USGS
science for a changing world

National and Global Petroleum Assessment

Assessment of Undiscovered Continuous Oil and Gas Resources in the Bohaiwan Basin Province, China, 2017

*U*sing a geology-based assessment methodology, the U.S. Geological Survey estimated mean undiscovered, technically recoverable continuous resources of 2.0 billion barrels of oil and 20.3 trillion cubic feet of gas in the Bohaiwan Basin Province, China.

Introduction

The U.S. Geological Survey (USGS) completed an assessment of undiscovered, technically recoverable continuous oil and gas resources in the Bohaiwan Basin (or Bohai Bay Basin) Province (fig. 1), the most prolific petroleum province in China. The basin is a composite of grabens, half-grabens, tilted fault blocks, and horsts within which sedimentary rocks range in age from Cambrian to Neogene (Mao and others, 2017). The complex tectonic history of the Bohaiwan Basin Province affected the development of petroleum systems (Allen and others, 1998; Ryder and others, 2011; Liang and others, 2016; Mao and others, 2017). Two major petroleum systems are related to the tectonic history. Coals of the late Carboniferous–Permian are known sources of gas in the deep subbasins (Huang and others, 2010), whereas Paleogene lacustrine shales are known sources of oil and gas and are the major petroleum source rocks in the basin (Jiang and others, 2016; He and others, 2017).

Total Petroleum Systems and Assessment Units

For the Bohaiwan Basin Province, the USGS defined two total petroleum systems (TPSs) and related assessment units (AUs): the Carboniferous–Permian Coal TPS with the Carboniferous–Permian Tight Gas AU within this TPS and the Eocene Lacustrine Shale TPS with the Eocene Shahejie Lacustrine Shale Oil AU and Eocene Shahejie Lacustrine Shale Gas AU within this TPS. The geologic model for the Carboniferous–Permian Tight Gas AU is for gas that was generated from coals to have migrated locally into low-permeability rocks at depths generally deeper than 5,000 meters. As many as 25 coals, the thickest at 9 meters, have been recorded in the Carboniferous–Permian section. The major source of geologic risk in the assessment unit is the presence of recoverable gas from low-permeability rock. The geologic models for the Eocene Shahejie Lacustrine Shale Oil and Shale Gas AUs are for some portion of the oil or gas generated within the shales to be retained within the shales following oil or gas migration. Members 1, 3, and 4 of the lacustrine Shahejie Formation are potential petroleum source rocks with a cumulative source-rock thickness of several hundred meters. These lacustrine shales contain Type I and Type II organic matter and have total organic carbon contents as high as 13 weight percent, averaging 3 weight percent (Li and others, 2013; Jiang and others, 2016; He and others, 2017). The sources of geologic risk in the lacustrine AUs are retention of recoverable oil or gas in the shales, heterogeneity of lacustrine rift facies (Li and others, 2013), and extent of source rocks that are thermally mature for gas in the subbasins (Jiang and others, 2015).

Assessment input data are summarized in table 1. Well drainage areas, success ratios, and estimated ultimate recoveries are taken from U.S. tight-gas, shale-oil, and shale-gas analogs. Assessment input was modeled using vertical wells.

