0.00	1.15	25.82	0.05	0.12	0.00	00.0	0000	0.00	0.00	0.00	0.00	00.0	1.80	9.15	2.74	13.92			F95	39.74	
CC.U	24.46	1.44	0.56	50.81	19.47	0.00	10.40	0.00	90.00	0.00	0.00	55.08	32.54	92.15	0.00	18.29	0.00	109.92	0.00	6.33	15.21	40.00	4.22	0.00	2.09	0.00	0.56	0.00	0.56	0.00	0.00	1 69	0.00	162.60	1,998.09	10.61	29.19	13.26	0.00	0.00	0.00	0.00	747.47	0.00	74.66	369.82	1,506.52	479.10	3,230.62	rces		Mean	5,228.71	
1. /V	74.00	4.40	1.73	154.67	60.07	0.00	27.85	0.00	521.82	0.00	0.00	152.58	84.08	237.53	0.00	49.70	0.00	286.70	0.00	17.10	33.45	0.04	11.19	0.00	5.78	0.00	1.65	0.00	1.62	0.00	0.00	4 95	00.0	412.88	4,444.51	24.10	68.78	30.98	0.00	0.00	0.00	0.00	1,114.73	0.00	179.31	674.58	2,179.97	756.52	5,028.97	red resou	CFG)	ъ	9,473.48	
0C.U	16.72	66.0	0.38	34.84	13.00	0.00	7.87	0.00	140.20	0.00	0.00	41 19	25.54	72.02	0.00	13.83	0.00	85.05	0.00	4.84	13.27	0.00	3.28	0.00	1.58	0.00	0.41	0.00	0.40	0.00	0.02	1 21	00.0	128.57	1,711.59	8.94	24.32	11.07	0.00	0000	0.00	0.00	728.39	0.00	63.95	339.16	1,505.53	463.27	3,144.64	undiscove	Gas (B	F50	4,856.23	
0.02	1.11	0.07	0.03	2.33	0.87	0.00	1.63	0.00	10.04	0.00	0.00	5 54	4.89	15.65	0.00	2.23	0.00	16.81	0.00	0.69	3.60	0.00	0.54	0.00	0.13	0.00	0.03	0.00	0.03	0.00	9.0 1	0.00	0.00	29.15	531.61	2.75	6.18	2.98	00.0	0000	0.00	0.00	445.18	0.00	5.51	166.18	843.70	252.61	1,725.09	Total ı		F95	2,256.70	
	12.21	0.72		25.27		0.00	0	0.00	000	0.00	0000	00.00	6.51		0.00		0.00		0.00		3.04	0000	00.0	0.00		00.0		0.00		0.00	000	00.0	0.00		311.71				t	Ì												Mean	311.71 2	
	36.33	2.15		74.13		0.00	000	0.00		0.00	000	00.00	16.25		0.00		0.00		0.00		6.43	000	00.0	0.00		0.00		0.00	000	0.00	000	00.00	0.00		675.82				T												MBO)	ម	675.82	
	8.59	0.51		17.93		0.00	0000	0.00		0.00	00.0	0.0	5.22		0.00		0.00		0.00		2.73	00.0	0.0	0.00		0.00		0.00	000	0.00	000	0.00	0.00		271.03				T	T											0il (MI	F50	271.03	
	0.59	0.03		1.23		0.00	000	0.00		0.00	0000	00.0	1.03		0.00		0.00		0.00		0./8	0000	00.0	0.00		00.00		0.00	000	0.00	000	00.0	0.00		86.98				T	T	ľ											F95	86.98	
Cas	ii j	Dio	Gas	Oil	Gas	0il	Gas	ii c	Cas	ii j	Oil Oil	Cas Cas	Oil	Gas	Oil	Gas	Oil	Gas	Oil	Gas	3	Cas	Gas	liO	Gas	Oil	Gas	0il	Gas	3	Cas	UII UII	Oil	Gas	Total	Gas	Gas	Gas	Cas	Gas	Gas	Gas	Gas	Gas	Gas	Gas	Gas	Gas	Total					
	lichigan	'isconsin		lichigan		ew York		hio	-	ennsylvania	ew York	CW TOTY	hio		ennsylvania	1	ew York		ew York		hio	ennewlwania	aumy r Kenne	ew York		linois		idiana		lichigan	lieconein	ISCOUSIII	lichigan	D		ew York	hio i	ennsylvania	ew York	ennsvlvania	lichigan	diana	lichigan	<i>'</i> isconsin	lichigan	ew York	hio	ennsylvania					FOTALS	
	Lake Michigan N	Lake Michigan W		Lake Huron N		Lake Erie N		Lake Erie 0		Lake Erie P	I ake Frie		Lake Erie		Lake Erie P		Lake Ontario N		Lake Erie N		Lake Erie	ake Frie D		Lake Ontario N		Lake Michigan II		Lake Michigan Ir		Lake Michigan M	Wichigan W		Lake Huron			Lake Erie N	Lake Erie O	Lake Erie	Lake Erie IN	Lake Erie O	Lake Erie	Lake Michigan Ir	Lake Michigan N	Lake Michigan W	Lake Huron N	Lake Erie N	Lake Erie O	Lake Erie P						
-			•			Lockport Dolomite	AU				Black River-Trenton	Uvdrothermol	Delemite ATT	Domine AU					Knox Unconformity	AU						Ordovician	Sandstones and	Carbonates AU								Northwestern Ohio	Shale AU		Marcellus Shale AU		Devonian Antrim	Continuous Gas	All			Clinton-Medina	Transitional AU							
						Utica-Lower I	Paleozoic TPS					<u> </u>							1							Ordovician Foster (SdT									Devonian Shale-	Middle and	Upper Paleozoic	TPS		Devonian Antrim	SdT				Utica-Lower (Paleozoic TPS							
IG	оли	00)																																	S	ວວ.	ine	DS:	LG.	seg	88	sno	on	uŗ	uc	20)						

