UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Assessment of undiscovered conventionally recoverable petroleum resources in Tertiary sedimentary basins of Malaysia and Brunei

by

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Open-File Report 84-328

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

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[1]Denver, Colorado

CONTENTS

ILLUSTRATIONS

TABLES

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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 Malaysia and Brunei 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 volume of non-melange, unmetamorphosed Tertiary sediments in selected basins within the assessment area are given. Figures 2 and 3 show the western Malaysia and the eastern Malaysia-Brunei assessment areas, respectively, together with the location of known oil fields, gas fields, and discovery wells as of 1982. The fields and discovery wells are identified in tables 2, 3, and 4, as are the location, discovery date, field type or discovery, and status. Table 5 lists estimates by the USGS of oil and gas resources for the West Malaysia province and the East Malaysia-Brunei province, both separately and for the two areas as a whole. Figures 4 to 9 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 6.

With the exception of Sumatra, Tertiary sedimentary basins in Southeast Asia of a size and volume suitable for hydrocarbon generation and accumulation are located mostly in offshore areas. This is especially true for Malaysia and Brunei. As a consequence, the assessment of undiscovered petroleum resources is confined primarily to areas of Tertiary sedimentation underlying marine territorial waters claimed by Malaysia and Brunei, 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 Malaysia and Brunei encompass most of the Malay, Penyu, Sarawak, and Sabah Basins, together with smaller areas of the Sandakan and Tarakan Basins; the latter two are located off the east coast and in the southern part of the Malaysian State of Sabah, respectively. The Malay and Penyu Basins are located in the West Malaysia assessment area, which also includes the Malaysian part of the Strait of Malacca, located off the west coast of the Malaya Peninsula (fig. 2). The Sarawak and Sabah Basins are located off the northwest coast of East Malaysia and Brunei. On the basis of structural geology and stratigraphy, the Sarawak Basin may be conveniently divided into four major provinces. These are the West Luconia, Balingian, Central Luconia, and Baram Delta Provinces (fig. 1).

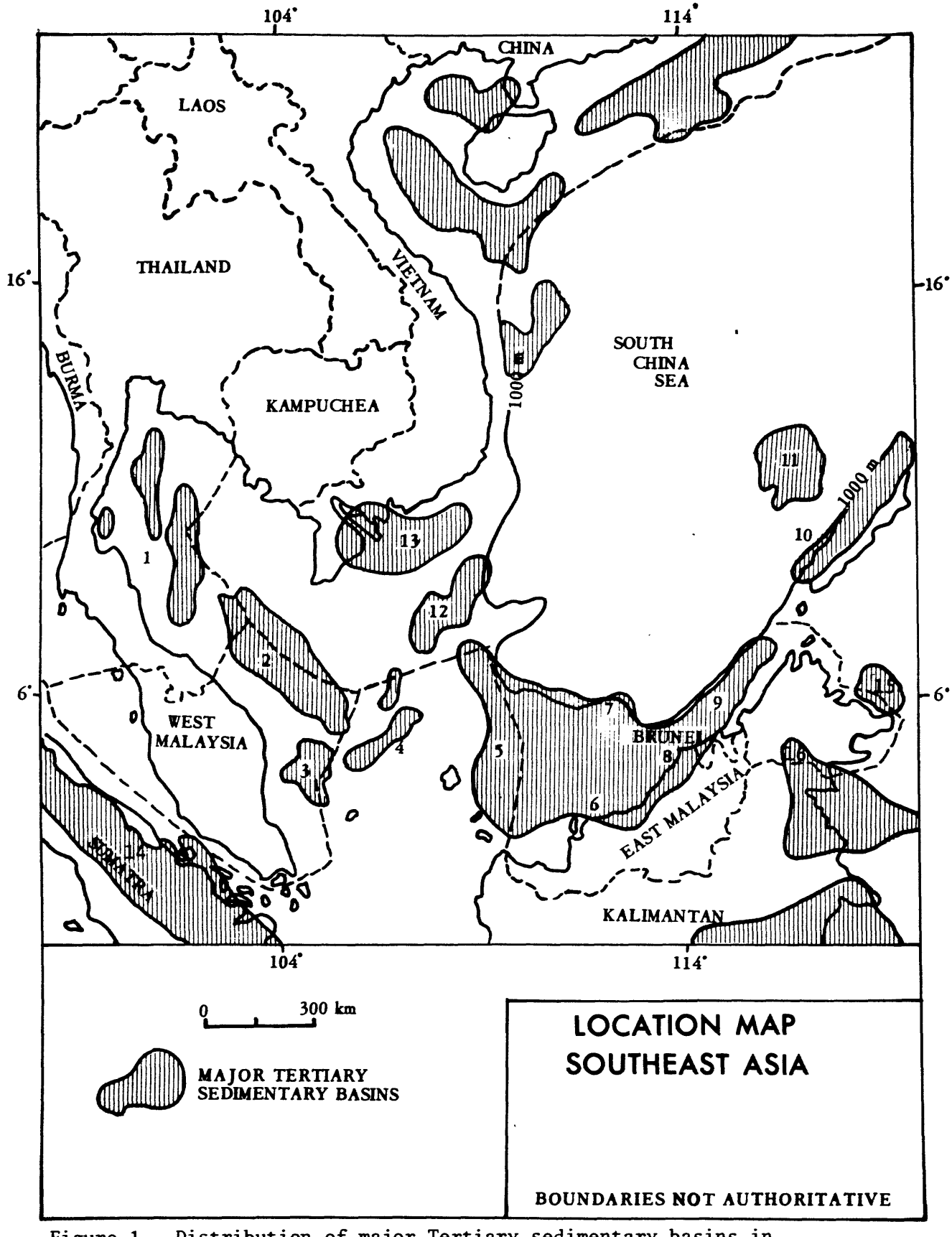

Figure 1.--Distribution of major Tertiary sedimentary basins in southeast Asia.