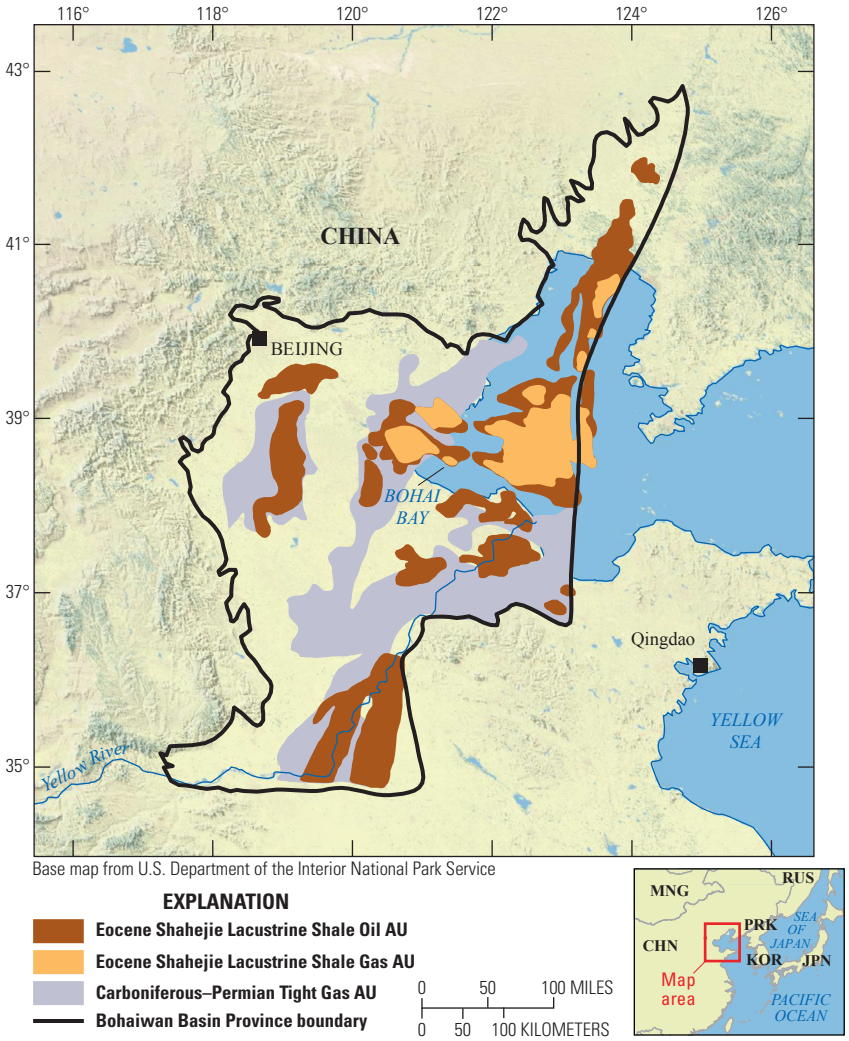

Figure 1. Location of the Bohaiwan Basin Province, China, and the three assessment units (AUs) defined in this study.

Undiscovered Resources Summary

The USGS quantitatively assessed undiscovered continuous shale-oil, shale-gas, and tight-gas resources in the Bohaiwan Basin Province (table 2). For undiscovered resources, the estimated means are 2,036 million barrels of oil (MMBO), or 2.0 billion barrels of oil, with an F95 to F5 range from 423 to 4,774 MMBO; 20,320 billion cubic feet of gas (BCFG), or 20.3 trillion cubic feet of gas, with an F95–F5 range from 4,325 to 46,124 BCFG; and 203 million barrels of natural gas liquids (MMBNGL) with an F95–F5 range from 41 to 479 MMBNGL. Of the mean total of 20,320 BCFG, 16,814 BCFG, or 83 percent, are estimated to be potential tight-gas resources.

Table 1. Key assessment input data for three continuous assessment units in the Bohaiwan Basin Province, China.

[AU, assessment unit; %, percent; EUR, estimated ultimate recovery per well; MMBO, million barrels of oil; BCFG, billion cubic feet of gas. Well drainage areas, EUR, and success ratios are from U.S. shale-gas, shale-oil, 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	Eocene Shahejie Lacustrine Shale Oil AU				Eocene Shahejie Lacustrine Shale Gas AU			
	Minimum	Mode	Maximum	Calculated mean	Minimum	Mode	Maximum	Calculated mean
Potential production area of AU (acres)	800	5,156,000	10,313,000	5,156,767	800	2,011,250	4,023,000	2,011,683
Average drainage area of wells (acres)	40	120	200	120	80	120	160	120
Success ratios (%)	10	50	90	50	10	50	90	50
Average EUR (MMBO, oil; BCFG, gas)	0.04	0.08	0.3	0.092	0.1	0.25	0.7	0.273
AU probability	1.0				1.0			

Assessment input data—Continuous AU	Carboniferous–Permian Tight Gas AU			
	Minimum	Mode	Maximum	Calculated mean
Potential production area of AU (acres)	800	8,784,000	17,568,000	8,784,267
Average drainage area of wells (acres)	40	120	200	120
Success ratios (%)	10	50	90	50
Average EUR (BCFG)	0.2	0.4	1.2	0.444
AU probability	1.0			

Table 2. Assessment results for three continuous assessment units in the Bohaiwan Basin Province, China.

