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Assessment of undiscovered conventionally recoverable petroleum resources in Tertiary sedimentary basins of Thailand

by

Keith Robinson[1/]

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

[1/] Denver, Colorado

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ASSESSMENT OF ENERGY RESOURCES

This report was prepared as part of the World Energy Resources Program of the U.S. Geological Survey (USGS). The objective of the study is to assess the undiscovered conventionally recoverable resources remaining within petroleum-producing provinces. The study utilizes geological and petroleum engineering data, in conjunction with statistical techniques, to estimate undiscovered resources by a process involving a team of geologists and statisticians. The geologic investigation leading to the assessment was conducted by Keith Robinson. The estimates represent the views of the U.S. Geological Survey estimation team and should not be regarded as an official position of the Department of the Interior.

Other U.S. Geological Survey publications relating to the assessment of undiscovered conventionally recoverable petroleum resources include the following:

Open-File Reports
- 81-0986 - Persian Gulf Basin and Zagros fold belt (Arabian-Iranian Basin)
- 81-1027 - Volga-Ural Basin
- 81-1142 - Indonesia
- 81-1143 - Northeastern Mexico
- 81-1144 - Southeastern Mexico, northern Guatemala, and Belize
- 81-1145 - Trinidad
- 81-1146 - Venezuela
- 81-1147 - West Siberia and Kara Sea Basins, USSR
- 82-0296 - Middle Caspian Basin, USSR
- 82-1027 - East Siberian Basin, USSR
- 82-1056 - North Africa
- 82-1057 - Timan-Pechora Basin, USSR, and Barents-northern Kara shelf
- 83-0598 - Northwestern, central, northeastern Africa
- 83-0801 - Onshore China
- 84-0094 - Northwest European region
- 84-0158 - New Zealand

ACKNOWLEDGMENTS

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INTRODUCTION

The location of Thailand is shown in figure 1, together with the distribution of major Tertiary sedimentary basins in Southeast Asia. Sedimentary basins and provinces immediately adjacent to the assessment area are identified in table 1, and the area and volumes of non-melange, unmetamorphosed Tertiary sediments in selected basins and regions within the assessment area are given. Figure 2 shows the areas of assessment in Thailand, which include the Gulf of Thailand, the Andaman Sea, and numerous relatively small, onshore Tertiary basins, extending from Bangkok to the northern border of Thailand. The Khorat Plateau area was not included in the assessment. Figure 3 shows the location of known gas fields in the Gulf of Thailand, together with oil, gas, and condensate discovery wells as of 1982. The fields and discovery wells are identified in table 2, as are the location, discovery date, type of field or discovery, and status. Table 3 lists estimates by the USGS appraisal group of oil and gas resources for Tertiary sedimentary basins in offshore and onshore areas of Thailand as a whole. Figures 4 and 5 are computer generated graphs showing the probability of occurrence relative to specific amounts of oil and gas resources. Data supplementary to these estimates are given in table 4.

In Southeast Asia, Tertiary sedimentary basins, of a size and volume suitable for hydrocarbon generation and accumulation, are located mostly in offshore areas. This is essentially true for Thailand, although several relatively small, and possibly deep, Tertiary basins do occur in onshore areas of northern Thailand. As a consequence, the assessment of undiscovered petroleum resources is confined primarily to areas of Tertiary sedimentation underlying marine territorial waters claimed by Thailand, and restricted to areas with water depths of less than 1,000 meters. This report is not authoritative with respect to the delineation of international maritime boundaries, and those shown are only approximate for the convenience of the assessment. They are not to be regarded as the official position of the Department of the Interior or the U.S. Government.

The offshore regions of Thailand encompass most of the Thai Basin, the northwest part of the Malay Basin, the smaller isolated Chumphon, Thammarat and Songkhla Basins, and the Ranong and Mergui Basins. The Ranong and Mergui Basins are located off the west coast of Thailand in the Andaman Sea. The Thai, Malay, Chumphon, Thammarat and Songkhla Basins are located off the southeast coast in the Gulf of Thailand. The Thai Basin may be subdivided into a number of distinct provinces, or parallel and en echelon troughs and ridges, separated by marked north-south oriented faulting. The troughs and ridges have resulted from block faulting in Late Cretaceous or early Tertiary time that formed a complex series of north-south trending horst and graben structures. The most prominent troughs are the deep Pattani Trough and the shallower Kra and Prachuap (Western) Basins (fig. 2). The Pattani Trough is separated from the Kra and Prachuap Basins to the west by the Ko Kra Ridge. The Ko Kra Ridge extends in a north-south direction for a few hundred miles and effectively separates the Gulf of Thailand into eastern and western sectors. The eastern sector contains the deep Pattani Trough and the Malay