Table 1.--Tertiary sedimentary basins in southeast Asia

Number (ref. fig. 1)	Name	Area (mi^2)	Volume Tertiary sediment (mi^3)
1	Thai Basin	--	--
2	Malay Basin	32,000	81,000 [1/]
3	Penyu Basin	19,500	20,000
4	West Natuna Basin	--	--
5	East Natuna and West Luconia Province	-- 28,500	-- 68,000 [2/]
6	Balingian Province	17,000	53,000
7	Central Luconia Province	-- 14,000	-- 61,000
8	Baram Delta Province	10,500	45,000
9	Sabah Basin	14,000	50,000
10	West Palawan Basin	--	--
11	Reed Bank	--	--
12	Saigon Basin	--	--
13	Mekong Basin	--	--
14	Sumatra Basins	--	--
15	Sandakan Basin	14,000	10,000
16	North Tarakan Basin	3,400	3,500 [3/]

Note: The Sarawak Basin comprises the West Luconia, Balingian, Central Luconia, and Baram Delta Provinces

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[1/] Includes only that part in Malaysia.

[2/] West Luconia Province only.

[3/] Includes only that part in Sabah, Malaysia.

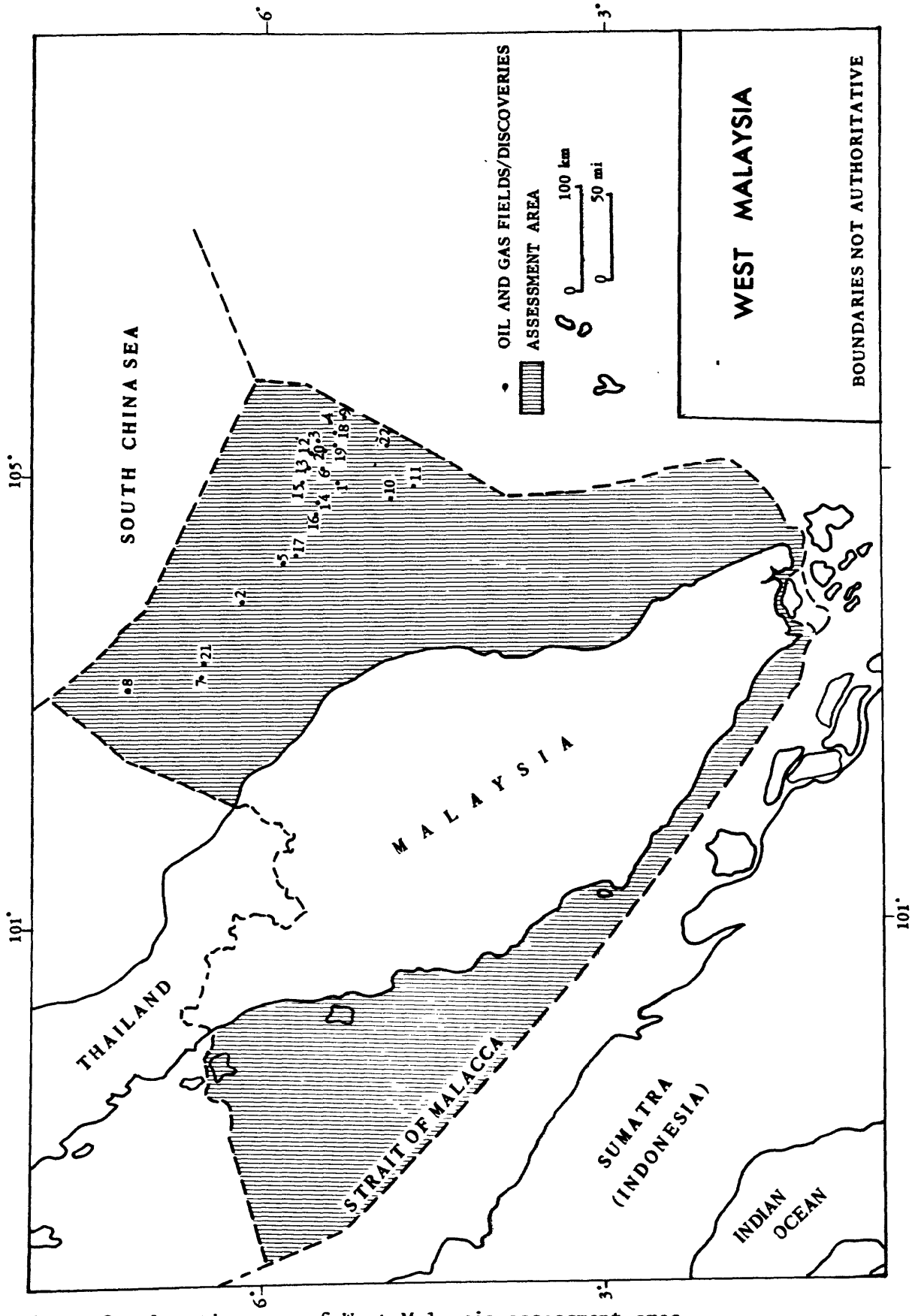

Figure 2.--Location map of West Malaysia assessment area.

