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World Petroleum Resources Project

Assessment of Undiscovered Oil and Gas Resources of the Assam, Bombay, Cauvery, and Krishna–Godavari Geologic Provinces, South Asia, 2011

Using a geology-based assessment methodology, the U.S. Geological Survey estimated volumes of undiscovered, technically recoverable, conventional petroleum resources for the Assam, Bombay, Cauvery, and Krishna–Godavari Provinces,* South Asia. The estimated mean volumes are as follows: (1) Assam Province, 273 million barrels of crude oil, 1,559 billion cubic feet of natural gas, and 43 million barrels of natural gas liquids; (2) Bombay Province, 1,854 million barrels of crude oil, 15,417 billion cubic feet of natural gas, and 498 million barrels of natural gas liquids; (3) Cauvery Province, 941 million barrels of crude oil, 25,208 billion cubic feet of natural gas, and 654 million barrels of natural gas liquids; and (4) Krishna–Godavari Province, 466 million barrels of crude oil, 37,168 billion cubic feet of natural gas, and 484 million barrels of natural gas liquids. The totals for the four provinces are 3,534 million barrels of crude oil, 79,352 billion cubic feet of natural gas, and 1,679 million barrels of natural gas liquids.

Introduction

The U.S. Geological Survey (USGS) estimated volumes of undiscovered, technically recoverable, conventional oil and gas resources of the Assam, Bombay, Cauvery, and Krishna–Godavari Provinces, South Asia. The assessment is part of a project to estimate petroleum resources for priority basins around the world, specifically for total petroleum systems (TPS). Assessment units (AU) are defined on the basis of their geologic attributes that are favorable for the generation and accumulation of petroleum. This assessment was based on data provided by the Indian Directorate General of Hydrocarbons, published geologic information, commercial data from oil and gas wells and fields, and field production records.

*The term "provinces" refers to geologically defined units accessed by USGS for the purposes of this report and carries no political or diplomatic connotation.

Total Petroleum Systems and Assessment Units

Assam Province

The Assam Province is in northeastern India and northwestern Myanmar (fig. 1). The province is interpreted to have originated as a Mesozoic rifted passive margin, but evolved into a foreland basin during the Neogene, when the Indian plate collided with the Eurasian continent.

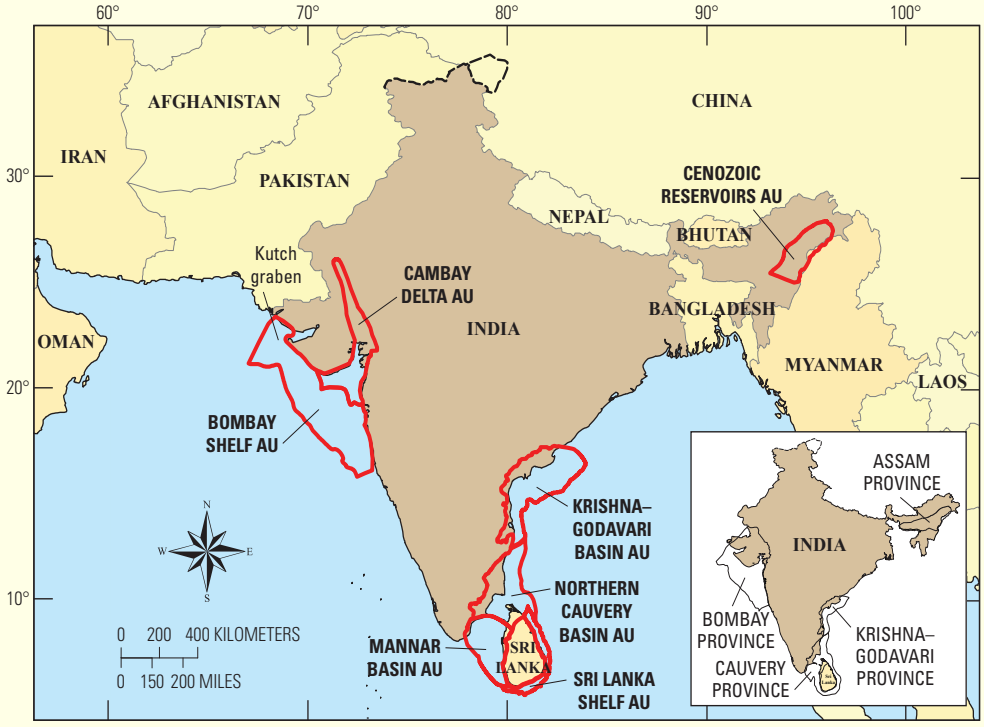

Figure 1. Generalized map showing the boundaries of the Bombay Shelf, Cambay Delta, Cenozoic Reservoirs, Krishna–Godavari Basin, Northern Cauvery Basin, Mannar Basin,and Sri Lanka Shelf assessment units (modified from Wandrey, 2004a, b). The Sri Lanka Shelf assessment unit was not quantitatively assessed in this study. Inset map shows locations of Bombay, Assam, Cauvery, and Krishna–Godavari Provinces (Wandrey and Law, 1998). Dashed boundaries indicate lines of control and area of Indian claim.