Basin. The latter is situated to the southeast of the Thai Basin and separated from it on the west and northwest by the Narathiwat Ridge. The western sector contains the Kra and Prachuap Basins of the Thai Basin, together with the much smaller Thammarat and Songkhla Basins; the latter two are situated to the south of the western sector of the Thai Basin but in the same structural graben. The Chumphon Basin is an isolated basin situated in a north-south structural graben or trough, located to the west of the Kra and Prachuap Basins and separated from them by the Samui Shelf and a zone of major northeast-southwest trending strike-slip faults.

The Andaman Sea area of Thailand is structurally controlled by north-south and northeast-southwest oriented pre-Tertiary basement horsts and grabens that form a series of troughs and ridges. From the west, eastward toward the coast of Thailand, the Andaman Sea area consists of the Mergui Ridge or Terrace, the Mergui Basin, the Ranong Ridge, and the Ranong Basin.

Onshore, in northern Thailand, it is possible that the numerous Tertiary basins or pockets of Tertiary sediments have formed as a result of the landward continuation of the north-south oriented, fault-bounded, horst and graben structures noted in the Gulf of Thailand. Little data or information are available in the literature, but mention is made of the existence of fault-bounded graben and half-graben structures. The basins extend north from Bangkok along the Chao Phraya valley to the northern border of Thailand. Although most are relatively small in areal extent, thicknesses of Tertiary sediments up to 4,000 feet are given for the most northern basins and in excess of 7,500 feet in the Sukhothai area and south of Bangkok (fig. 2).