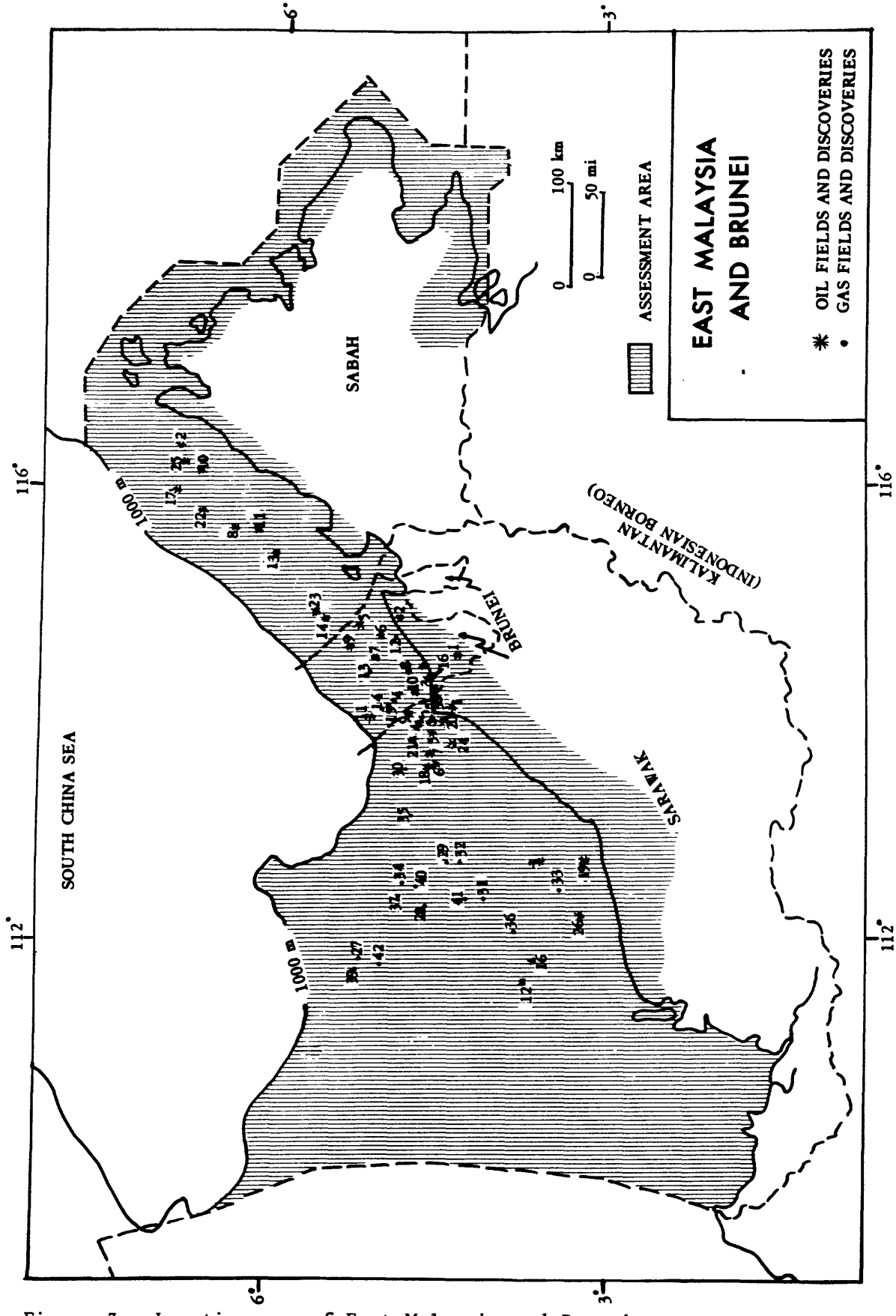

Figure 3.--Location map of East Malaysia and Brunei assessment area.

Table 2.--West Malaysia fields and discoveries

Number[1/]	Field name or discovery well	Location	Date of discovery	Type field or discovery	Status
1	Ophir 1	Malay Basin	1979	Oil	Discovery
2	Inas 1	do	1979	do	Development
3	Kepong	do	1979	do	Do
4	Tinggi	do	1980	do	Do
5	Dulang 1	do	1981	do	Do
6	Tapis	do	1969	Oil and gas	Producing
7	Bintang	do	1970	do	Do
8	Pilong	do	1971	do	Discovery
9	Pulai	do	1973	do	Producing
10	Sotong	do	1973	do	Development
11	Anding	do	1974	do	Discovery
12	Palas	do	1977	do	Development
13	Guntong	do	1978	do	Discovery
14	Irong	do	1978	do	Do
15	Tabu 1	do	1978	do	Development
16	Irong Barat 1	do	1979	do	Do
17	Semangkok	do	1980	do	Do
18	Seligi	do	1971	Oil, gas, and condensate	Do
19	Bekok	do	1971	do	Producing
20	Tiong	do	1978	do	Discovery
21	Lawit 1	do	1979	Gas	Do
22	Duyong	do	1974	Gas and condensate	Do

[1/] See figure 2.

Table 3.--East Malaysia fields and discoveries

Number[1/]	Field name or discovery well	Location	Date of discovery	Type field or discovery	Status
1	Miri	Baram Delta Prov.	1910	Oil	Shut in
2	Barton	Sabah Basin	1971	do	Development
3	Acis South	Balingian Prov.	1962	do	Discovery
4	Baram	Baram Delta Prov.	1964	do	Development
5	Bakau	do	1967	do	Producing
6	Betty	do	1968	do	Do
7	Bokor	do	1971	do	Discovery
8	Erb West	Sabah Basin	1972	do	Producing
9	Fairley/Baram	Baram Delta Prov.	1973	do	Do
10	Saint Joseph	Sabah Basin	1975	do	Do
11	Ketam	do	1977	do	Do
12	J-4-1X	Balingian Prov.	1978	do	Discovery
13	Lokan	Sabah Basin	1979	do	Do
14	Samarang Kechil	Baram Delta Prov.	1979	do	Do
15	Salbiah	do	1979	do	Do
16	J-12-1	Balingian Prov.	1980	do	Do
17	SW Emerald	Sabah Basin	1980	do	Do
18	Laila	Baram Delta Prov.	1980	do	Do
19	Temana	Balingian Prov.	1962	Oil and gas	Producing
20	Lutong West	Baram Delta Prov.	1966	do	Do
21	Baronia	do	1967	do	Do
22	Tembungo	Sabah Basin	1971	do	Do
23	Samarang	Baram Delta Prov.	1972	Oil and gas	Producing
24	Tukau	do	1973	do	Do
25	Furious South	Sabah Basin	1974	do	Do
26	C-8-1	Balingian Prov.	1981	do	Discovery
27	M-3-1X	C. Luconia Prov.	1980?	Gas	Do
28	F-6-1X	do	1969	do	Do
29	F-13-1X	do	1969	do	Do
30	Beryl	Baram Delta Prov.	1969	do	Development
31	E-8-1X	C. Luconia Prov.	1969	do	Discovery
32	E-11	do	1974	do	Do
33	N. Bayan 1	Balingian Prov.	1976	do	Development
34	F-27-1	C. Luconia Prov.	1979	do	Discovery
35	B11-1	do	1980	do	Do
36	D12-1	do	1980	do	Do
37	F29-1	do	1980	do	Do
38	Fatimah 1	Baram Delta Prov.	1980	do	Do
39	M4-1	C. Luconia Prov.	1980	do	Do
40	F-23	do	1973	Condensate and gas	Development

[1/] See figure 3.

