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National and Global Petroleum Assessment

Assessment of Continuous Gas Resources in the Khorat Plateau Province, Thailand and Laos, 2016

*U*sing a geology-based assessment methodology, the U.S. Geological Survey assessed mean undiscovered, technically recoverable resources of 2.3 trillion cubic feet of continuous gas in the Khorat Plateau Province of Thailand and Laos.

Introduction

The U.S. Geological Survey (USGS) completed a geology-based assessment of undiscovered, technically recoverable shale-gas and tight-gas resources in the Khorat Plateau Province of northeast Thailand and western Laos (fig. 1). The Khorat Plateau Province is part of Sundaland, a geologically complex continental area that consists of several terranes that originated from the northern margin of the supercontinent Gondwana and accreted to Eurasia from the late Paleozoic through the Mesozoic (Barber and others, 2011; Metcalfe, 2011; Morley, 2012; Hall, 2013; Morley and others, 2013). Progressive accretion of several Gondwanan blocks resulted in a mosaic of terranes, suture zones, accretionary wedges, and arc rocks that record a complex geologic history that may have affected the development and preservation of viable petroleum systems. Petroleum source rocks were deposited in extensional basins formed in the late Carboniferous–late Permian and Late Triassic (Booth and Sattayarak, 2011; Racey, 2011). Upper Carboniferous–upper Permian source rocks are marine shales, carbonaceous shales, and coals; Triassic source rocks are organic-rich, deep-basin lacustrine shales. Burial history modeling suggests that petroleum residing in potential tight (low permeability) sandstone or shale reservoirs entered the thermal window for dry gas during Late Jurassic–Early Cretaceous burial by more than 5 kilometers of Khorat Group rocks. Both source-rock intervals were exposed to several phases of deformation, uplift, and erosion that may have adversely affected the retention of gas in tight sandstones, siltstones, and shale reservoirs. This assessment quantifies the volumes of gas potentially retained within lacustrine shales of the Triassic Kuchinarai Group and gas potentially retained within tight-clastic reservoirs of the Triassic through Lower Cretaceous (Koysamran and Comrie-Smith, 2011). Shows of gas from tight rock have been reported from wells in the Khorat Plateau Province (Booth, 1998; Malila, 2011; Racey, 2011), but there are no reports of recoverable gas from shales (Chumkratoke and Dunn-Norman, 2015).