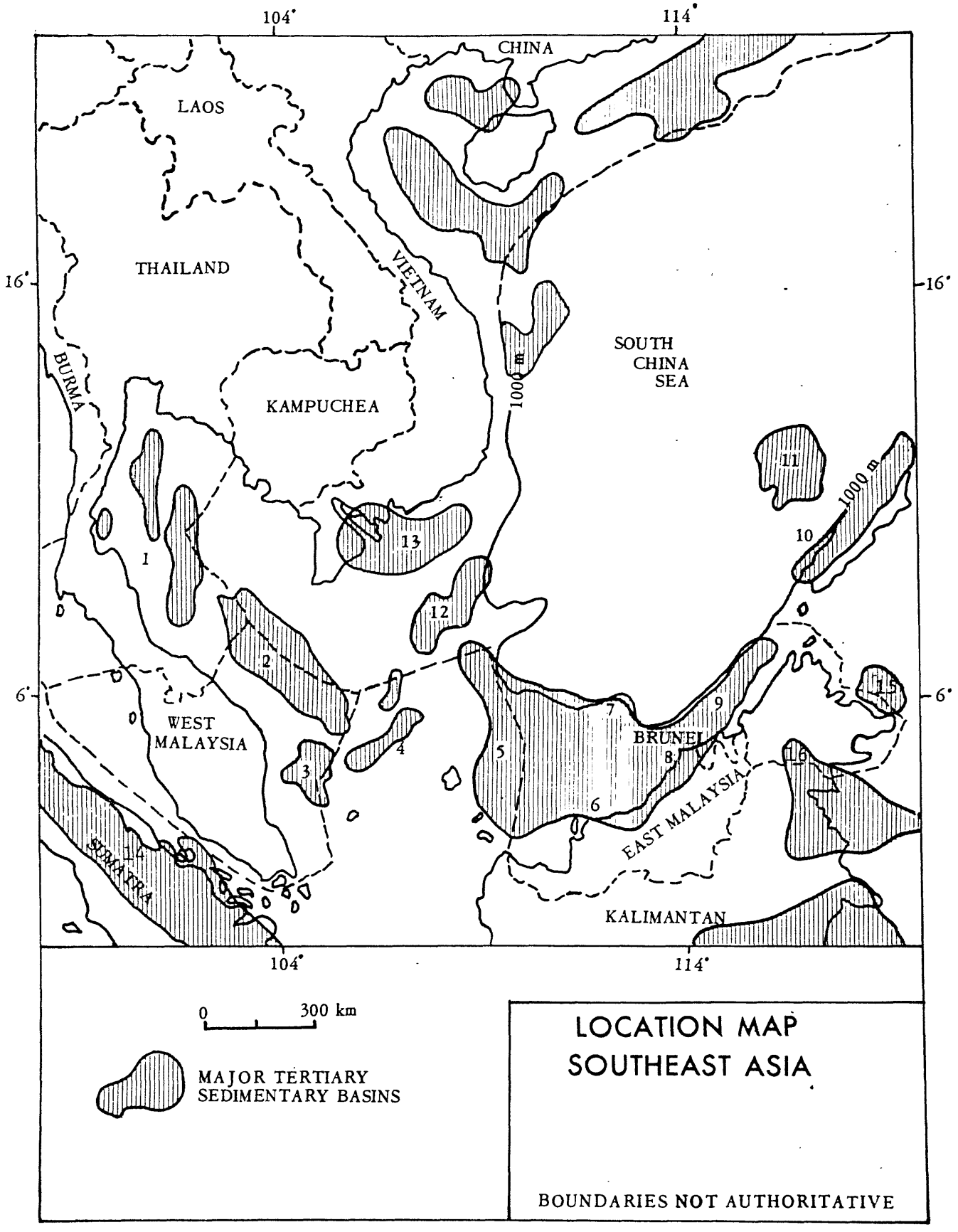

Figure 1.--Distribution of major Tertiary sedimentary basins in southeast Asia.

Table 1.--Major Tertiary sedimentary basins in Southeast Asia

Number (ref. fig. 1)	Name	Area (mi^2)	Volume Tertiary sediment (mi^3)
1	Gulf of Thailand:		
	Thai Basin	75,000	62,000[1/]
	Pattani Trough		
	Kra Basin		
	Prachuap (Western) Basin		
	Chumphon-Thammarat-Songkhla Basins	3,300	3,700
	Andaman Sea:	39,000	29,000
	Mergui-Ranong Basins		
2	North Malay Basin	8,400	12,000[1/]
3	Penyu Basin		
4	West Natuna Basin		
5	East Natuna and West Luconia Province		
6	Balingian Province		
7	Central Luconia Province		
8	Baram Delta Province		
9	Sabah Basin		
10	West Palawan Basin		
11	Reed Bank		
12	Saigon Basin		
13	Mekong Basin		
14	Sumatra Basins		
15	Sandakan Basin		
16	North Tarakan Basin		

[1/] Includes only that part in Thailand.