Table 4.--Brunei fields and discoveries

Number[1/]	Field name or discovery well	Location	Date of discovery	Type field or discovery	Status
1	Belait	Baram Delta Prov.	1913	Oil and gas	Abandoned
2	Jerudong	do	1955	do	Do
3	Rasau	do	1979	do	Producing
4	Fairley	do	1969	Oil	Do
5	Champion	do	1970	do	Do
6	Iron Duke	do	1973	do	Discovery
7	Magpie	do	1975	do	Producing
8	Chearnley West	do	1976	do	Discovery
9	Pelican IX	do	1978	do	Do
10	Ampa SW	do	1963	Oil and gas	Producing
11	Petrel	do	1972	do	Discovery
12	Scout Rock	do	1976	Gas	Do
13	Osperey	do	1977	do	Do
14	Parak X-1	do	1980	do	Do
15	Fulmar 1-X	do	1977	Gas and condensate	Do
16	Seria	do	1928	Oil, gas and condensate	Producing

[1/] See figure 3.

Table 5.--Assessment of undiscovered conventionally recoverable petroleum resources of Malaysia and Brunei

Resource assessment by USGS as of 7/28/82; see also figures 4 to 9

Region	Crude Oil in billions of barrels (BB) Low (F_{95})[1]/	High (F_5)[1]/	Mean		Natural gas in trillions of cubic feet (Tcf) and billions of barrels of oil equivalent (BBOE) @ 6,000 cu ft/bbl. Low (F_{95})[1]/	High (F_5)[1]/	Mean
I. West Malaysia	0.50	4.30	1.98	Tcf	4.70	35.00	17.17
				BBOE	0.78	5.83	2.86
II. East Malaysia and Brunei	1.60	12.83	6.04	Tcf	15.63	138.33	63.06
				BBOE	2.61	23.06	10.51
Total of West Malaysia, East Malaysia, and Brunei [2]/	3	15	8	Tcf	30	161	80
				BBOE	5	27	13

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/ Totals are derived by statistical aggregation, only the mean total equals the sum of the component parts.

Assessment date - 02/25/82

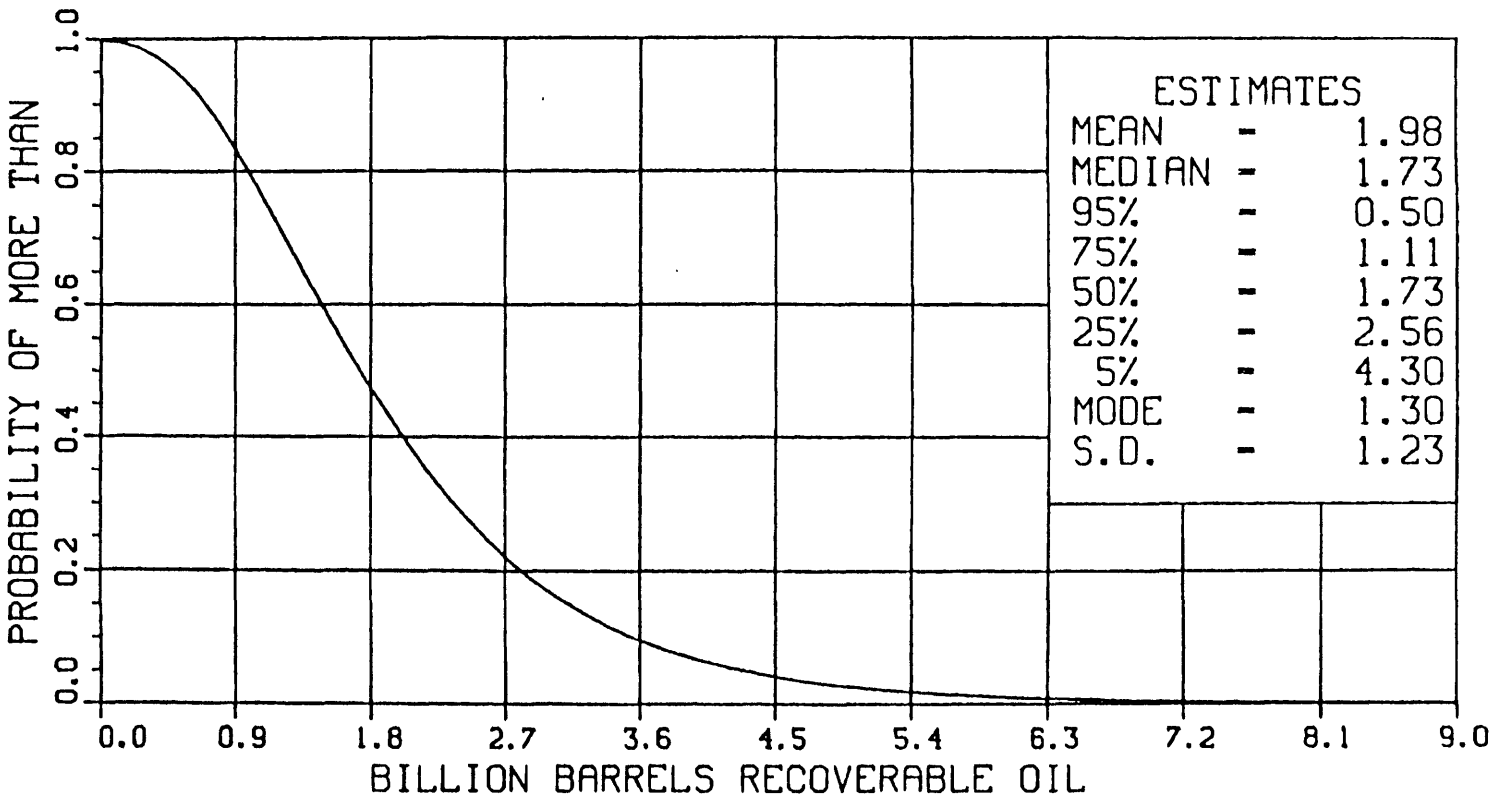

Figure 4.--West Malaysia, undiscovered recoverable oil.

