UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Assessment of undiscovered conventionally recoverable petroleum resources of the northwest European assessment region

By

H. Douglas Klemme[2] and Charles D. Masters[1]

Open-File Report 84-94

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

1. Reston, Virginia

2. Westport, Connecticut

1984

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Assessment of undiscovered conventionally recoverable petroleum resources of the northwest European assessment region

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PREFACE

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 the 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 estimates represent the views of the U.S. Geological Survey estimation team and should not be regarded as an official Department of the Interior position.

Other U.S. Geological Survey reports 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 Siberian and Kara Sea basins
- 82-0296 - Middle Caspian basin
- 82-1027 - East Siberian basin, U.S.S.R.
- 82-1056 - North Africa
- 82-1057 - Timan Pechora basin, U.S.S.R., and Barents-northern Kara shelf
- 83-0598 - Northwestern, central, and northeastern Africa
- 83-0801 - Onshore China

ACKNOWLEDGMENTS

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INTRODUCTION

The location of the North Sea region is shown in figure 1. Estimates by the U.S. Geological Survey of oil and gas resources in this basin are given in table 1 and in figures 2 through 15. Data supplementary to these estimates are supplied in table 3.

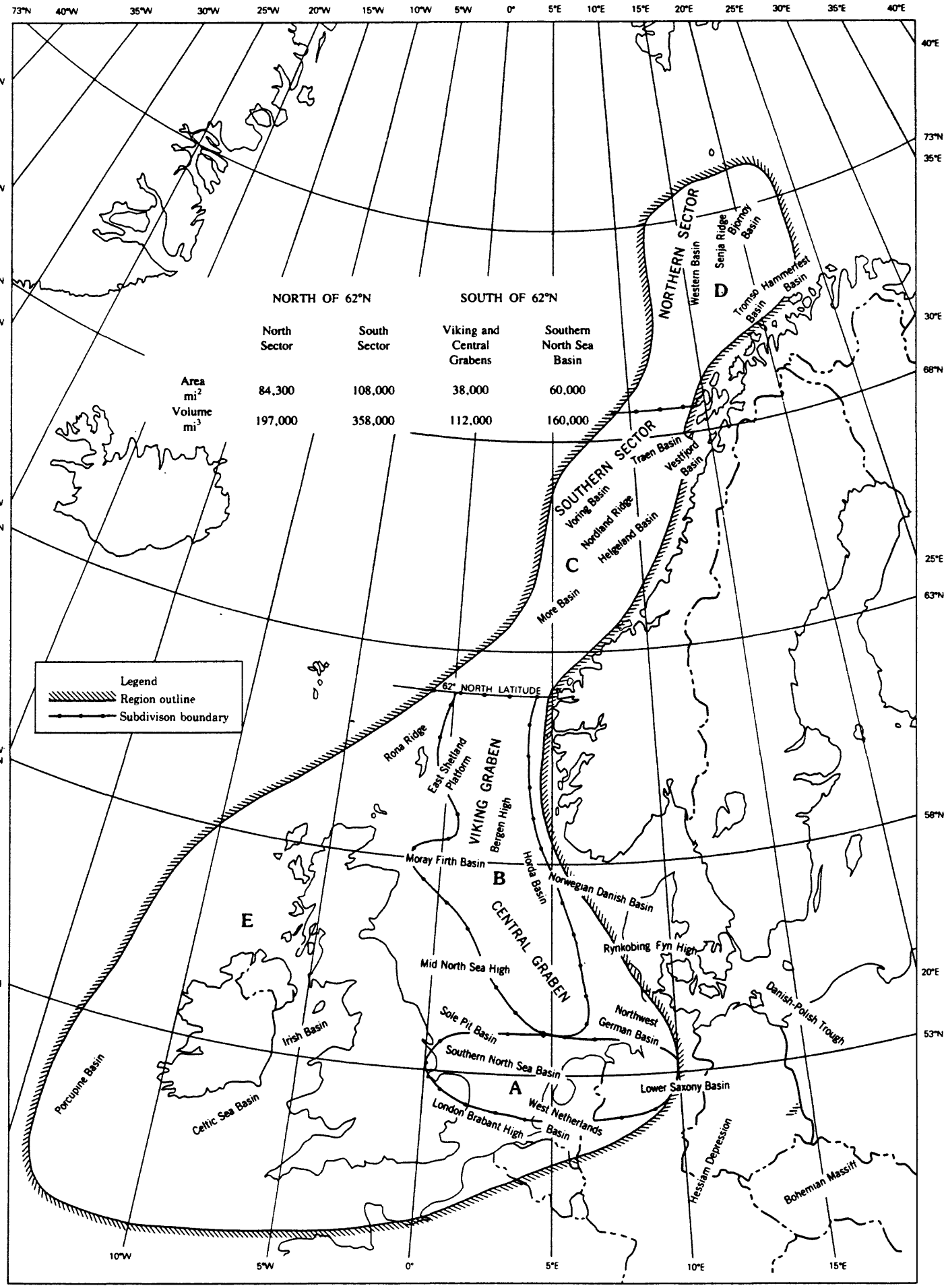


Figure 1.--Location of Northwest European assessment region, including North Sea, and showing areas and volumes of sedimentary rocks for the various subdivisions.

Table 1.--Assessment of undiscovered conventionally recoverable petroleum resources of the northwest European assessment region.

Resource assessment by USGS as of 7/20/82; see also figures 2 through 15.

	Crude oil in Billions of Barrels				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	Mode	Low F_{95} 1/	High F_5 1/	Mean	Mode
Estimate	9	34	20	15 (fig. 2)	92	258	167 (27 BBOE)	162 (fig. 3)
Total oil and gas (mode) = 42 BBOE								

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

Table 2.--Distribution by country and by subregion of undiscovered recoverable petroleum resources in the northwest European assessment region.

South of 62° N latitude - Assessment date: 3/10/82

	Crude oil (BB)			Natural gas (Tcf)		
	Low	High	Mean	Low	High	Mean
Viking and Central grabens, Moray Firth basin and Ireland area (Play I)						
All countries	3.7	23.2	11.9 (fig. 10)	25.4	145.7	78.6 (fig. 11)
United Kingdom	.7	4.2	2.2	2.3	13.1	7.0
Norway	2.8	17.6	9.0	21.6	123.8	66.8
Denmark	0.1	0.7	0.4	0.8	4.4	2.4
Germany	<0.1	0.2	0.1	0.2	1.5	0.8
Ireland	0.1	0.5	0.2	0.5	2.9	1.6
Southern North Sea basin and Ireland area (Play II)						
All countries	0.2	2.0	0.9 (fig. 8)	8.4	44.1	23.8 (fig. 9)
United Kingdom	0.0	0.5	0.0	4.2	19.8	11.9
Netherlands	0.2	1.5	0.9	4.2	22.5	11.9
Ireland	0.0	0.0	0.0	0.0	1.8	0.0
Total South of 62° N latitude (Play I and Play II)						
All countries	4.4	23.8	12.8 (fig. 4)	47.3	174.0	102.4 (fig. 5)
United Kingdom	0.8	4.3	2.3	7.6	27.8	16.4
Norway	3.0	17.1	9.2	32.2	118.3	69.6
Denmark	0.2	0.5	0.3	0.9	3.5	2.0
Germany	<0.1	0.2	0.1	0.5	1.8	1.0
Netherlands	0.3	1.2	0.6	5.2	19.1	11.4
Ireland	0.1	0.5	0.3	0.9	3.5	2.0