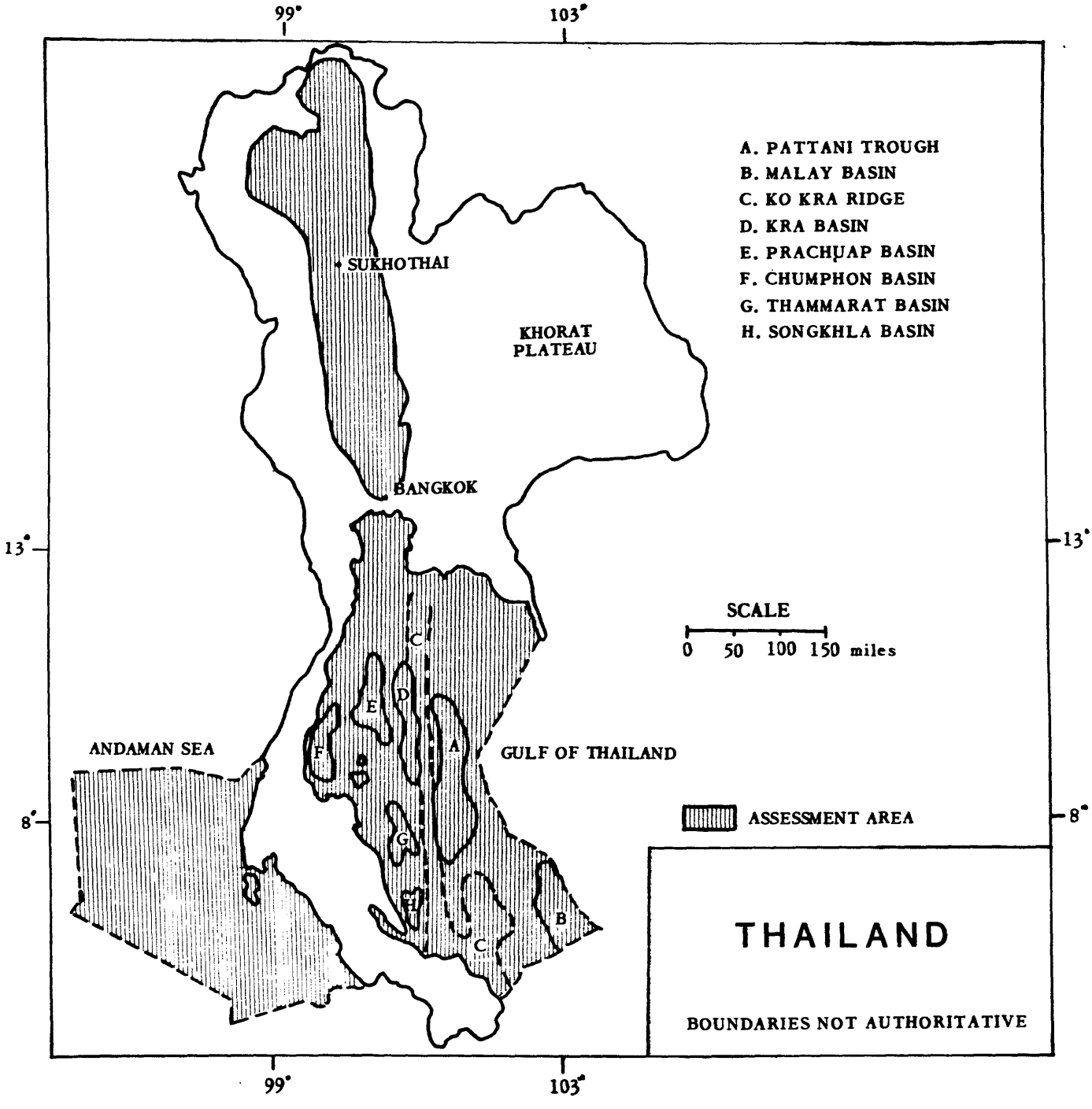

Figure 2.--Location map of Thailand assessment area.