These tectonic events controlled the distribution of Paleogene source rocks, as well as the oil and gas accumulations (Wandrey, 2004a). The Cenozoic Composite TPS was defined for the Assam Province (table 1), which includes petroleum source rocks ranging in age from Eocene to Oligocene. The Cenozoic Reservoirs AU, containing conventional undiscovered oil and gas resources, was defined geologically within the Assam Province and encompasses more than 42,300 square kilometers (km^2).

Bombay Province

The Bombay Province, located along the northwestern coast of India (fig. 1), includes a rifted passive margin comprising a marine shelf, carbonate platform, and rift/sag basins. These structures were used to define the Bombay Shelf AU and the Cambay Delta AU (Wandrey, 2004b). The Bombay Shelf AU includes the Bombay structural high and part of a failed rift system of the Kutch graben and encompasses more than 180,140 km^2. The Cambay Delta AU includes the failed rift of the Cambay graben and encompasses more than 70,120 km^2. Source rocks are correlative between the two AUs, therefore, one Mesozoic–Cenozoic Composite TPS was defined for both the Bombay Shelf and Cambay Delta AUs (table 1).

Cauvery Province

The Cauvery Province is located along the southeastern coast of India and includes coastal parts of Sri Lanka (fig. 1). The Mesozoic–Cenozoic Composite TPS was defined for the province. The Northern Cauvery Basin AU, the Mannar Basin AU, and the Sri Lanka Shelf AU were delineated by major structures. The Northern Cauvery Basin AU is a Mesozoic-age, rifted passive margin that encompasses more than 80,090 km^2. The Mannar Basin AU is also a Mesozoic-age, rifted passive margin, but underwent later compression. It includes about 58,600 km^2 and is separated from the Northern Cauvery Basin AU by an arch extending from India to Sri Lanka (fig. 1). The Sri Lanka Shelf AU is located along the east side of the Sri Lanka block and encompasses approximately 22,590 km^2. Because of paucity of data, the Sri Lanka Shelf AU was not quantitatively assessed in this study.

Krishna–Godavari Province

The Krishna–Godavari Province is a rifted passive margin along the eastern coast of India (fig. 1). A Mesozoic–Cenozoic Composite TPS was defined for the province; however, the source rocks are of somewhat different ages than those in the neighboring Cauvery Province. The Krishna–Godavari Basin AU encompasses the the entire province and is an area of approximately 109,070 km^2 (fig. 1).

Assessment Results

Estimates of volumes of undiscovered, technically recoverable, conventional oil and gas resources are listed in table 1. No attempt was made to estimate economically recoverable resources. The estimated mean volumes for the Cenozoic Reservoirs AU of the Assam Province are approximately 273 million barrels (MMB) of crude oil, 1,559 billion cubic feet (BCF) of natural gas (568 BCF of associated and dissolved natural gas and 991 BCF of nonassociated natural gas), and 43 MMB of natural gas liquids (26 MMB of natural gas liquids in oil accumulations and 17 MMB of total liquids in nonassociated gas accumulations).

The estimated mean volumes for the Bombay Province are about 1,854 MMB of crude oil, 15,417 BCF of natural gas (4,710 BCF of associated and dissolved natural gas and 10,707 BCF of nonassociated natural gas), and 498 MMB of natural gas liquids (55 MMB of natural gas liquids in oil accumulations and 443 MMB of total liquids in nonassociated gas accumulations). The volumetric contributions from each AU are (1) Bombay Shelf AU, approximately 1,449 MMB of crude oil, 13,579 BCF of natural gas (3,986 BCF of associated and dissolved natural gas and 9,593 BCF of nonassociated natural gas), and 447 MMB of natural gas liquids (35 MMB of natural gas liquids in oil accumulations and 412 MMB of total liquids in nonassociated gas accumulations); and (2) Cambay Delta AU, about 405 MMB of crude oil, 1,838 BCF of natural gas (724 BCF of associated and dissolved natural gas and 1,114 BCF of nonassociated natural gas), and 51 MMB of natural gas liquids (20 MMB of natural gas liquids in oil accumulations and 31 MMB of total liquids in nonassociated gas accumulations).