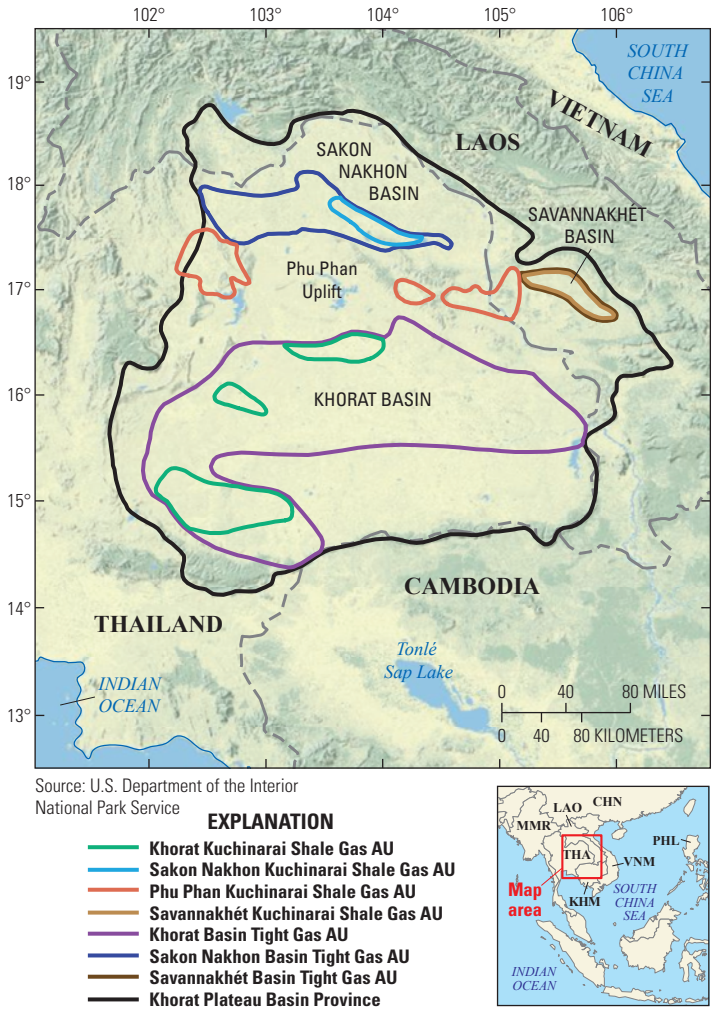

Figure 1. Map showing the location and boundaries of the Khorat Plateau Province, Thailand and Laos, and the seven continuous assessment units (AUs) defined for this study.

Total Petroleum Systems and Assessment Units

For the Khorat Plateau Province, the USGS defined two total petroleum systems. The Triassic Kuchinarai Total Petroleum System was defined to include gas that was generated and potentially retained within synrift lacustrine organic-rich shales of the Triassic Kuchinarai Group (fig. 2). The Khorat Kuchinarai Shale Gas Assessment Unit (AU), the Sakon Nakhon Kuchinarai Shale Gas AU, the Phu Phan Kuchinarai Shale Gas AU, and the Savannakhét Kuchinarai Shale Gas AU were defined within this TPS. The Upper Carboniferous–Triassic Composite Total Petroleum System was defined to include gas that is potentially retained within tight-clastic reservoirs of the Upper Triassic, Jurassic, and Cretaceous. The Khorat Basin Tight Gas AU, the Sakon Nakhon Basin Tight Gas AU, and the Savannakhét Basin Tight Gas AU were defined within this TPS. Assessment unit boundaries were developed using published maps depicting Permian and Triassic depocenters (Booth and Sattayarak, 2011). We