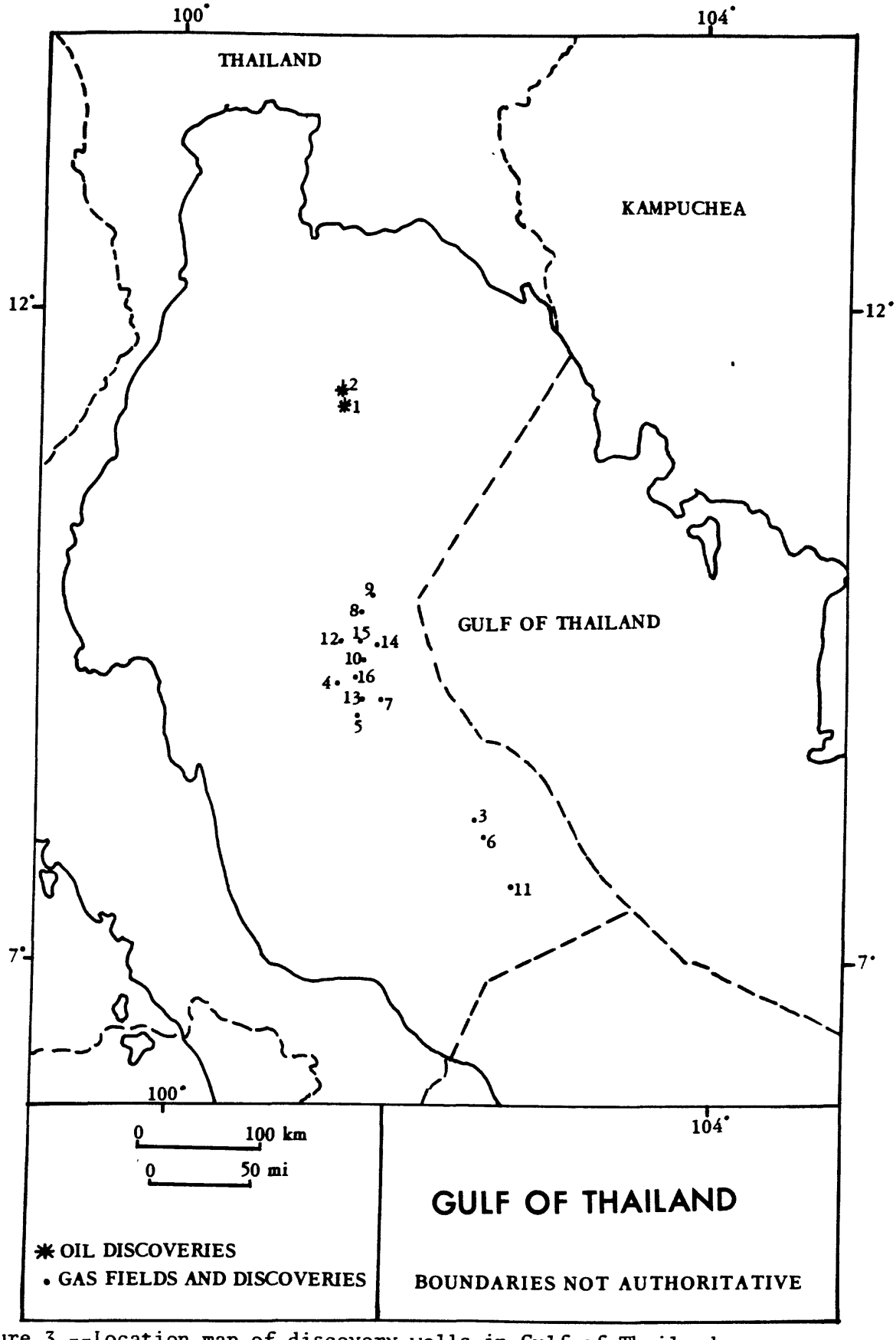

Figure 3.--Location map of discovery wells in Gulf of Thailand.

Table 2.--Thailand fields and discoveries

Number (ref. fig. 3)	Field name or discovery well	Location	Discovery date	Type field or discovery	Status
1	6-2	Pattani Trough[1/]	1974	Oil	Discovery
2	5-1-L	do	1978	Oil	Do
3	"B" Structure	N. Malay Basin	1973	Gas and condensate	Development
4	Dara 1	Pattani Trough	1974	do	Discovery
5	Baanpot	do	1974	do	Do
6	16-B-1	N. Malay Basin	1974	do	Do
7	Jakrawan 1	Pattani Trough	1976	do	Development
8	Platong	do	1976	do	Discovery
9	Kaphong	do	1979	do	Do
10	Satun	do	1980	do	Do
11	17-E-1	N. Malay Basin	1981	do	Do
12	Pladang	Pattani Trough	1981	do	Do
13	Funan 1	do	1981	do	Do
14	Trat 1	do	1981	do	Do
15	Pakarang 1	do	1982	do	Do
16	Erawan	do	1973	Gas, condensate and oil	Producing
	Boh Ton Kham	Northern Thailand[2/]	1953	Oil	Producing
	Mae Soon Luang	do	1963	do	Do
	Lang Kraui	do	1981	do	Development
	Pratu Tao 1	do[3/]	1981	Oil and Gas	Discovery
	Sirikit (Lan Krabu)	do[3/]	1981	do	Do
	Nam Phong	Khorat Plateau	1982	Gas	Development

1/ Pattani Trough is in eastern sector of Thai Basin.

2/ Located in onshore Tertiary basins of northern Thailand.

3/ Located in onshore Tertiary basins of northern Thailand near Sukhothai in Chao Phraya valley.

Table 3.--Assessment of undiscovered conventionally recoverable petroleum resources in onshore and offshore Tertiary sedimentary basins of Thailand.

Resource assessment by USGS as of March 10, 1982; see also figures 4 and 5.

Region	Crude oil in billions of barrels (BB)			Natural gas in trillions of cubic feet (Tcf) and billions of barrels of oil equivalent (BBOE) @ 6,000 cuft/bbl			
	Low (F_{95}) 1/	High (F_5) 1/	Mean		Low (F_{95}) 1/	High (F_5) 1/	Mean
Thailand 2/	0.10	2.50	0.99	Tcf	6.80	38.50	20.68
				BBOE	1.13	6.42	3.45

1/ F_{95} denotes the 95th fractile; the probability of more than the amount F_{95} is 95 percent. F_5 is defined similarly.