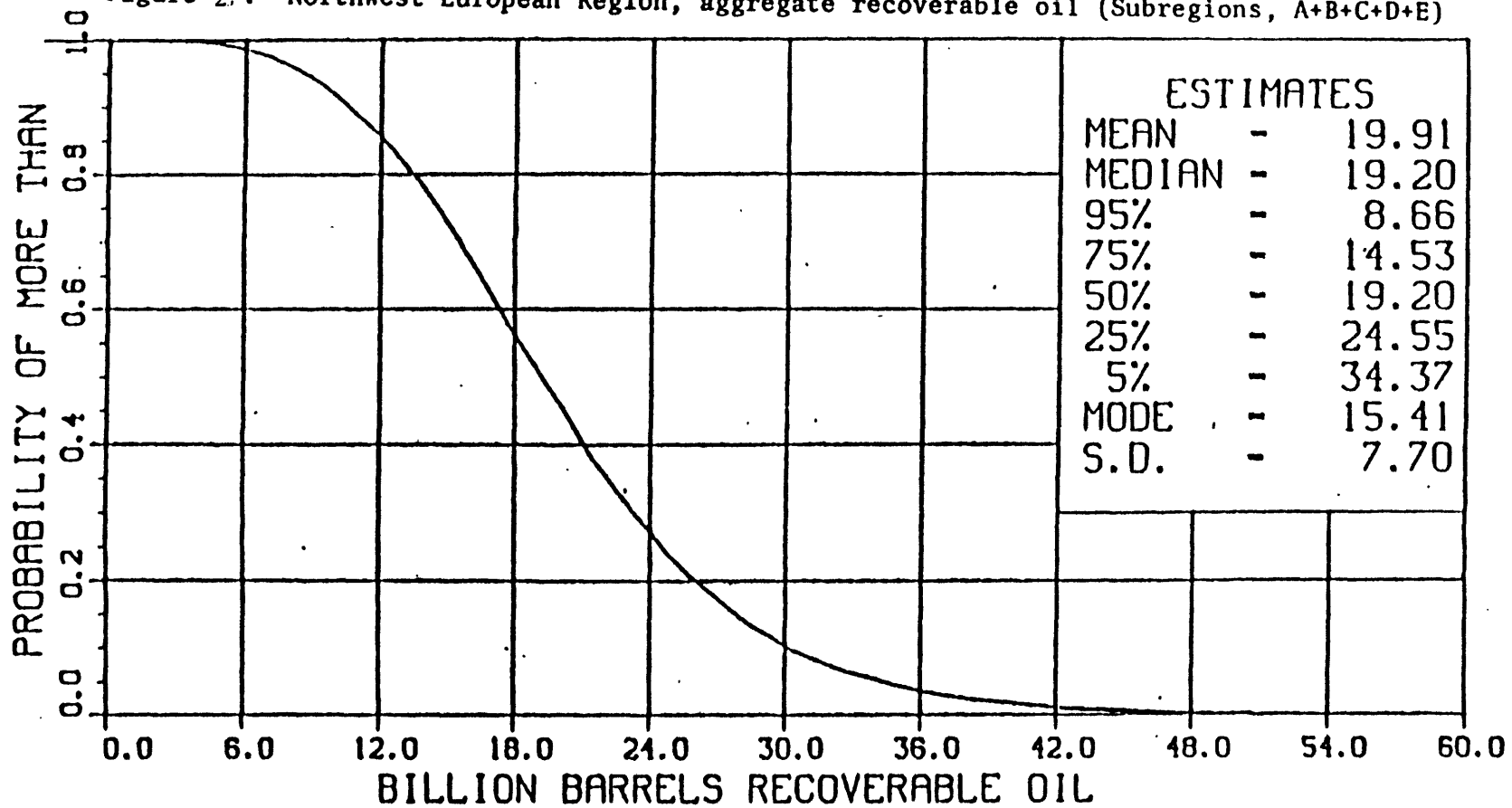
North of 62° N latitude - Assessment date: 7/30/82

Southern sector (More, Hegeland, Voring, etc.):						
	0.0	8.9	3.3 (fig. 12)	0.0	80.2	34.0 (fig. 13)
Northern sector (Tromso, Hammerfest, etc.):						
	0.0	10.3	3.8 (fig. 14)	0.0	69.9	31.0 (fig. 15)
Total North of 62° N latitude						
Norway	0.0	15.7	7.1 (fig. 6)	17.9	127.6	65.0 (fig. 7)

UNCOND

Assessment date: 7/13/82

Figure 2.--Northwest European Region, aggregate recoverable oil (Subregions, A+B+C+D+E)



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Assessment date: 7/13/82

Figure 3.--Northwest European Region, aggregate recoverable total gas (Subregions, A+B+C+D+E)