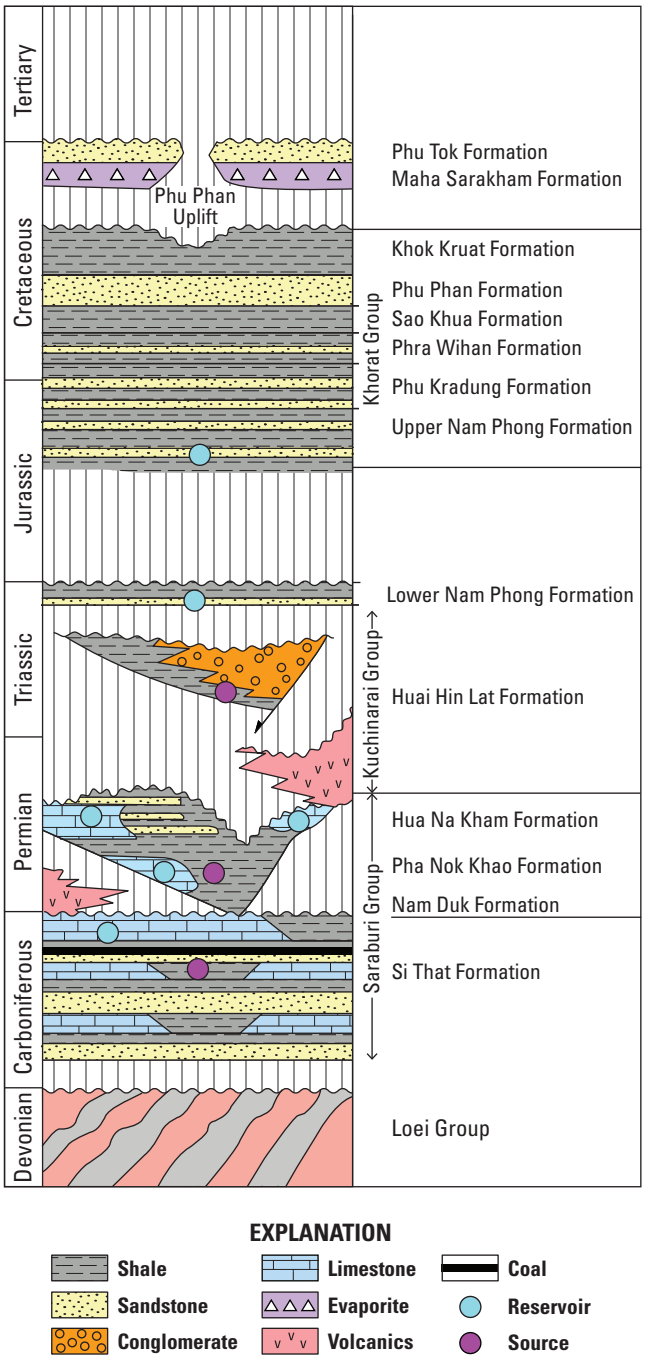

Figure 2. Stratigraphy of the Khorat Plateau Province, Thailand and Laos (modified from Koysamran and Comrie-Smith, 2011).

recognize that there were three episodes of basin formation in the province, but the AUs were named using the present geomorphic elements of Khorat Basin, Sakon Nakhon Basin, Phu Phan Uplift, and Savannakhét Basin. Assessment input data for seven continuous AUs are shown in table 1. Well drainage areas, estimated ultimate recoveries, and success ratios were taken from U.S. shale-gas and tight-gas analogs.

Undiscovered Resources Summary

In the Khorat Plateau Province, the USGS quantitatively assessed total mean undiscovered, technically recoverable shale-gas and tight-gas resources of 2,301 billion cubic feet of gas (BCFG), or 2.3 trillion cubic feet of gas, with an F95–F5 range from 0 to 9,268 BCFG and 17 million barrels of natural gas liquids (MMBNGL) with an F95–F5 range from 0 to 67 MMBNGL (table 2). For undiscovered, technically recoverable shale-gas resources, the mean total is 586 BCFG with an F95–F5 range from 0 to 2,150 BCFG, and 6 MMBNGL with an F95–F5 range from 0 to 19 MMBNGL. For undiscovered tight-gas resources, the mean total is 1,715 BCFG with an F95–F5 range from 0 to 7,118 BCFG and 11 MMBNGL with an F95–F5 range from 0 to 48 MMBNGL. The wide ranges of estimated undiscovered gas resources reflect the level of geologic uncertainty on the retention of gas within tight clastic reservoirs and shale reservoirs given the tectonic history. For gas accumulations, zeros at F95 reflect the chance that continuous gas might not exist in the AU, and the geologic AU probability (risk) was estimated to be less than one.

Multistory, high-sinuosity fluvial channel sandstone with lateral accretion, Phra Wihan Formation of the Khorat Group near Ban Nong Khu, Thailand. Sandstone is 4.5 meters thick.

Table 1. Key assessment input data for seven continuous assessment units in the Khorat Plateau Basin Province, Thailand and Laos.

[AU, assessment unit; %, percent; EUR, estimated ultimate recovery per well; BCFG, billion cubic feet of gas. EUR, well drainage area, and success ratios are from U.S. shale-gas and tight-gas analogs. The average EUR input is the minimum, median, maximum, and calculated mean. Shading indicates not applicable]