2/ Assessment does not include Khorat Plateau.

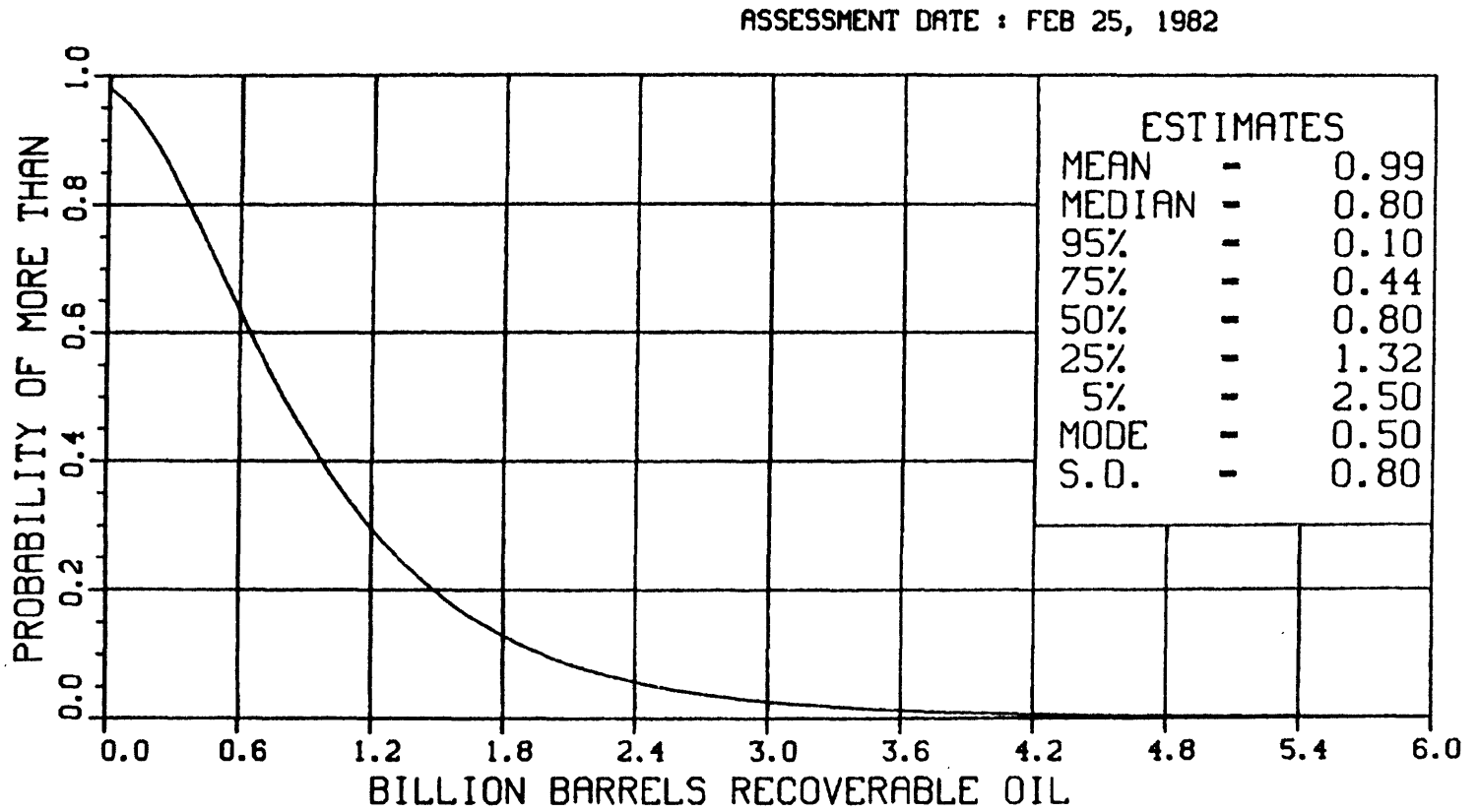

Figure 4.--Thailand, undiscovered recoverable oil.