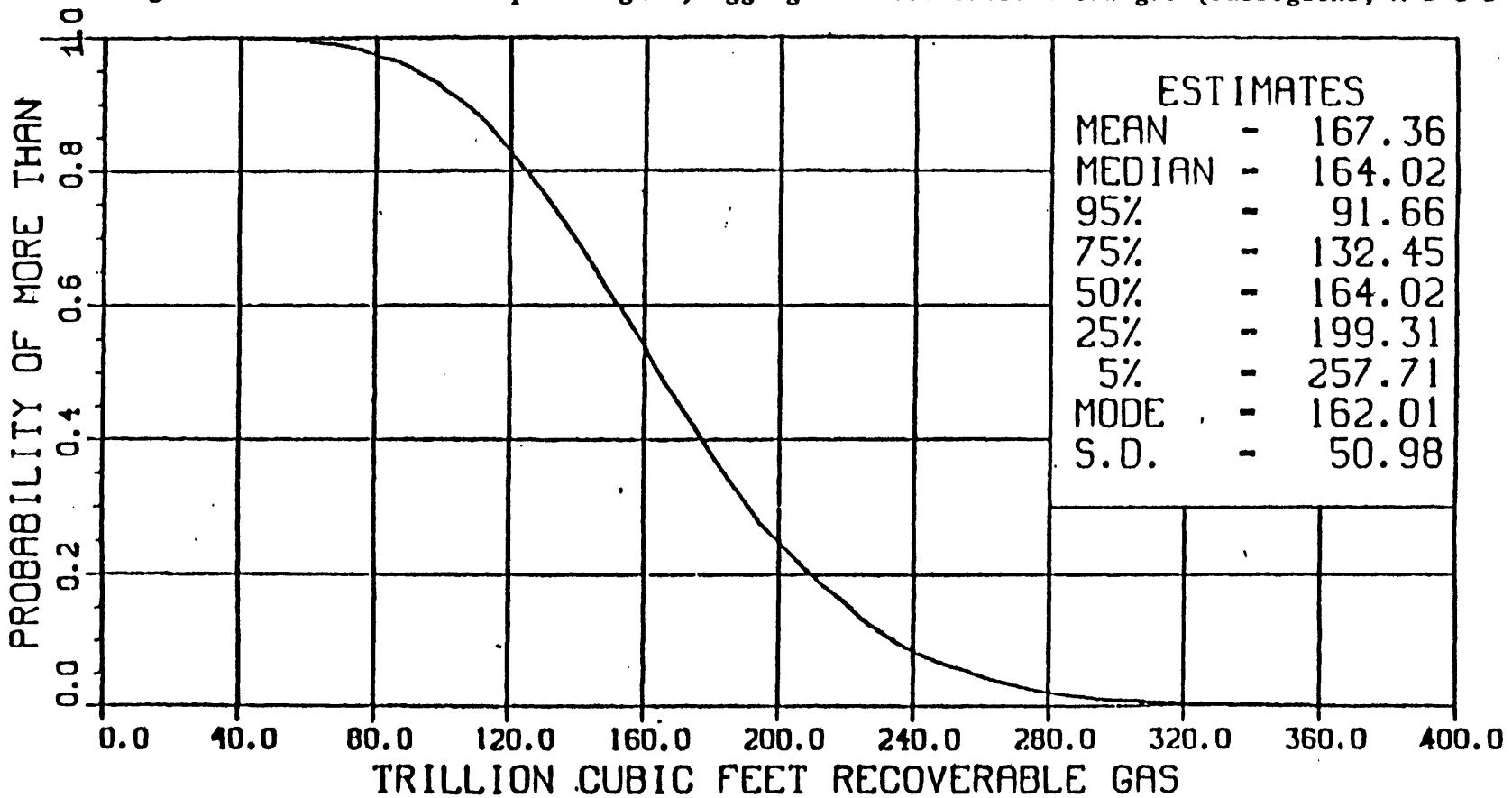

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Figure 4.--Northwest European Region, south of 62°, aggregate recoverable oil (Subregions A+B+E)

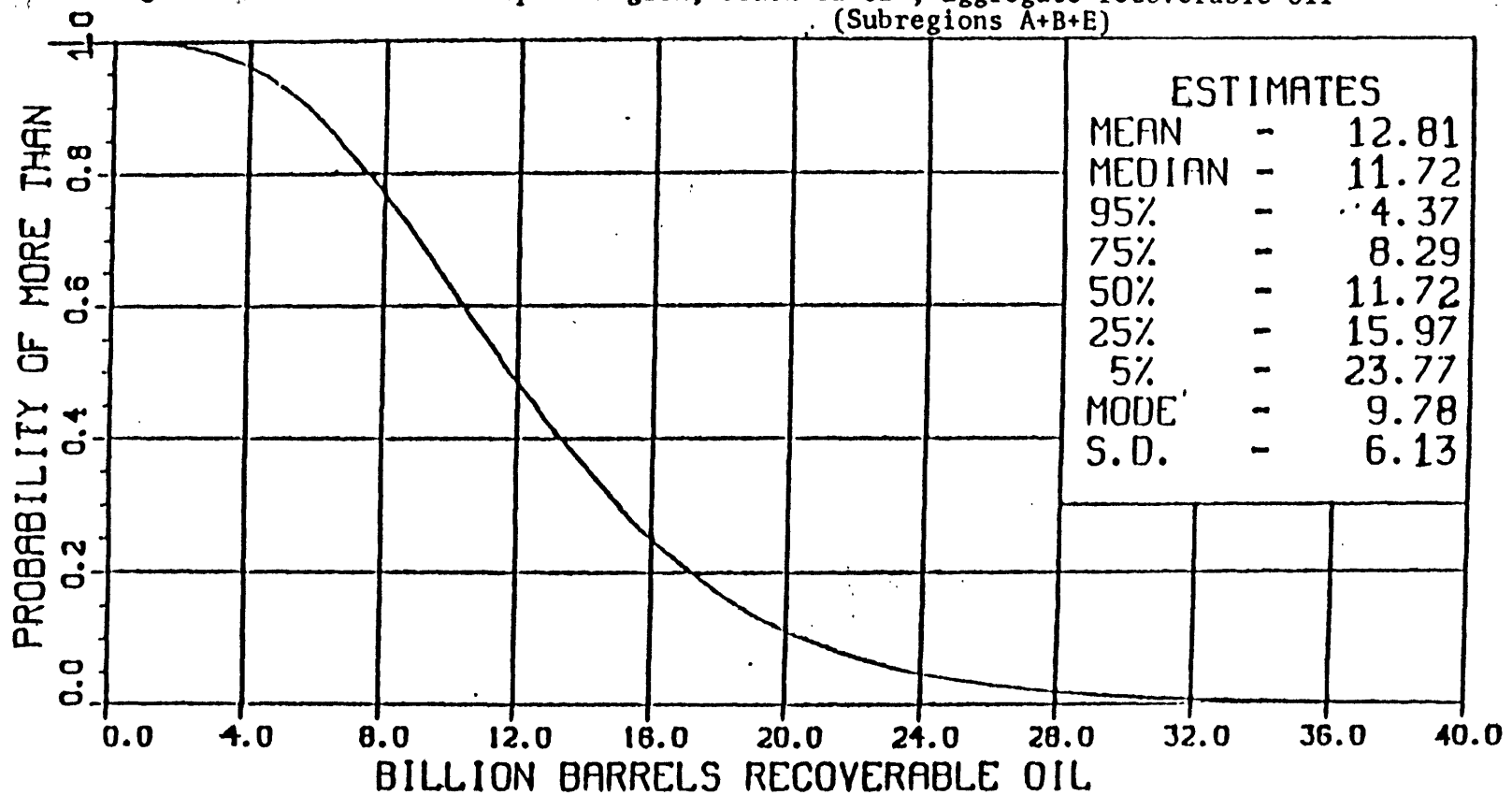

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Figure 5.--Northwest European Region, south of 62°, aggregate recoverable total gas (Subregions A+B+E)