Assessment date - 02/25/82

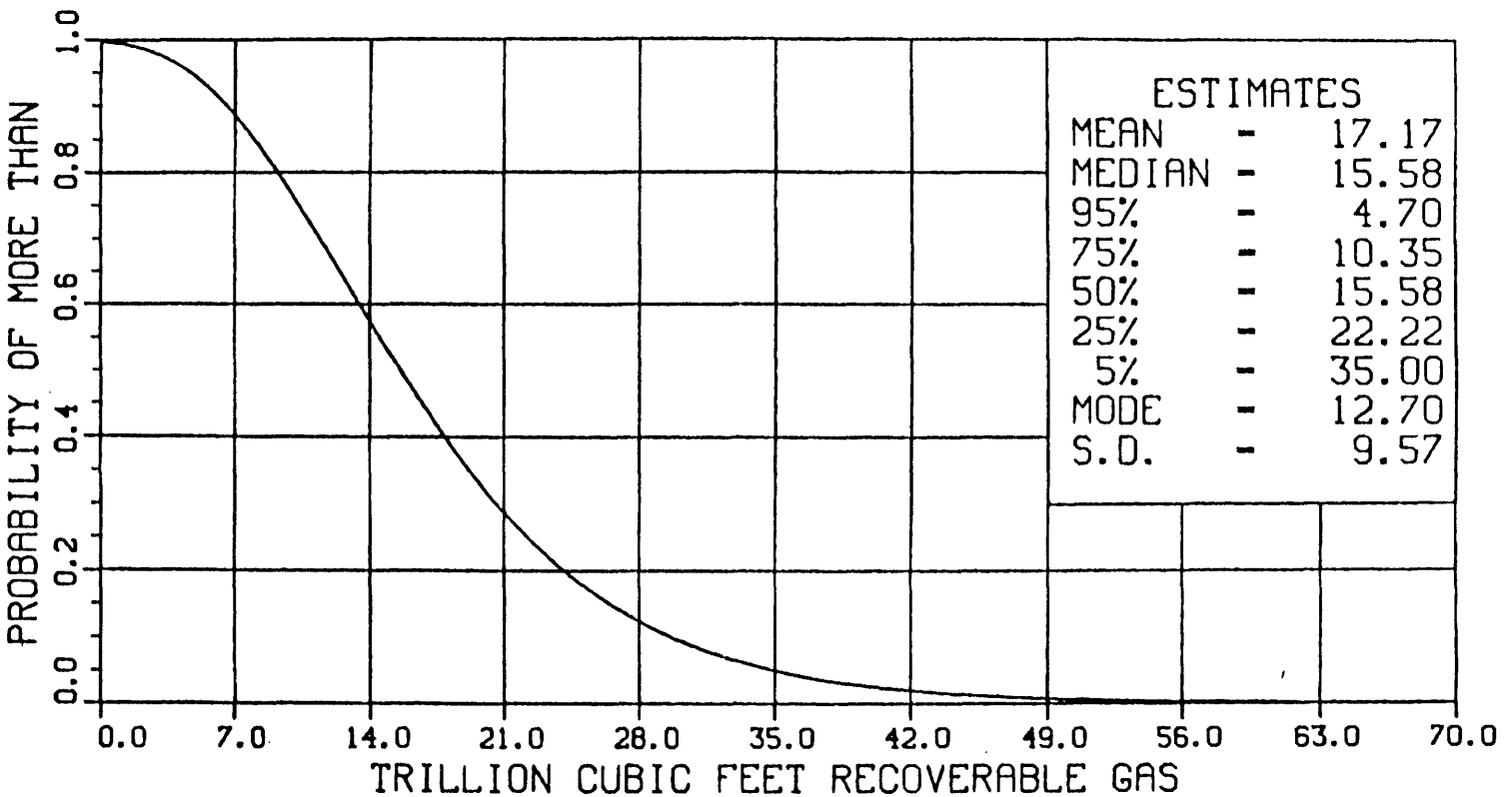

Figure 5.--West Malaysia, undiscovered recoverable total gas.