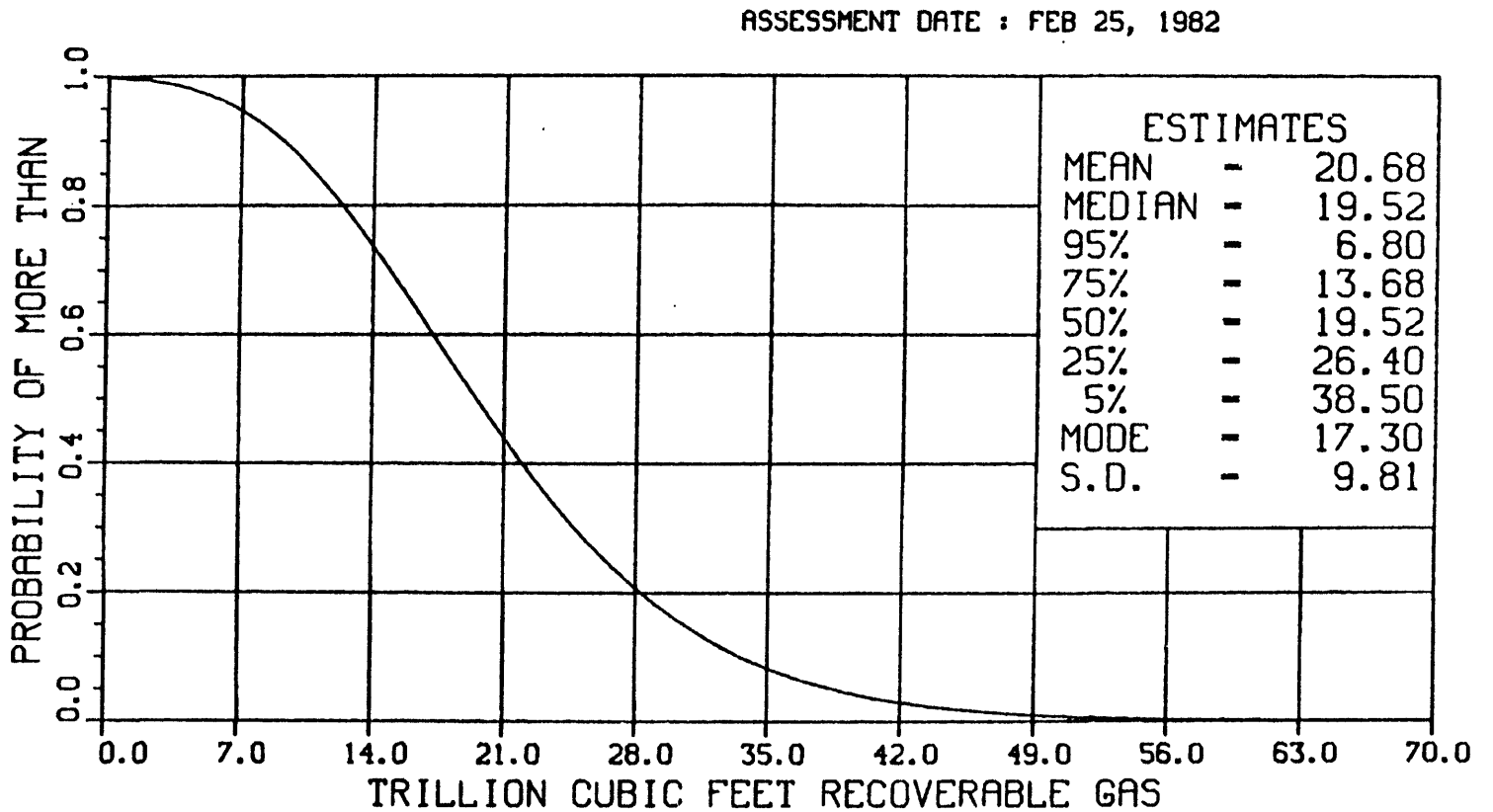

Figure 5.--Thailand, undiscovered recoverable total gas

Table 4.--Supplementary and comparative data supporting the resource assessment for Thailand [1/]

	Crude oil (BB)	Natural gas (Tcf)
Cumulative production to 7/82		
Onshore	0.0008	+ [3/]
Offshore	0.0014 [2/]	0.05
Measured reserves to 7/82		
Onshore	0.0007	+ [3/]
Offshore	0.3 [4/]	16.0
Undiscovered Resources (mean)	0.99	20.68
Original Recoverable Resources (or Total)	1.3	36.7 (6.1 BBOE)

[1/] Cumulative production and reserves are composited estimates from various sources.