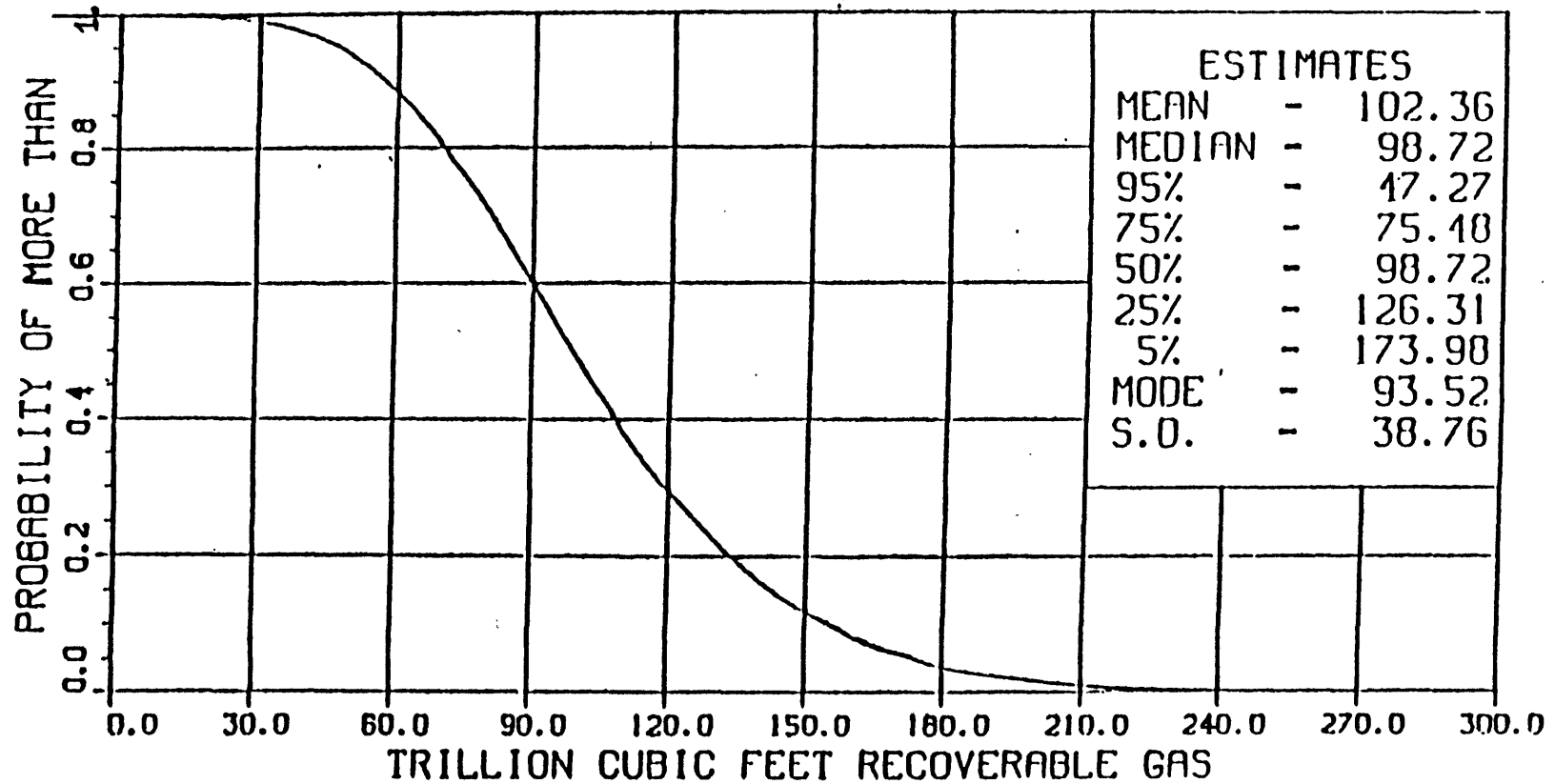

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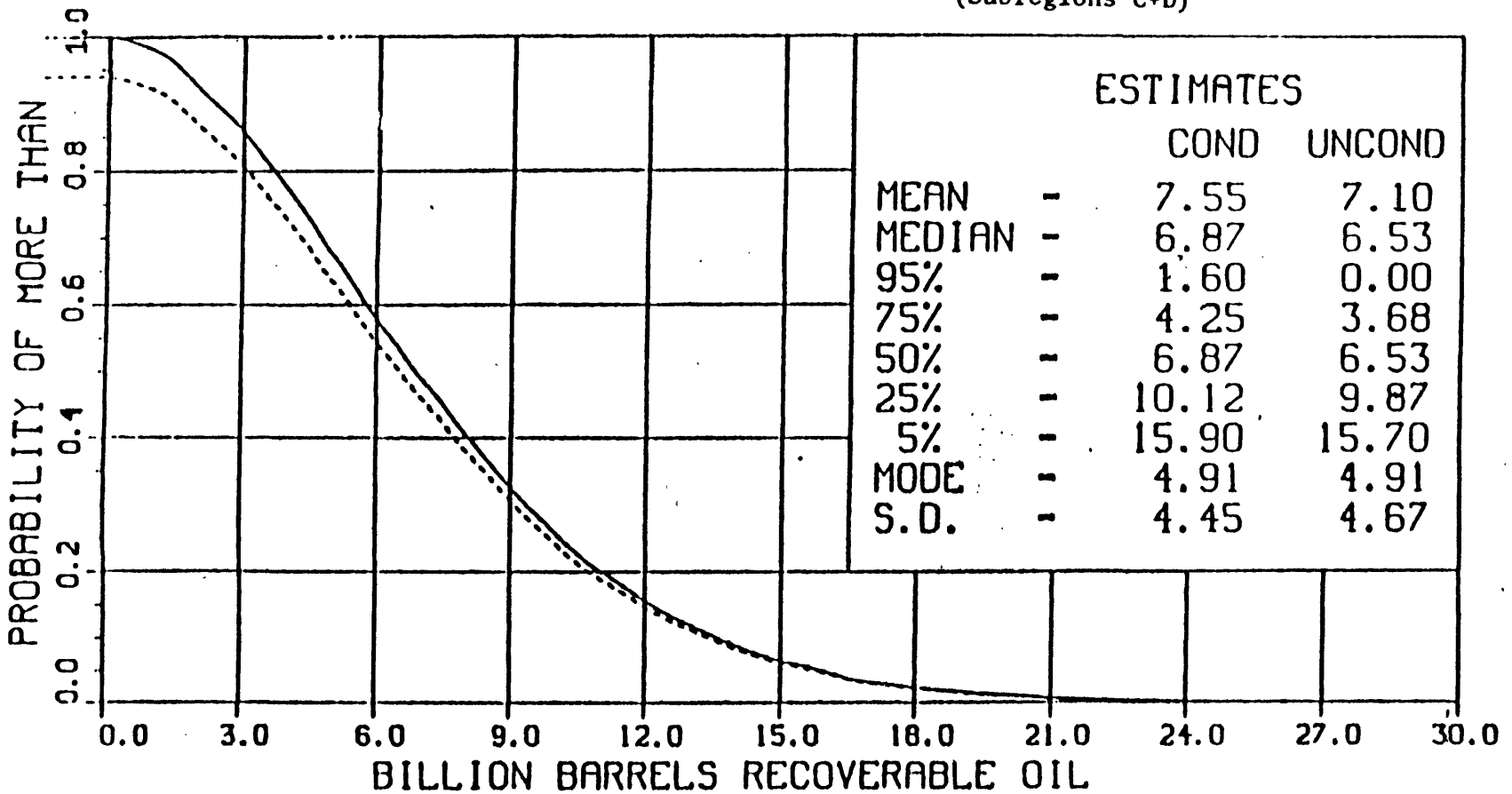
Figure 6.--Northwest European Region, north of 62°, aggregate recoverable oil (Subregions C+D)