[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. 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											
			Oil (MMBO)				Gas (BCFG)				NGL (MMBNGL)			
			F95	F50	F5	Mean	F95	F50	F5	Mean	F95	F50	F5	Mean
Eocene Lacustrine Shale Total Petroleum System														
Eocene Shahejie Lacustrine Shale Oil AU	1.0	Oil	423	1,710	4,774	2,036	240	998	2,964	1,224	2	10	30	12
Eocene Shahejie Lacustrine Shale Gas AU	1.0	Gas					499	1,975	5,084	2,282	5	19	53	23
Carboniferous–Permian Coal Total Petroleum System														
Carboniferous–Permian Tight Gas AU	1.0	Gas					3,586	14,415	38,076	16,814	34	141	396	168
Total undiscovered continuous resources			**423**	**1,710**	**4,774**	**2,036**	**4,325**	**17,388**	**46,124**	**20,320**	**41**	**170**	**479**	**203**

References Cited

Allen, M.B.; Macdonald, D.I.M.; Xun Zhao; Vincent, S.J.; and Brouet-Menzies, Christine, 1998, Transtensional deformation in the evolution of the Bohai Basin, northern China, *in* Holdsworth, R.E., Strachan, R.A., and Dewey, J.F., eds., Continental transpressional and transtensional tectonics: London, Geological Society, Special Publications, v. 135, p. 215–229.

He Jianhua; Ding Wenlong; Jiang Zaixing; Jui Kai; Li Ang; and Sun Yaxiong, 2017, Mineralogical and chemical distribution of the Es_3^L oil shale in the Jiyang depression, Bohai Bay Basin (E. China)—Implications for paleoenvironmental reconstruction and organic matter accumulation: Marine and Petroleum Geology, v. 81, p. 196–219.

Huang Shipeng; Liao Fengrong; and Wu Xiaoqi, 2010, Geochemical characteristics of Carboniferous–Permian coal-formed gas in Bohai Bay Basin: Energy Exploration and Exploitation, v. 28, no. 1, p. 13–24.

Jiang Fujie; Pang Xiongqi; Bai Jing; Zhou Xinhuai; Li Jianping; and Guo Yonghua, 2016, Comprehensive assessment of source rocks in the Bohai Sea area, eastern China: American Association of Petroleum Geologists Bulletin, v. 100, no. 6, p. 969–1002.

Jiang Fujie; Pang Xiongqi; Yu Sa; Hu Tao; Bai Jing; Han Guomeng; and Li Boyuan, 2015, Charging history of Paleogene deep gas in the Qibei sag, Bohai Bay Basin, China: Marine and Petroleum Geology, v. 67, p. 617–634.

Li Maowen; Li Zhiming; Jiang Qigui; and Cao Tingting, 2013, Reservoir quality, hydrocarbon mobility and implications for lacustrine shale oil productivity in the Paleogene sequence, Bohai Bay Basin: American Association of Petroleum Geologists, Search and Discovery Article No. 80342, November 25, 2013, 33 p.

Liang Jintong; Wang Hongliang; Bai Ying; Ji Xinyuan; and Duo Xuemei, 2016, Cenozoic tectonic evolution of the Bohai Bay Basin and its coupling relationship with Pacific plate subduction: Journal of Asian Earth Sciences, v. 127, p. 257–266.

Mao Liguang; Xiao Ancheng; Zhang Hongwei; Wu Zhankui; Liufu Yi; Wu Lei; and Zhao Xianzheng, 2017, Structural patterns of the late Mesozoic crustal detachment system in the Raoyang Sag, Bohai Bay Basin, eastern China—New insights from 3D seismic data: Marine and Petroleum Geology, v. 84, p. 215–224.

Ryder, R.T.; Qiang Jin; McCabe, P.J.; Nuccio, V.F.; and Persits, Felix, 2011, Shahejie–Shahejie/Guantao/Wumishan and Carboniferous/Permian coal–Paleozoic total petroleum systems in the Bohaiwan Basin, China (based on geologic studies for the 2000 World Energy Assessment Project of the U.S. Geological Survey): U.S. Geological Survey Scientific Investigations Report 2011–5010, 89 p.

Bohaiwan Basin Province Assessment Team

Christopher J. Schenk, Marilyn E. Tennyson, Tracey J. Mercier, Cheryl A. Woodall, Thomas M. Finn, Michael E. Brownfield, Phuong A. Le, Timothy R. Klett, Stephanie B. Gaswirth, Kristen R. Marra, Heidi M. Leathers-Miller, and Christopher J. Potter

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/fs20173082