[2/] Condensate from Erawan field.

[3/] Quantity positive but data unavailable.

[4/] Condensate, estimated at an average of 20 barrels per million cubic feet of gas.

COMMENTS

- The Thai Basin contains in excess of 25,000 feet of Tertiary sediments in its deepest part. The Pattani Trough, in the eastern sector, contains the thickest Tertiary section of dominantly non-marine clastic sediments, which were deposited in a continental rifted-basin environment. Depositional environments vary from occasional shallow marine to littoral, coastal, deltaic, delta-plain and fluvial facies in cyclic alternations. The northern part of the Malay Basin contains a section similar to that of the Pattani Trough but slightly more marine.

- Commercial discoveries of natural gas, condensate, and possibly marginally economic amounts of crude oil have been made in only the eastern part of the Thai Basin, namely the Pattani Trough, and in the northern part of the Malay Basin. Both basins are located in the eastern sector of the Gulf of Thailand. The geothermal gradients are high, ranging from 2°F to 4°F/100 ft. The Pattani Trough and northern part of the Malay Basin are gas prone. Production is from deltaic sands of lower to middle Miocene age, which are closely associated with mature source beds at depths ranging from 3,500 to 9,000 feet.

- No significant discoveries of petroleum and only a few shows of gas have been found in the western sector of the Gulf of Thailand and the Andaman Sea areas. The western sector contains the Kra and Prachuap Basins of the Thai Basin and the smaller isolated Chumphon, Thammarat, and Songkhla Basins. With the possible exception of the Chumphon Basin, the Tertiary section is relatively thin in the western sector basins by comparison with the Pattani Trough. Geothermal gradients are generally less than 2°F/100 ft; the area is referred to as the "Cold Basin" region of the Gulf of Thailand. The Andaman Sea area contains the Mergui and Ranong Basins where the Tertiary section is approximately 12,000 and 5,000 feet in thickness, respectively. Lower Tertiary sediments are of shallow marine to deltaic and fluvial origin; some carbonates are present. Upper Tertiary sediments become progressively more marine and of deep-water origin. Geothermal gradients are low, generally averaging less than 2°F/100 ft. Very few exploratory holes have been drilled in the Kra, Prachuap, and Chumphon Basins, and none in the Thammarat and Songkhla Basins. The Andaman Sea basins are considered to have been adequately tested and rated as low potential for petroleum occurrence.

- Onshore, the Tertiary basins of northern Thailand have considerable potential for commercial discoveries of petroleum, particularly the Chao Phraya Basin. Field sizes, however, will probably be small. The region appears to be oil prone, and the Tertiary section to be lacustrine.

- The Khorat Plateau region was not included in the assessment. Commercial amounts of natural gas are reported to have been discovered in Jurassic limestones, and significant shows of noncommercial amounts of crude oil in Permo-Carboniferous rocks. The region appears to have considerable potential for petroleum resources.

- If future discoveries of natural gas are confined to the eastern sector of the Gulf of Thailand, in the Pattani Trough and northern part of the Malay Basin, the assessed mean estimate of 20.7 Tcf remaining undiscovered recoverable natural gas for Thailand may be too high. A resource assessment of the area, based on a play-analysis approach and restricted to the deeper Pattani Basin, suggests 10 Tcf undiscovered recoverable natural gas may be a more appropriate value.

- Though the assessment by the World Energy Resources Program group stands, the computer-generated assessed mean estimates of almost 1 billion barrels remaining of undiscovered recoverable crude oil for Thailand is too high in the judgment of the author. The modal value of 0.5 billion barrels may be more realistic and is closer to the overall "most-likely" consensus of the appraisal group. The assessment allows for significant new discoveries of crude oil in the immaturely explored and geothermally cooler area of the Thai Basin, west of the Ko Kra Ridge, and in the northern part of the Malay Basin.

- Condensate was not included in the assessment of undiscovered recoverable crude oil. It must be noted, however, that from 0.5 to 1.5 billion barrels of condensate remain to be discovered in association with the estimate of undiscovered recoverable natural gas.