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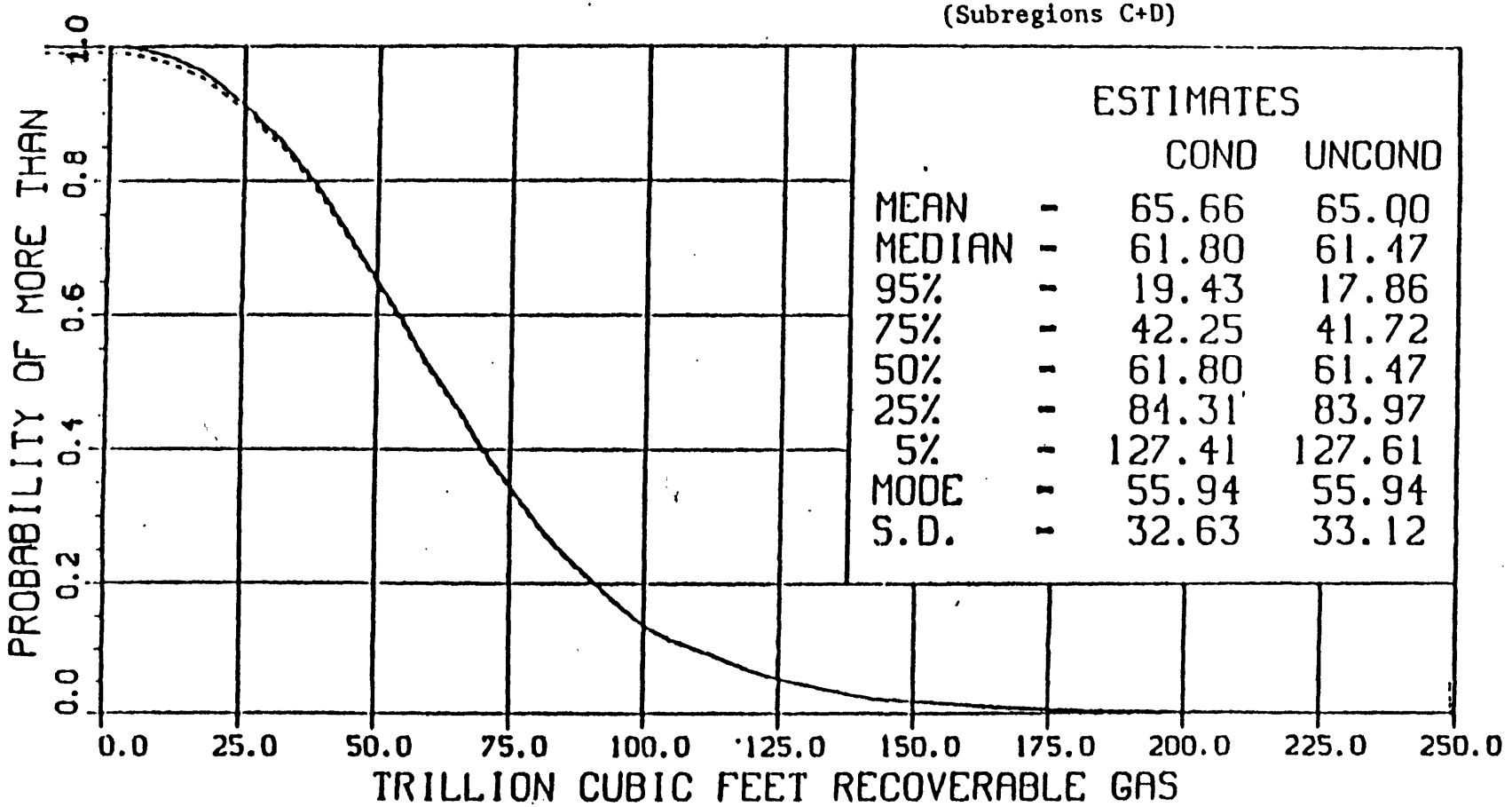
Assessment date: 7/13/82

Figure 7.--Northwest European Region, north of 62°, aggregate recoverable total gas (Subregions C+D)



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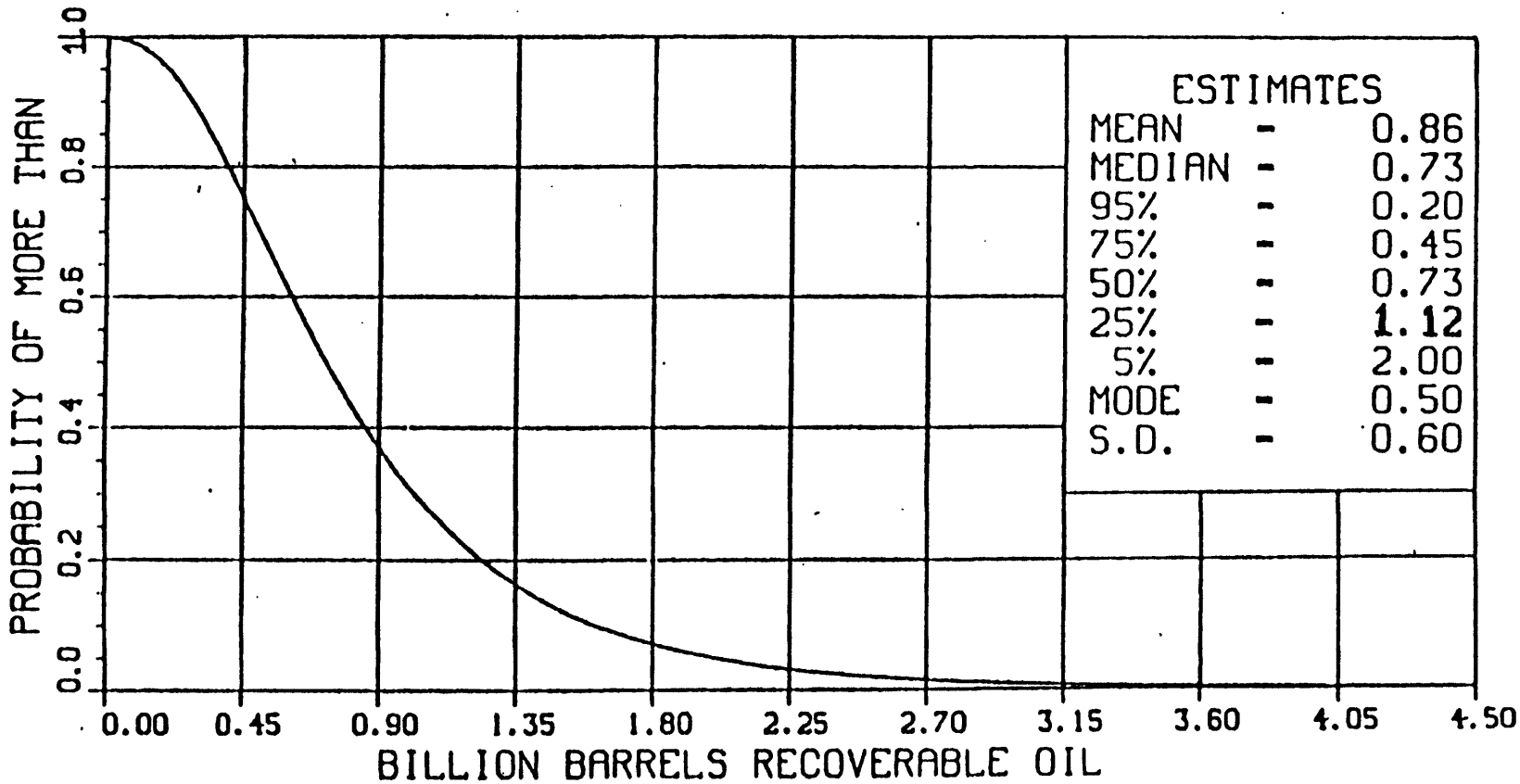
Assessment date: 2/23/82

