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World Petroleum Resources Assessment Project

Assessment of Undiscovered Oil and Gas Resources of Southeast Asia, 2010

Using a geology-based assessment methodology, the U.S. Geological Survey estimated a mean of 21.6 billion barrels of oil and a mean of 299 trillion cubic feet of undiscovered natural gas in 23 provinces of southeast Asia.

Introduction

The U.S. Geological Survey (USGS) assessed the potential for undiscovered conventional oil and gas fields within geologic provinces of southeast Asia as part of the USGS World Petroleum Resources Assessment Project (fig. 1). Twenty-three provinces were assessed in this study (table 1), including provinces entirely or partially within Thailand, Laos, Cambodia, Vietnam, Myanmar, Malaysia, Indonesia, Brunei, China, and Philippines. Many of the oil and gas basins within these geologic provinces originated as extensional basins that evolved into a post-rift thermal subsidence phase, which is characterized by carbonate platform deposits or prograding clastic wedges typical of passive margins. This simple sketch does not reflect the complexity of the tectonic history in southeast Asia, which has included rifting and attenuation of continental crust, opening and closing of ocean basins, development of regional fault systems and associated structures, collision and suturing of terranes, formation of accretionary prisms and local uplifts (Morley, 2001, 2002; Hutchinson, 2004; Hall and others, 2008).

Petroleum systems in provinces of southeast Asia reflect the complex tectonic evolution, but generalities can be made concerning the origin of oil and gas in what are mainly Cenozoic basins (Todd and others, 1997; Doust and Sumner, 2007; Hall, 2009). Petroleum source rocks mainly are synrift deep-basin lacustrine and marginal lacustrine shales; post-rift marginal marine to marine coaly mudstones, coals, and marine shales (Todd and others, 1997). Oil predominantly is generated from synrift lacustrine shales, whereas gas is generated from the post-rift coaly mudstones, coals, and shales, and by cracking of earlier-formed oil. As gas generation