Assessment input data—Continuous AUs	Khorat Kuchinarai Shale Gas AU				Sakon Nakhon Kuchinarai Shale Gas AU			
	Minimum	Mode	Maximum	Calculated mean	Minimum	Mode	Maximum	Calculated mean
Potential production area of AU (acres)	600	821,000	1,967,000	929,533	600	187,000	374,000	187,200
Average drainage area of wells (acres)	80	120	160	120	80	120	160	120
Success ratios (%)	10	50	90	50	10	50	90	50
Average EUR (BCFG)	0.04	0.1	0.8	0.138	0.04	0.1	0.8	0.138
AU probability	0.6				0.6			
Assessment input data—Continuous AUs	**Phu Phan Kuchinarai Shale Gas AU**				**Savannakhét Kuchinarai Shale Gas AU**			
	Minimum	Mode	Maximum	Calculated mean	Minimum	Mode	Maximum	Calculated mean
Potential production area of AU (acres)	600	675,000	1,351,000	675,533	600	249,000	498,000	249,200
Average drainage area of wells (acres)	80	120	160	120	80	120	160	120
Success ratios (%)	10	50	90	50	10	50	90	50
Average EUR (BCFG)	0.04	0.08	0.4	0.098	0.04	0.08	0.4	0.098
AU probability	0.6				0.5			
Assessment input data—Continuous AUs	**Khorat Basin Tight Gas AU**				**Sakon Nakhon Basin Tight Gas AU**			
	Minimum	Mode	Maximum	Calculated mean	Minimum	Mode	Maximum	Calculated mean
Potential production area of AU (acres)	600	1,303,000	12,408,000	4,570,533	600	371,000	2,081,000	817,533
Average drainage area of wells (acres)	40	80	120	80	40	80	120	80
Success ratios (%)	10	50	90	50	10	50	90	50
Average EUR (BCFG)	0.04	0.08	0.4	0.098	0.04	0.08	0.4	0.098
AU probability	0.5				0.5			
Assessment input data—Continuous AUs	**Savannakhét Basin Tight Gas AU**							
	Minimum	Mode	Maximum	Calculated mean				
Potential production area of AU (acres)	600	249,000	498,000	249,200				
Average drainage area of wells (acres)	40	80	120	80				
Success ratios (%)	10	50	90	50				
Average EUR (BCFG)	0.04	0.08	0.4	0.098				
AU probability	0.5							

Lateral accretion surfaces and bedding in high-sinuosity fluvial channel sandstone of the Khorat Group along Highway 304, near kilometer marker 70. Sandstone is 5 meters thick.

Table 2. Assessment results for seven continuous assessment units in the Khorat Plateau Basin Province, Thailand and Laos.

[BCFG, billion cubic feet of gas; NGL, natural gas liquids; MMBNGL, million barrels of natural gas liquids. Results shown are fully risked estimates. For gas accumulations, all liquids are included in the NGL category. 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							
			Gas (BCFG)				NGL (MMBNGL)			
			F95	F50	F5	Mean	F95	F50	F5	Mean
Triassic Kuchinarai Total Petroleum System										
Khorat Kuchinarai Shale Gas AU	0.6	Gas	0	162	1,172	312	0	1	10	3
Sakon Nakhon Kuchinarai Shale Gas AU	0.6	Gas	0	33	233	62	0	0	2	1
Phu Phan Kuchinarai Shale Gas AU	0.6	Gas	0	105	554	162	0	1	5	1
Savannakhét Kuchinarai Shale Gas AU	0.5	Gas	0	0	191	50	0	0	2	1
Total shale-gas resources			**0**	**300**	**2,150**	**586**	**0**	**2**	**19**	**6**
Upper Carboniferous–Triassic Composite Total Petroleum System										
Khorat Basin Tight Gas AU	0.5	Gas	0	0	5,801	1,389	0	0	36	8
Sakon Nakhon Basin Tight Gas AU	0.5	Gas	0	0	1,024	250	0	0	8	2
Savannakhét Basin Tight Gas AU	0.5	Gas	0	0	293	76	0	0	4	1
Total tight-gas resources			**0**	**0**	**7,118**	**1,715**	**0**	**0**	**48**	**11**
Total continuous resources			**0**	**300**	**9,268**	**2,301**	**0**	**2**	**67**	**17**

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For More Information

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

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