Figure 8.--Northwest European Region, southern North Sea Basin, recoverable oil (Subregion A)



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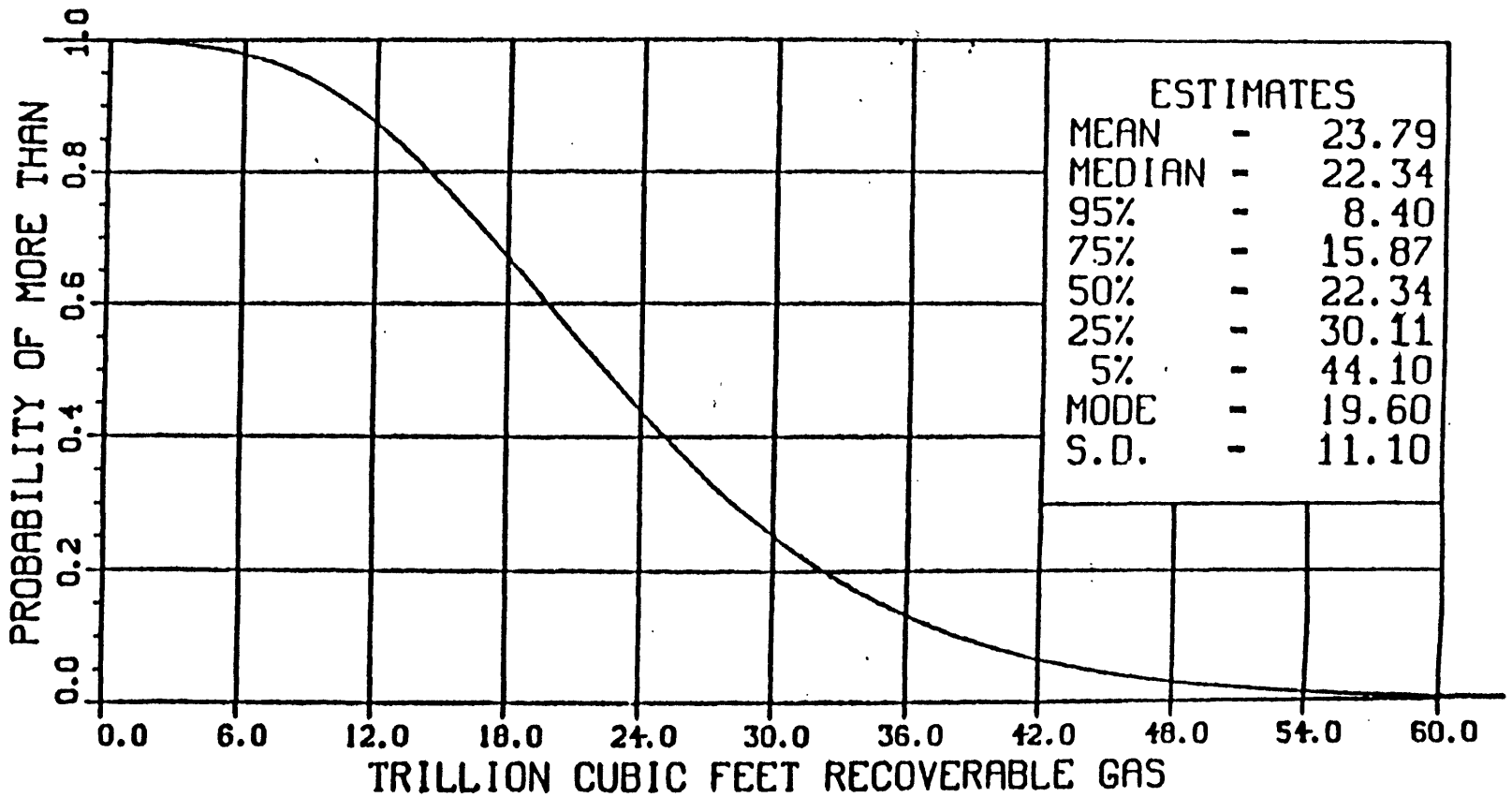
Assessment date: 2/23/82

Figure 9.--Northwest European Region, southern North Sea Basin, recoverable total gas (Subregion A)



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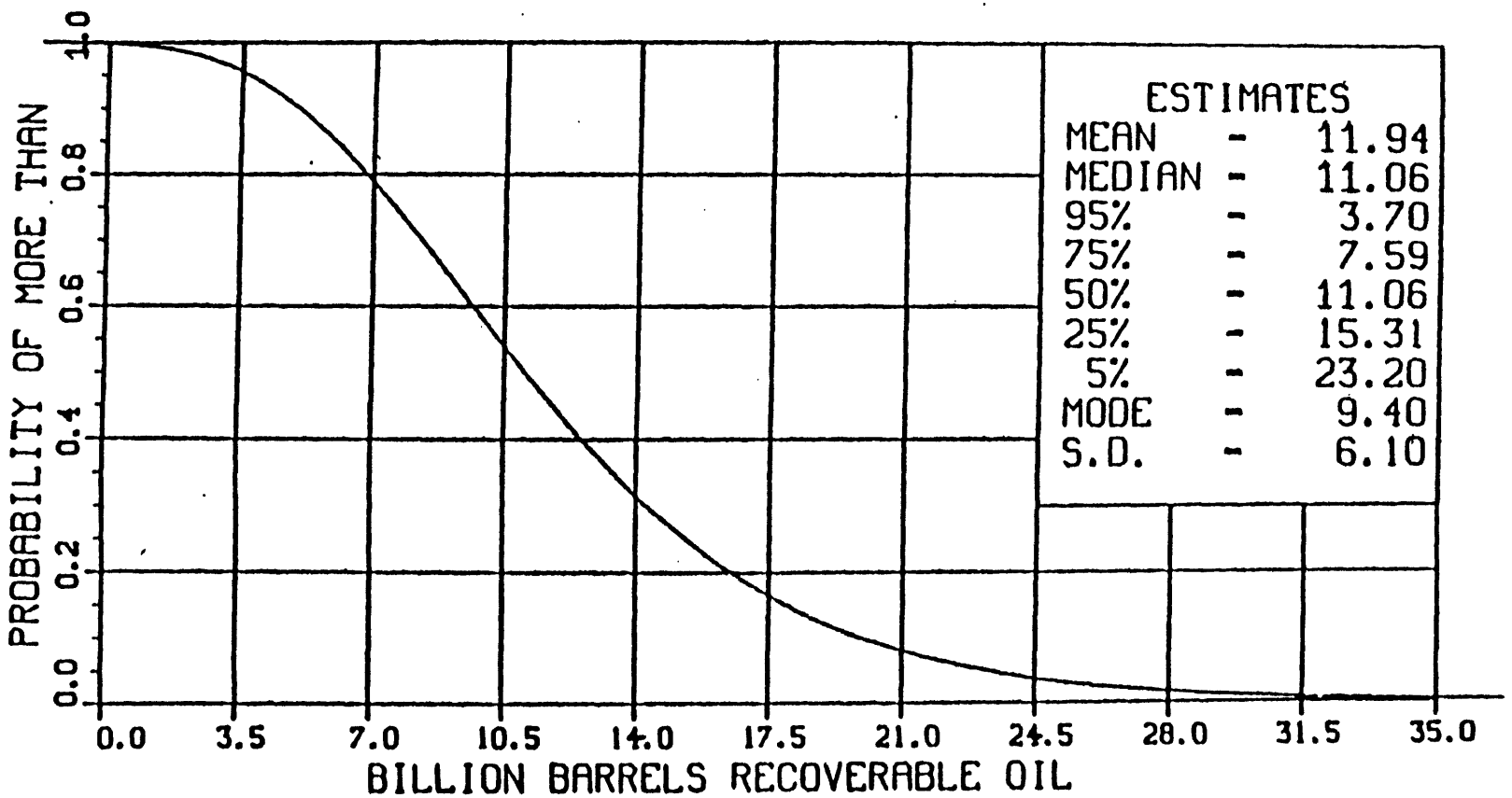
Assessment date: 2/23/82