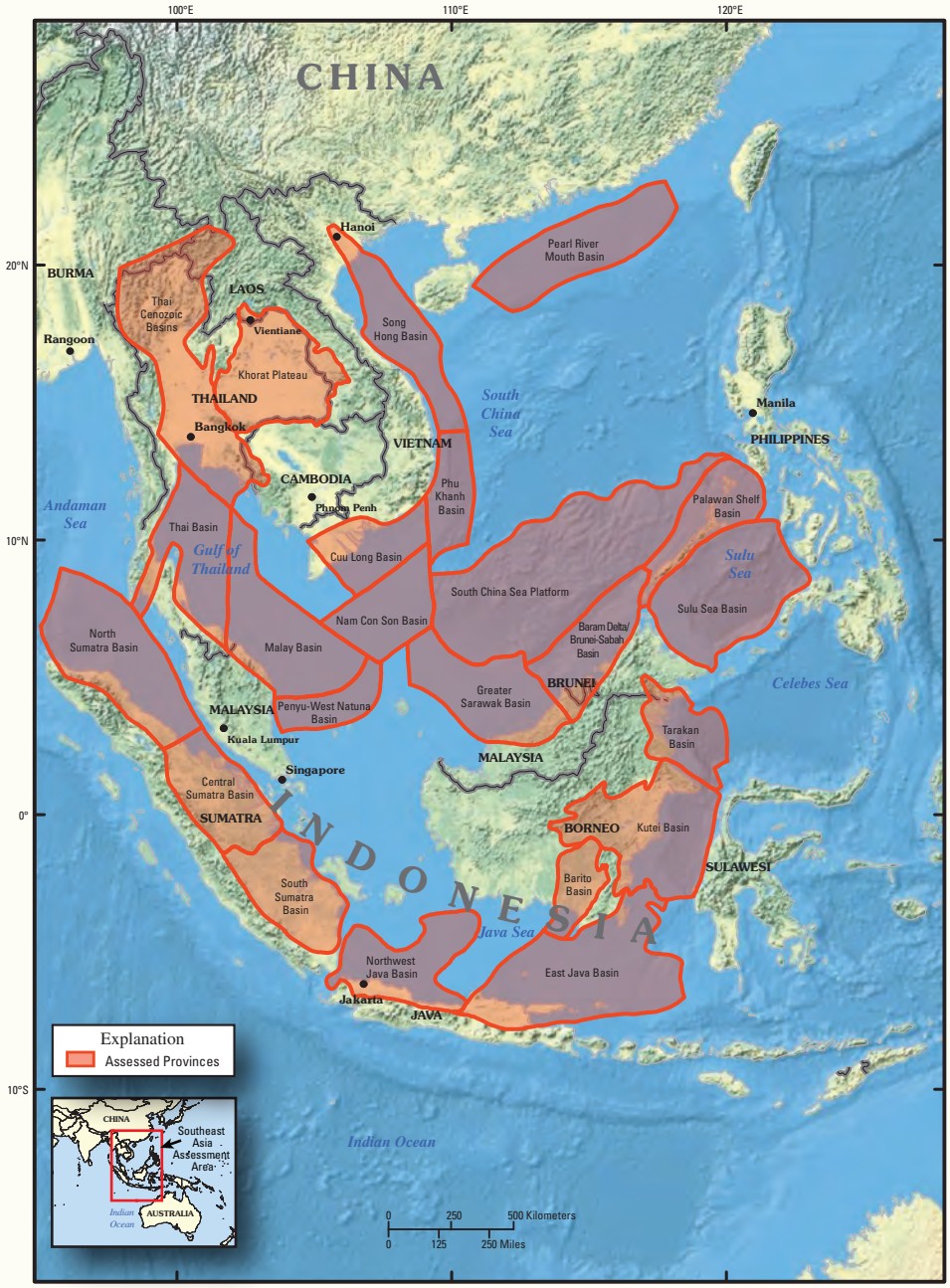

Figure 1. Locations of 23 provinces of southeast Asia assessed in this study.

Table 1. *Southeast Asia assessment results.*

[MMBO, million barrels of oil. BCFG, billion cubic feet of gas. MMBNGL, million barrels of natural gas liquids. Results shown are fully risked estimates. For gas accumulations, all liquids are included as NGL (natural gas liquids). Undiscovered gas resources are the sum of nonassociated and associated gas. F95 represents a 95-percent chance of at least the amount tabulated; other fractiles are defined similarly. AU, assessment unit. AU probability is the chance of at least one accumulation of minimum size within the AU. TPS, total petroleum system. Gray shading indicates not applicable. Largest expected oil field size in MMBO; gas field size is in BCFG]