Assessment date - 07/28/82

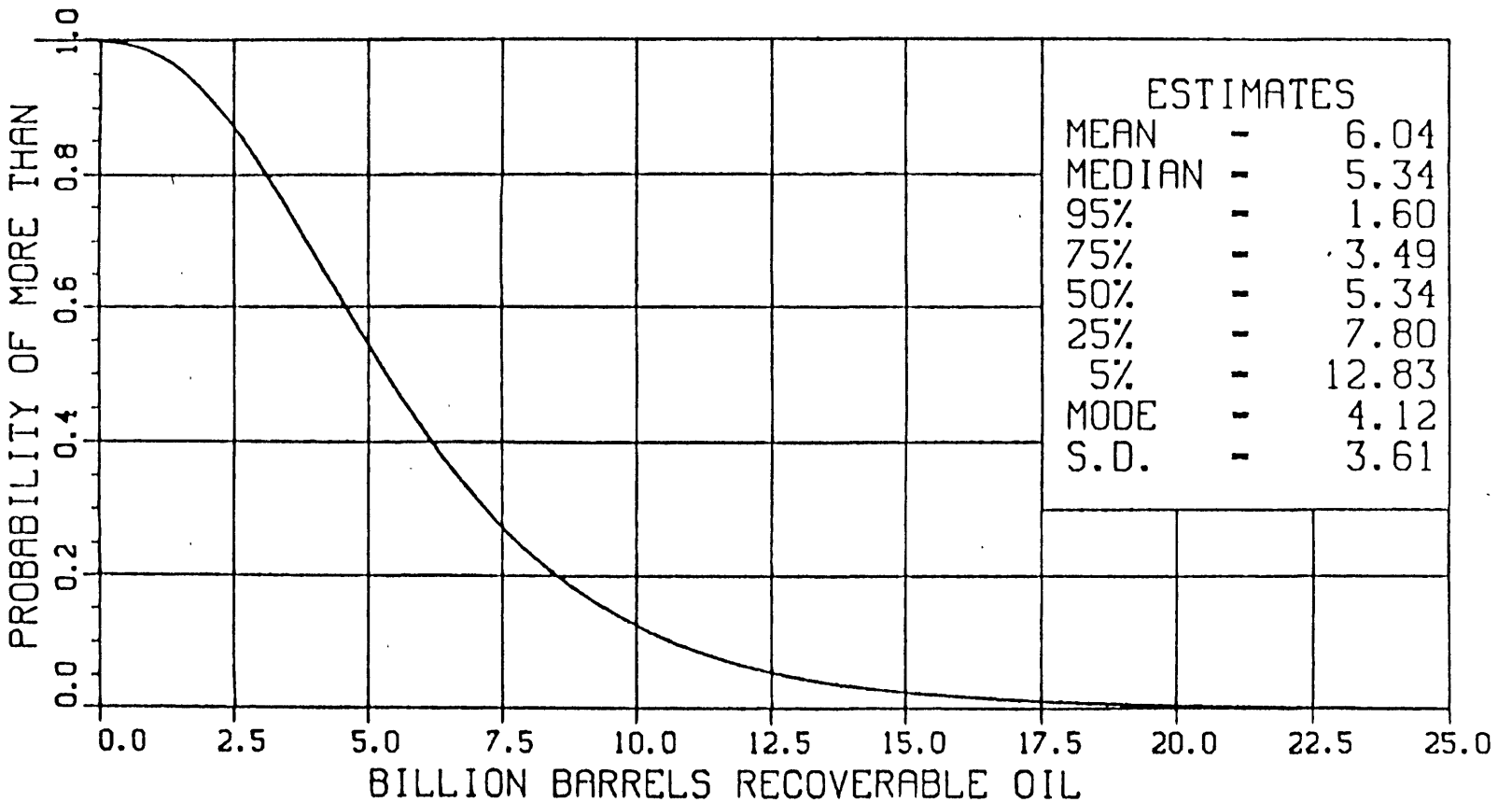

Figure 6.--East Malaysia and Brunei, undiscovered recoverable oil.

Assessment date - 07/28/82

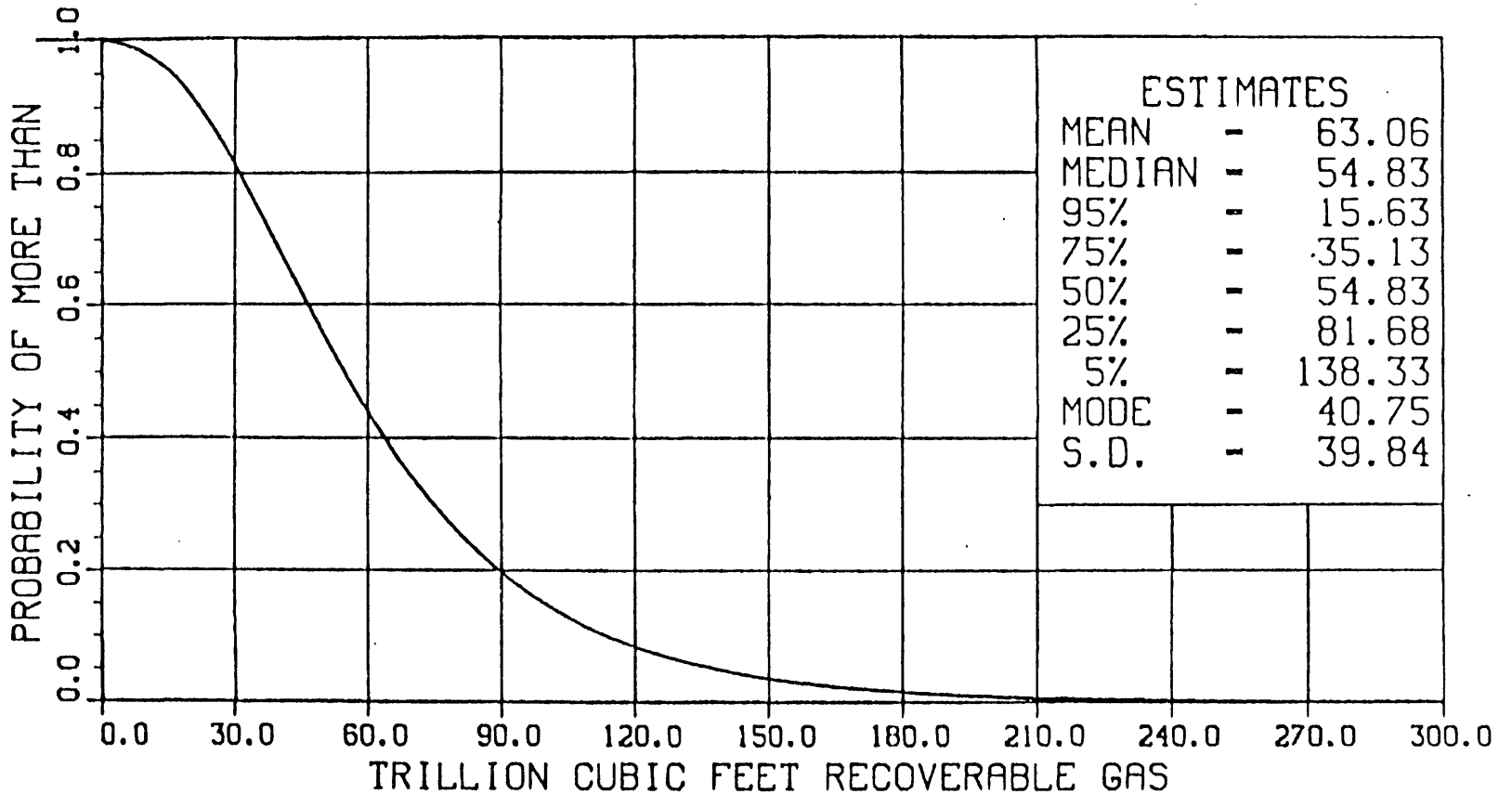

Figure 7.--East Malaysia and Brunei, undiscovered recoverable total gas.