Figure 10.--Northwest European Region, Viking and Central Grabens, recoverable oil (Subregions B+E)



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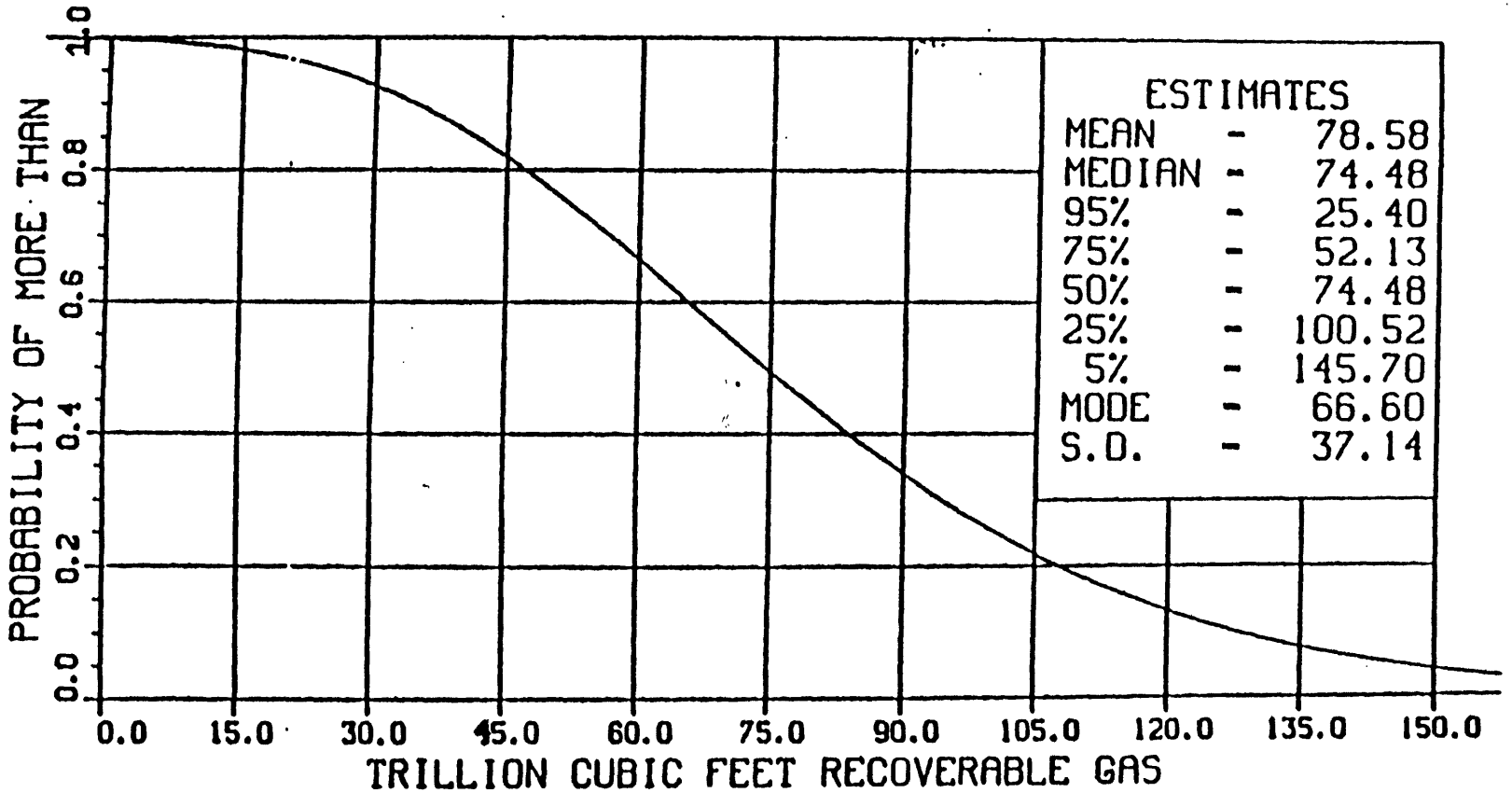
Assessment date: 2/23/82

Figure 11.--Northwest European Region, Viking and Central Grabens, recoverable total gas (Subregions B+E)