The estimated mean volumes for the Cauvery Province are approximately 941 MMB of crude oil, 25,208 BCF of natural gas (3,255 BCF of associated and dissolved natural gas and 21,953 BCF of nonassociated natural gas), and 654 MMB of natural gas liquids (82 MMB of natural gas liquids in oil accumulations and 572 MMB of total liquids in nonassociated gas accumulations). The volumetric contributions from each AU are as follows: (1) Northern Cauvery Basin AU approximately 458 MMB of crude oil, 12,979 BCF of natural gas (1,585 BCF of associated and dissolved natural gas and 11,394 BCF of nonassociated natural gas), and 337 MMB of natural gas liquids (40 MMB of natural gas liquids in oil accumulations and 297 MMB of total liquids in nonassociated gas accumulations); and

Table 1. Assam, Bombay, Cauvery, and Krishna–Godavari Provinces assessment results (undiscovered, technically recoverable, conventional petroleum resources).

[MMB, million barrels; BCF, billion cubic feet. Results shown are fully risked estimates. For gas fields, all liquids are included under the natural gas liquids (NGL) category. F95 denotes 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. TPS, total petroleum system; AU, assessment unit. Gray shading indicates not applicable]

Total petroleum systems (TPS) and assessment units (AU)	Field type	Mean (expected) largest field size (MMB or BCF)	Total undiscovered resources											
			Oil (MMB)				Gas (BCF)				NGL (MMB)			
			F95	F50	F5	Mean	F95	F50	F5	Mean	F95	F50	F5	Mean
Assam Province, Cenozoic Composite TPS														
Cenozoic Reservoirs AU	Oil	23	151	261	436	273	297	542	936	568	14	25	43	26
	Gas	92					550	949	1,579	991	8	16	29	17
Total undiscovered petroleum resources						**273**				**1,559**				**43**
Bombay Province, Mesozoic–Cenozoic Composite TPS														
Bombay Shelf AU	Oil	24	857	1,388	2,257	1,449	2,298	3,821	6,264	3,986	20	34	55	35
	Gas	271					5,573	9,182	14,962	9,593	238	394	645	412
Cambay Delta AU	Oil	29	259	394	588	405	427	697	1,111	724	11	19	30	20
	Gas	186					621	1,068	1,769	1,114	14	28	58	31
Total undiscovered petroleum resources						**1,854**				**15,417**				**498**
Cauvery Province, Mesozoic–Cenozoic Composite TPS														
Northern Cauvery Basin AU	Oil	22	274	440	705	458	908	1,520	2,485	1,585	23	39	63	40
	Gas	755					6,407	10,922	18,010	11,394	164	284	473	297
Mannar Basin AU	Oil	59	234	451	837	483	762	1,554	2,969	1,670	19	39	76	42
	Gas	905					5,222	9,897	18,153	10,559	133	258	477	275
Total undiscovered petroleum resources						**941**				**25,208**				**654**
Krishna–Godavari Province, Mesozoic–Cenozoic Composite TPS														
Krishna–Godavari Basin AU	Oil	46	262	448	737	466	919	1,668	2,843	1,746	28	51	87	53
	Gas	6,908					15,792	33,088	63,273	35,422	154	367	915	431
Total undiscovered petroleum resources						**466**				**37,168**				**484**
Assam, Bombay, Cauvery, and Krishna–Godavari Provinces														
Total undiscovered petroleum resources						**3,534**				**79,352**				**1,679**

(2) Mannar Basin AU, about 483 MMB of crude oil, 12,229 BCF of natural gas (1,670 BCF of associated and dissolved natural gas and 10,559 BCF of nonassociated natural gas), and 317 MMB of natural gas liquids (42 MMB of natural gas liquids in oil accumulations and 275 MMB of total liquids in nonassociated gas accumulations).

The estimated mean volumes for the Krishna–Godavari Basin AU of the Krishna–Godavari Province are approximately 466 million barrels (MMB) of crude oil, 37,168 billion cubic feet (BCF) of natural gas (1,746 BCF of associated and dissolved natural gas and 35,422 BCF of nonassociated natural gas), and 484 MMB of natural gas liquids (53 MMB of natural gas liquids in oil accumulations and 431 MMB of total liquids in nonassociated gas accumulations).

For Further Information

Supporting geologic studies of total petroleum systems and assessment units, and reports on the methodology used in the assessment of the Assam, Bombay, Cauvery, and Krishna–Godavari Provinces, as well as the assessment results, are available at the USGS Energy website: *http://energy.usgs.gov*.

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