Total Petroleum Systems (TPS) *and Assessment Units (AU)*	AU probability	Field type	Largest expected field size	***Total Undiscovered Resources***											
				Oil (MMBO)				***Gas (BCFG)***				***NGL (MMBNGL)***			
				F95	**F50**	**F5**	**Mean**	**F95**	**F50**	**F5**	**Mean**	**F95**	**F50**	**F5**	**Mean**
Pearl River Mouth Basin Province (Paleogene Lacustrine TPS)															
Eocene-Miocene Reservoirs AU	1.0	***Oil***	97	279	567	1,079	608	290	694	1,526	773	10	26	63	30
		Gas	2,371					3,279	8,078	18,047	9,035	102	256	588	289
Song Hong Basin Province (Eocene-Miocene Composite TPS)															
Paleogene-Neogene Reservoirs AU	1.0	***Oil***	62	80	183	399	204	405	945	2,112	1,061	4	11	25	12
		Gas	922					5,782	10,599	18,625	11,205	121	226	399	238
Phu Khanh Basin Province (Paleogene TPS)															
Paleogene-Neogene Reservoirs AU	1.0	***Oil***	107	48	166	593	223	244	854	3,152	1,162	3	9	37	13
		Gas	1,955					4,268	10,679	23,532	11,878	89	226	507	253
Khorat Plateau Province (Mesozoic TPS)															
Permian Carbonates AU	1.0	***Oil***	–	0	0	0	0	0	0	0	0	0	0	0	0
		Gas	279					502	1,171	2,426	1,278	3	6	14	7
Khorat Group Sandstones AU	1.0	***Oil***	–	0	0	0	0	0	0	0	0	0	0	0	0
		Gas	202					187	568	1,478	665	1	3	8	4
Cuu Long Basin Province (Eocene-Oligocene Composite TPS)															
Syn-Rift Reservoirs AU	1.0	***Oil***	427	726	1,599	3,204	1,735	1,463	3,359	7,339	3,748	40	92	203	103
		Gas	315					112	487	1,750	649	3	14	50	19
Nam Con Son Basin Province (Eocene-Miocene Composite TPS)															
Oligocene-Miocene Reservoirs AU	1.0	***Oil***	146	321	643	1,192	685	1,165	2,376	4,524	2,547	38	79	151	85
		Gas	1,800					6,196	11,488	19,899	12,053	190	353	616	371
South China Sea Platform (Miocene TPS)															
Dangerous Grounds-Reed Bank AU	1.0	***Oil***	703	764	2,192	5,380	2,522	3,058	8,889	22,683	10,370	58	168	437	197
		Gas	4,217					4,609	13,151	32,381	15,149	260	756	1,928	881
Thai Basin Province (Eocene-Miocene Composite TPS)															
Pattani Trough AU	1.0	***Oil***	80	386	615	946	634	2,406	3,939	6,200	4,071	66	109	173	113
		Gas	787					3,739	6,055	9,419	6,253	148	242	379	250
Offshore Western Cenozoic Rifts AU	1.0	***Oil***	181	152	479	1,347	578	942	3,041	8,812	3,716	26	84	247	103
		Gas	257					136	426	1,360	543	5	17	55	22
Thai Cenozoic Basins Province (Eocene-Miocene Composite TPS)															
Onshore Cenozoic Rifts AU	1.0	***Oil***	76	162	362	727	391	104	240	503	263	2	5	10	5
		Gas	136					123	321	804	372	2	5	13	6
Palawan Shelf Province (Eocene-Miocene Composite TPS)															
Eocene-Miocene Reservoirs AU	1.0	***Oil***	101	84	226	609	270	54	147	417	179	2	5	13	6
		Gas	514					319	984	3,035	1,229	10	30	94	38
Tarakan Basin (Neogene TPS)															
Deltaic AU	1.0	***Oil***	38	22	64	198	81	32	96	307	123	1	3	10	4
		Gas	406					573	1,310	2,803	1,447	7	16	36	18
Turbidite AU	1.0	***Oil***	235	100	380	1,421	516	311	1,213	4,674	1,673	10	38	151	54
		Gas	2,376					2,076	6,441	17,361	7,668	24	78	223	95
Mangkalihat Carbonates AU	1.0	***Oil***	71	14	64	370	110	83	380	2,274	675	2	12	71	21
		Gas	590					162	710	3,343	1,089	4	16	76	25
Sulu Sea Province (Miocene TPS)															
Sandakan Reservoirs AU	1.0	***Oil***	178	58	231	997	339	84	345	1,536	515	3	11	53	18
		Gas	2,448					2,211	6,907	18,205	8,159	26	84	234	101
Baram Delta/Brunei-Sabah Basin Province (Brunei-Sabah TPS)															
Brunei-Sabah Deltaics AU	1.0	***Oil***	67	350	608	1,012	635	1,208	2,165	3,678	2,269	23	41	70	43
		Gas	444					2,905	5,130	8,618	5,366	90	160	270	168
Brunei-Sabah Turbidites AU	1.0	***Oil***	551	1,766	3,448	6,180	3,643	4,866	9,900	18,563	10,581	91	188	358	202
		Gas	1,352					3,384	7,515	15,100	8,159	128	290	594	316