Assessment date - 07/30/82

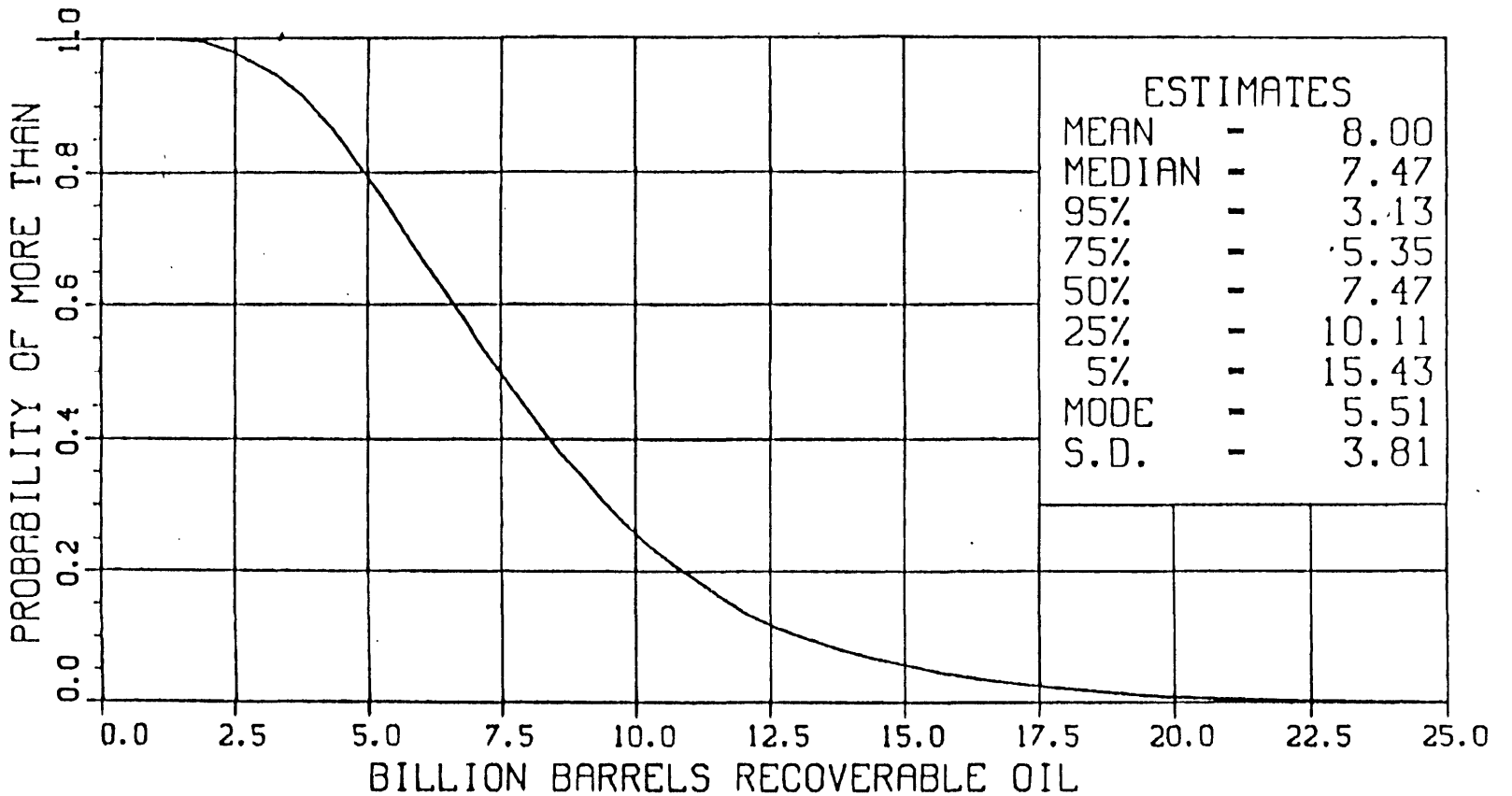

Figure 8.--West Malaysia, East Malaysia, and Brunei, aggregate undiscovered recoverable oil.