The eight continuous AUs (and associated basins) are as follows:

- 1. Pennsylvanian Saginaw Coal Bed Gas AU (Michigan Basin),
- 2. [Devonian] Northwestern Ohio Shale AU (Appalachian Basin),
- 3. [Devonian] Marcellus Shale AU (Appalachian Basin),
- 4. Devonian Antrim Continuous Gas AU (Michigan Basin),
- 5. Devonian Antrim Continuous Oil AU (Michigan Basin),
- 6. [Silurian] Clinton-Medina Transitional AU (Appalachian Basin),
- 7. [Ordovician] Utica Shale Gas AU (Appalachian Basin), and
- 8. Ordovician Collingwood Shale Gas AU (Michigan Basin).

Of these eight continuous AUs, only the following four AUs were assessed quantitatively: [Silurian] Clinton-Medina Transitional AU, Devonian Antrim Continuous Gas AU, [Devonian] Marcellus Shale AU, and [Devonian] Northwestern Ohio Shale AU. The other four continuous AUs lacked sufficient data to assess quantitatively.

Resource Summary

For the U.S. portions of the Great Lakes, the USGS estimated the following quantities of undiscovered, technically recoverable oil and gas resources (table 1):

- 1. a mean value of 312 million barrels of oil,
- 2. a mean value of 5.2 trillion cubic feet of natural gas, and
- 3. a mean value of 122 million barrels of natural gas liquids.

These estimates are mean estimates. The ranges of uncertainty of these estimates are shown in table 1.

Oil and Gas Resource Allocations by Lake

Allocated oil and gas resources were compiled for each of the Great Lakes (tables 1 and 2). The only identified petroleum system beneath Lake Superior is the Precambrian Nonesuch TPS, which lacked sufficient data to assess quantitatively.

Oil and Gas Resource Allocations by State

Allocated oil and gas resources were compiled for each of the Great Lakes States (tables 1 and 3). The only identified petroleum system in the Minnesota portion of the Great Lakes is the Precambrian Nonesuch TPS, which lacked sufficient data to assess quantitatively.

Additional Information

Supporting geologic studies of the U.S. portions of the Great Lakes total petroleum systems, assessment units, and allocations are in progress. The results of this work, as well as information on the assessment methodology, are posted on the USGS Web site at http://energy.cr.usgs.gov/oilgas/noga as they become available. Assessment results for undiscovered oil and gas resources of the U.S. portions of the Appalachian and Michigan Basins may be found online at http://pubs.usgs.gov/fs/fs-009-03 and http://pubs.usgs.gov/ fs/2005/3070/, respectively.

Table 2. Summary of mean values of Great Lakes oil and gas resource allocations by lake.

[Compiled from table 1, which contains the full range of statistical values]

	Total	undiscovere	d resources
Lake	Oil (million barrels), mean	Gas (trillion cubic feet), mean	Natural gas liquids (million barrels), mean
Lake Erie	46.10	3.013	40.68
Lake Huron	141.02	0.797	42.49
Lake Michigan	124.59	1.308	37.40
Lake Ontario	0.00	0.112	1.12
Lake Superior	not	assessed qua	ntitatively
Total	311.71	5.23	121.69

Table 3. Summary of mean values of Great Lakes oil and gas resource allocations by State.

[Compiled from table 1, which contains the full range of statistical values]

	Tota	al undiscovered	resources
State	Oil (million barrels), mean	Gas (trillion cubic feet), mean	Natural gas liquids (million barrels), mean
Illinois	0.75	0.003	0.14
Indiana	0.82	0.003	0.14
Michigan	282.48	2.157	83.27
Minnesota	nc	ot assessed quant	titatively
New York	0.00	0.564	6.49
Ohio	25.71	1.942	24.72
Pennsylvania	0.00	0.552	6.58
Wisconsin	1.95	0.008	0.34
Total	311.71	5.229	121.68

By James L. Coleman, Christopher S. Swezey, Robert T. Ryder, and Ronald R. Charpentier

Great Lakes Review Team

James L. Coleman (Co-Task Leader; jlcoleman@usgs.gov), Christopher S. Swezey (Co-Task Leader; cswezey@usgs.gov), Robert T. Ryder (Co-Task Leader; rryder@usgs.gov), Ronald R. Charpentier, Robert C. Milici, Joseph R. Hatch, Troy A. Cook, Timothy R. Klett, Richard M. Pollastro, Christopher J. Schenk, and James W. Schmoker.