Table 1. *Southeast Asia assessment results.—Continued*

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Total Petroleum Systems (TPS) and Assessment Units (AU)	AU probability	Field type	Largest expected field size	Total Undiscovered Resources											
				Oil (MMBO)				Gas (BCFG)				NGL (MMBNGL)			
				F95	F50	F5	Mean	F95	F50	F5	Mean	F95	F50	F5	Mean
Greater Sarawak Basin Province (Sarawak Basin TPS)															
Central Luconia AU	1.0	*Oil*	–	0	0	0	0	0	0	0	0	0	0	0	0
		Gas	2,492					11,849	20,048	32,212	20,759	318	542	878	562
Balingian AU	1.0	*Oil*	80	361	618	1,013	643	1,435	2,529	4,233	2,641	27	48	81	50
		Gas	687					2,340	4,189	7,169	4,392	132	243	425	256
East Natuna Carbonate AU	1.0	*Oil*	–	0	0	0	0	0	0	0	0	0	0	0	0
		Gas	1,913					4,729	9,646	18,038	10,281	126	260	494	278
Malay Basin Province (Oligocene-Miocene Composite TPS)															
Main Malay-Tho Chu AU	1.0	*Oil*	71	240	430	732	450	893	1,658	2,945	1,756	11	21	37	22
		Gas	1,158					4,200	7,661	13,049	8,008	87	160	275	167
Khmer Trough AU	1.0	*Oil*	82	60	179	493	214	215	681	1,974	835	3	8	25	10
		Gas	535					415	1,259	3,346	1,489	8	26	71	31
Barito Basin (Eocene-Miocene Composite TPS)															
Barito Foredeep Structures AU	1.0	*Oil*	84	20	94	460	146	32	160	816	256	1	3	16	5
		Gas	997					589	2,108	6,444	2,617	9	32	100	40
Central Sumatra Basin Province (Brown Shale-Sihapas TPS)															
Pematang/Sihapas Siliciclastics AU	1.0	*Oil*	14	84	142	233	148	70	133	240	141	6	12	23	13
		Gas	99					85	222	562	259	2	5	12	6
East Java Basin (Eocene-Miocene Composite TPS)															
East Java Carbonates AU	1.0	*Oil*	190	173	435	1,146	514	1,031	2,639	7,128	3,154	32	82	224	99
		Gas	1,742					3,049	6,319	12,670	6,879	68	142	288	155
East Java Siliciclastics AU	1.0	*Oil*	294	633	1,400	2,816	1,522	1,310	2,925	5,984	3,192	67	151	311	165
		Gas	2,358					8,286	17,078	32,285	18,264	613	1,291	2,471	1,381
Kutei Basin TPS															
Kutei Basin Deltaics AU	1.0	*Oil*	32	91	160	269	168	471	847	1,464	892	5	9	16	10
		Gas	952					1,299	3,056	6,652	3,401	58	143	331	162
Kutei Basin Turbidites AU	1.0	*Oil*	615	1,371	2,851	5,393	3,047	9,643	20,104	38,035	21,478	101	216	423	233
		Gas	2,471					11,212	19,416	31,896	20,230	187	328	546	342
North Sumatra Basin (Bampo-Cenozoic TPS)															
North Sumatra AU	1.0	*Oil*	12	48	77	119	79	288	478	763	495	5	10	17	10
		Gas	183					534	934	1,570	977	36	66	121	71
Mergui Basin AU	1.0	*Oil*	169	71	280	1,018	374	423	1,711	6,434	2,338	8	33	137	48
		Gas	1,493					2,796	6,486	13,524	7,096	188	461	1,031	516
Northwest Java Basin (Eocene-Miocene Composite TPS)															
Sunda-Asri Basins AU	1.0	*Oil*	31	90	161	274	169	152	279	495	296	5	9	16	9
		Gas	100					80	224	581	262	0	1	3	1
Ardjuna Basin AU	1.0	*Oil*	46	73	152	310	166	326	692	1,487	772	12	28	64	32
		Gas	378					625	1,350	2,729	1,474	15	33	71	36
Biliton-Vera Basins AU	1.0	*Oil*	116	136	348	797	391	606	1,588	3,818	1,819	23	63	163	74
		Gas	90					8	41	408	106	0	1	10	3
Penyu-West Natuna Basin Province (Oligocene-Miocene Composite TPS)															
Gabus-Udang-Urang Sandstones AU	1.0	*Oil*	24	27	66	150	74	109	284	699	329	1	4	10	5
		Gas	153					598	1,048	1,754	1,094	24	43	72	45
South Sumatra Basin (Lahat/Talang Akar-Cenozoic TPS)															
South Sumatra AU	1.0	*Oil*	82	133	321	681	353	537	1,338	2,967	1,491	11	28	65	32
		Gas	639					1,398	3,112	6,194	3,367	48	110	228	120
Total Conventional Resources				**8,922**	**19,541**	**41,558**	**21,632**	**128,908**	**272,848**	**557,051**	**298,761**	**3,828**	**8,270**	**17,216**	**9,099**