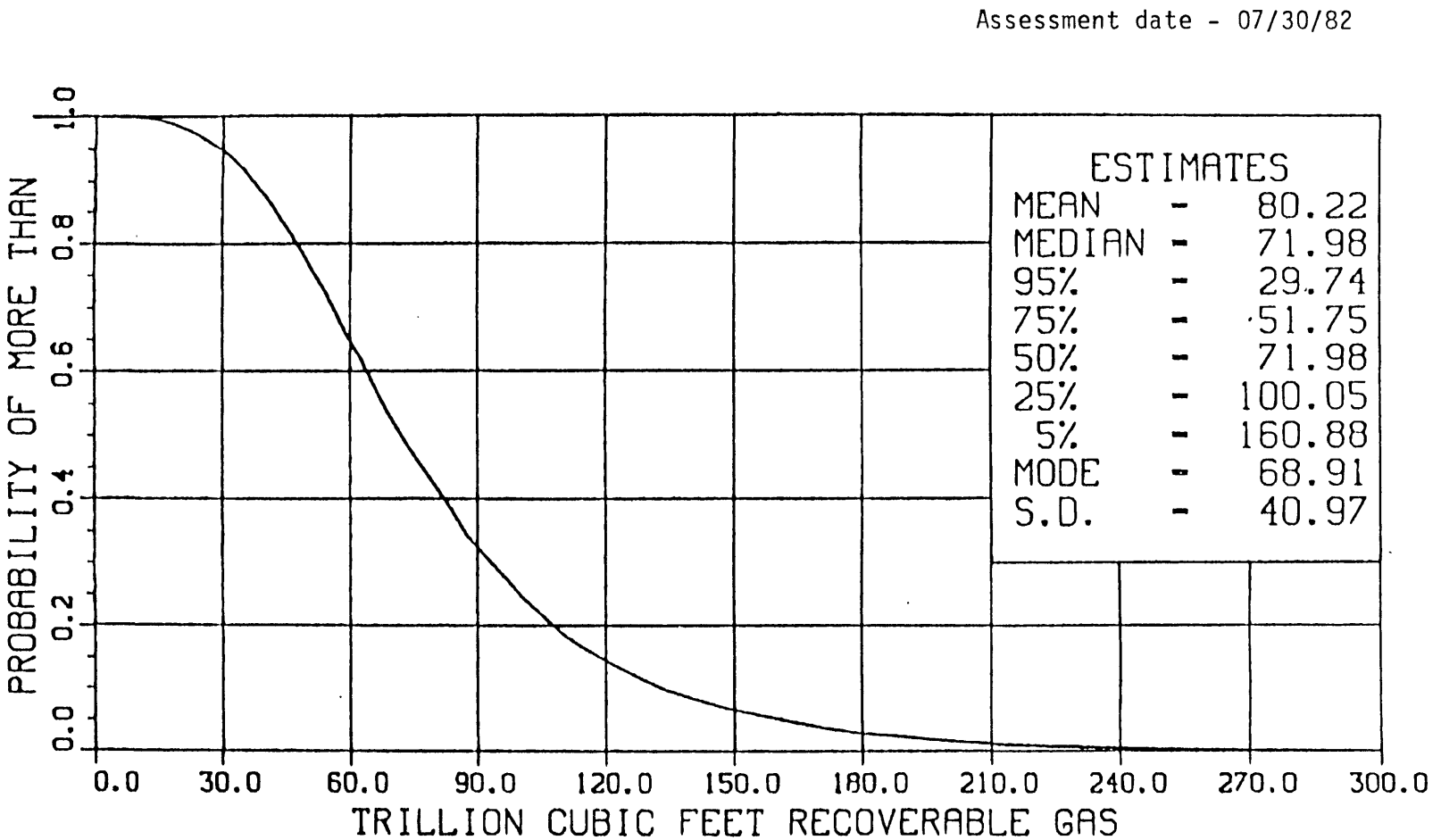

Figure 9.--West Malaysia, East Malaysia, and Brunei, aggregate undiscovered recoverable total gas.

Table 6.--Supplementary data relative to the resource assessment for Malaysia and Brunei [1]/

	Crude Oil (BB)	Natural gas (Tcf)
Cumulative production to 7/82		
West Malaysia	0.16	+ [2]/
East Malaysia	0.65	+ [2]/
Total Malaysia	0.81	0.05 [3]/
Brunei	1.70	1.30 [3]/
Subtotal	2.51	1.35 [3]/
Measured Reserves to 7/82		
Malaysia	3.06	36.00
Brunei	1.44	9.00
Subtotal	4.50	45.00
Undiscovered resources (mean)		
West Malaysia	1.98	17.17
East Malaysia - Brunei	6.04	63.06
Original recoverable resources (or total)	15.00	127.00 (21 BBOE)

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

2/ Quantity positive but data unavailable.

3/ Total estimate, this paper.

COMMENTS

West Malaysia

- In West Malaysia, commercial discoveries of crude oil and natural gas have been made only in the Malay Basin. The geothermal gradients are moderate to high, ranging from 3.5°F/100' in the northern part of the basin, which is located in Thai waters, to 2°F/100' at the southern end of the basin, located in Malaysian waters. The northern part of the basin tends to be gas prone while the southern part is both oil and gas prone. Several gas discoveries have been made in the central part of the basin.

- The Malay Basin may contain up to 30,000 feet of Tertiary nonmarine to marginal-marine clastic sediments deposited in a continental rifted-basin environment. The oldest Tertiary sediments are primarily nonmarine, the section becoming progressively more marine upward into younger sediments and to the southeast toward the South China Sea.

- No significant discoveries or shows of petroleum have been found in the Malaysian part of the Strait of Malacca or the Penyu Basin. Maximum geothermal gradients appear to approximate 2°F/100'. Very few exploratory wells have been drilled in either area. Available data suggest that the stratigraphic sections in both areas may be extremely sandy and that adequate sealing mechanisms may not be present. The existence of adequate source rock may also be a problem in the Penyu Basin and maturation a problem in the Strait of Malacca. The Tertiary section in the Malaysian part of the Strait of Malacca is quite thin, averaging generally less than 1 kilometer in thickness.

East Malaysia and Brunei

- In East Malaysia and Brunei, commercial discoveries of crude oil and natural gas have been made in the Balingian, Central Luconia, and Baram Delta Provinces of the Sarawak Basin, and in the Sabah Basin. The Balingian Province, Baram Delta Province, and the Sabah Basin are primarily oil prone, but also contain significant quantities of non-associated natural gas. Geothermal gradients are variable, ranging from a relatively high 2.3°F/100' in the Balingian Province to a relatively low 1.4°F/100' and 1.75°F/100' in the Baram Delta Province and Sabah Basin, respectively. The Central Luconia Province is essentially gas prone; only occasional accumulations of oil are observed, usually occurring as oil rims associated with the base of the gas columns. The geothermal gradient in the Central Luconia Province is similar to that in the Balingian Province, averaging 2.4°F/100'. The natural gas is contained in carbonate platform build-ups and large pinnacle reef structures.

- Other than a few shows, no commercial discoveries of either crude oil or natural gas have been found in the West Luconia Province or in the Malaysian part of the Sandakan and Tarakan Basins. The main part of the Tarakan Basin lies in Indonesia to the south, where commercial accumulations of petroleum have been discovered. Geothermal gradients in the West Luconia Province are high, ranging from 2° to 3.5°F/100'. In the Malaysian part of the Sandakan and Tarakan Basins, geothermal gradients range from 1° to 2°F/100'.

- Though the assessment by the World Energy Resources Program group stands, the assessed mean estimate of 6 billion barrels remaining of undiscovered recoverable crude oil for East Malaysia and Brunei is too high in the judgment of the author. To date, the Baram Delta Province has accounted for more than approximately 95 percent of the ultimate recoverable reserves and more than approximately 98 percent of the total production of East Malaysia and Brunei. The Baram Delta Province is, however, considered to have been thoroughly explored, and the remaining potential for crude oil will be limited to small traps. It is extremely unlikely that the Sabah Basin, Balingian and West Luconia Provinces will prove to be almost as rich again as the Baram Delta Province was originally. Those assessing to the contrary were allowing for significant new discoveries in deeper horizons as well.

- The West Luconia Province has been only lightly explored. Few wells have been drilled, but occasional shows of oil and gas have been reported. Because of the high geothermal gradient and relatively gentle folding, the area does not appear to be overly prospective and is probably gas prone. The province is considered to be a major Neogene depocenter, with sediment thicknesses in excess of 25,000 feet. It has been reported that exploratory wells drilled on the Terumbu Platform immediately west of and adjacent to the West Luconia Province have discovered significant amounts of natural gas. Amounts in excess of 100 Tcf natural gas have been reported but containing 75 to 80 percent carbon dioxide. The gas is reported to be contained in carbonate platform build-ups and pinnacle reef structures. If similar reef structures extend into the West Luconia Province or large anticlinal features can be detected, then the natural gas potential of the area may be exceedingly large, even after being discounted for inerts.