is later than oil, gas is focused into the younger, post-rift clastic and carbonate reservoirs. Volumetrically, gas would be expected to be more prevalent than oil in these provinces where post-rift sources have achieved the appropriate thermal maturity for generation (Doust and Sumner, 2007).

The methodology for the assessment included a complete geologic framework description for each province mainly based on published literature and definition of petroleum systems and assessment units within these systems. Exploration and discovery history was a critical part of the methodology used to estimate sizes and numbers of undiscovered accumulations. In areas where there are no discoveries (for example, Phu Khanh Basin) geologic analogs were used as a basis for volumes of undiscovered oil and gas resources. Each assessment unit was assessed for undiscovered oil and nonassociated gas accumulations, and coproduct ratios were used to calculate the volumes of associated gas (gas in oil fields) and natural gas liquids.

Resource Summary

The USGS assessed undiscovered conventional oil and gas resources in assessment units within 23 geologic provinces (table 1). For conventional oil resources, the mean total is 21,632 million barrels of oil (MMBO), with a range from 8,922 to 41,558 MMBO; for undiscovered conventional gas the mean total is 298,761 billion cubic feet (BCFG), with a range from 128,908 BCFG to 557,051 BCFG; and a mean total of 9,099 million barrels of natural gas liquids (MMBNGL), with a range from 3,828 to 17,216 MMBNGL.

Of the mean oil total of 21,632 MMBO, about 70 percent is estimated to be in six provinces—Baram Delta/Brunei-Sabah Basin (mean of 4,278 MMBO), Kutei Basin (mean of 3,215 MMBO), South China Sea Platform (mean of 2,522 MMBO), East Java Basin (mean of 2,036 MMBO), Cuu Long Basin (mean of 1,735 MMBO), and Thai Basin (mean of 1,212 MMBO). In addition, several provinces are estimated to have potential oil volumes greater than 500 MMBO—Northwest Java Basin (mean of 726 MMBO), Tarakan Basin (mean of 707 MMBO), Nam Con Son Basin (mean of 685 MMBO), Malay Basin (mean of 664 MMBO), Greater Sarawak Basin (mean of 643 MMBO), and Pearl River Mouth Basin (mean of 608 MMBO).

For the mean undiscovered gas total of 298,761 BCFG, about 60 percent is estimated to be in six provinces—Kutei Basin (mean of 46,001 BCFG), Greater Sarawak Basin (mean of 38,073 BCFG), East Java Basin (mean of 31,489 BCFG), Baram Delta/Brunei-Sabah Basin (mean of 26,375 BCFG), South China Sea Platform (mean of 25,519 BCFG), and Nam Con Son Basin (mean of 14,600 BCFG). Several other provinces are estimated to have potential gas volumes greater than 10,000 BCFG—Thai Basin (mean of 14,583 BCFG), Phu Khanh Basin (mean of 13,040 BCFG), Tarakan Basin (mean of 12,675 BCFG), Song Hong Basin (mean of 12,266 BCFG), and Malay Basin (mean of 12,088 BCFG). Overall, the assessment indicates that (1) more than 90 percent of the undiscovered oil and gas resources are offshore, and (2) there is more than twice as much undiscovered gas resource (298,761 BCFG, or 49,794 MMBOE) than undiscovered oil resource (21,632 MMBO) in the provinces of southeast Asia using a barrels of oil equivalent conversion.

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For Further Information

Supporting studies of the geologic models and the methodology used in the assessment of Southeast Asia Basins are in progress. Assessment results are available at the USGS Energy Program website, *http://energy.cr.usgs.gov/oilgas/*.

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