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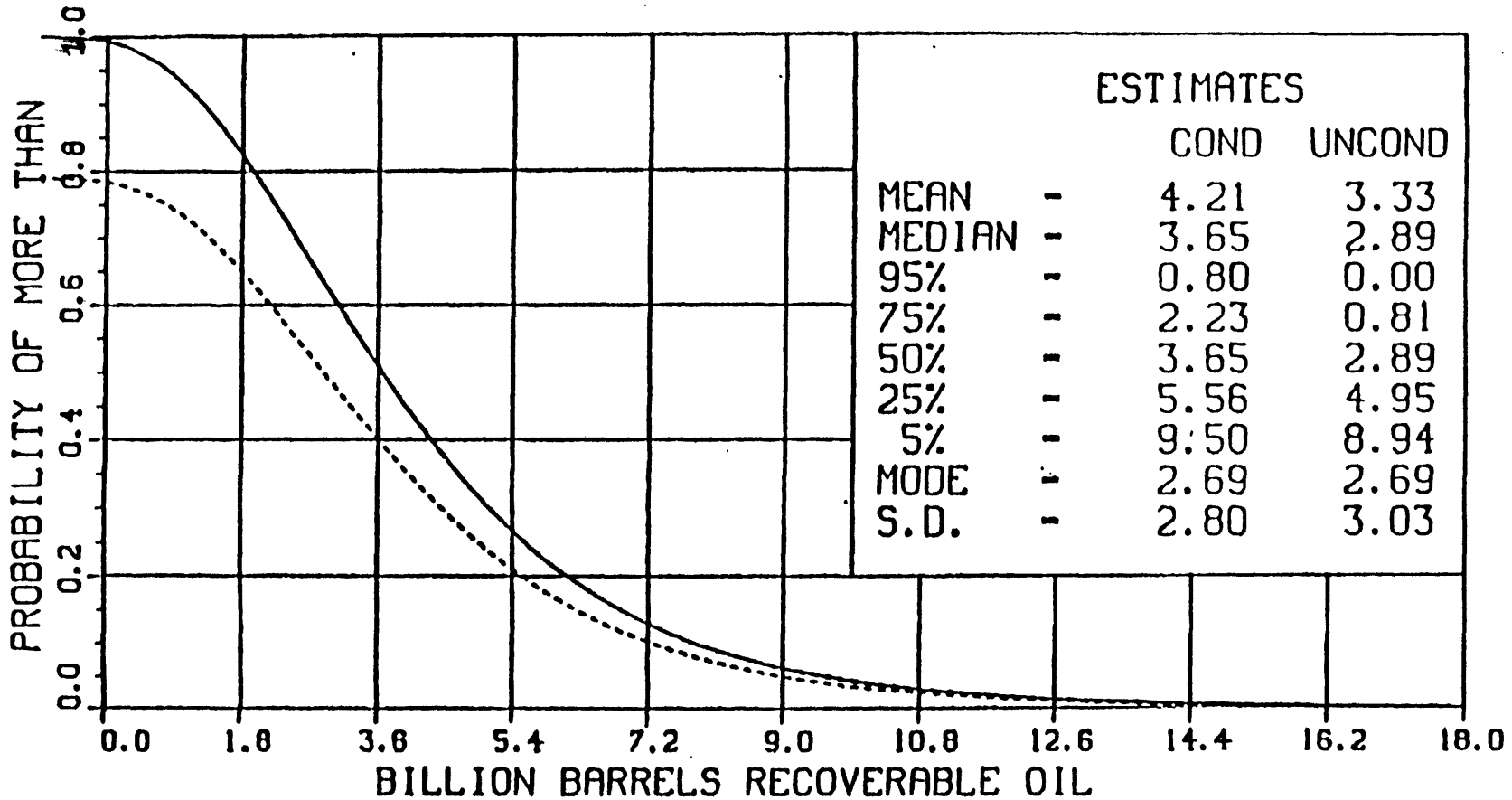
Assessment date: 7/13/82

Figure 12.--Northwest European Region, north of 62°, southern sector, recoverable oil (Subregion C)



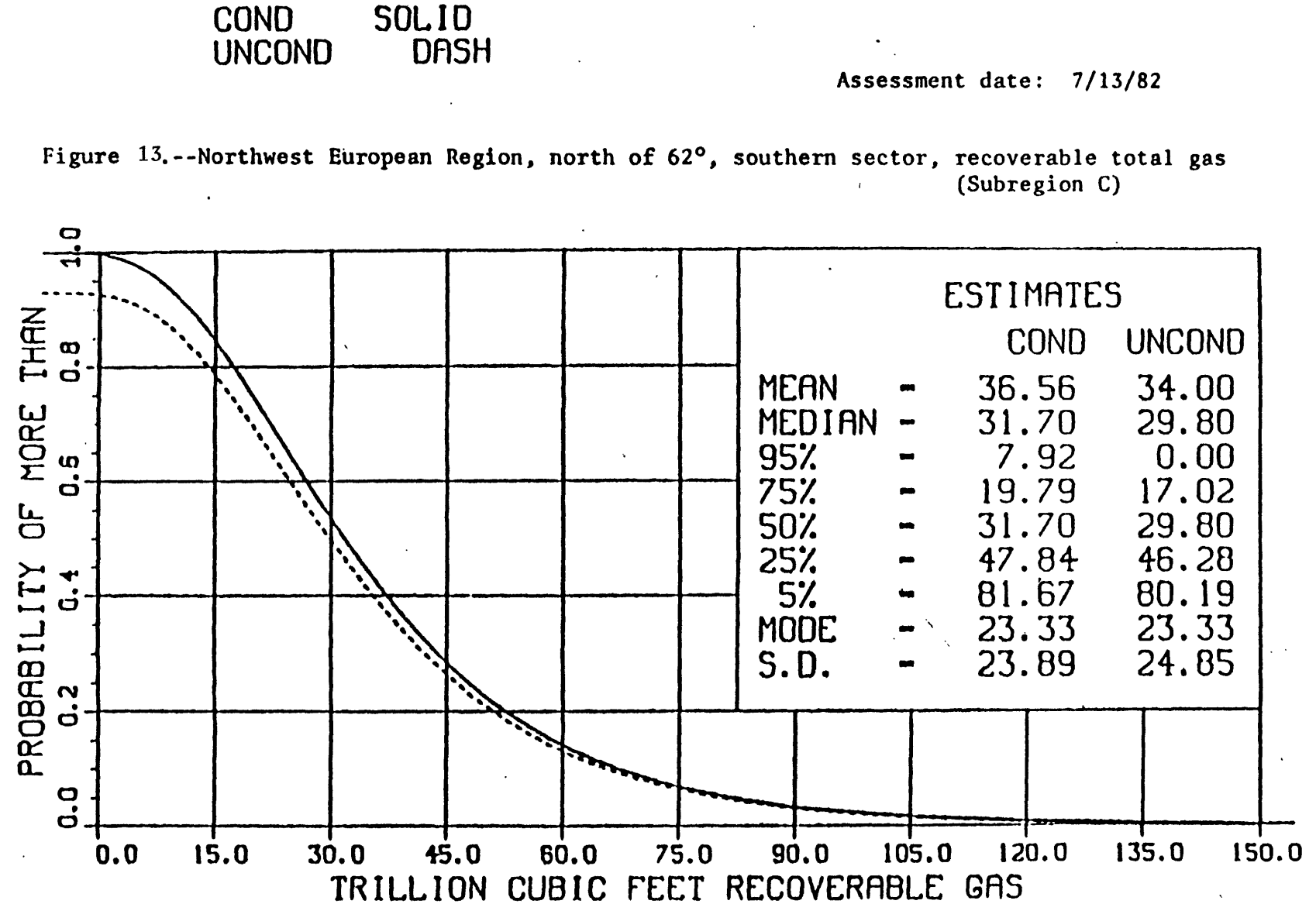


Figure 13.--Northwest European Region, north of 62°, southern sector, recoverable total gas (Subregion C)

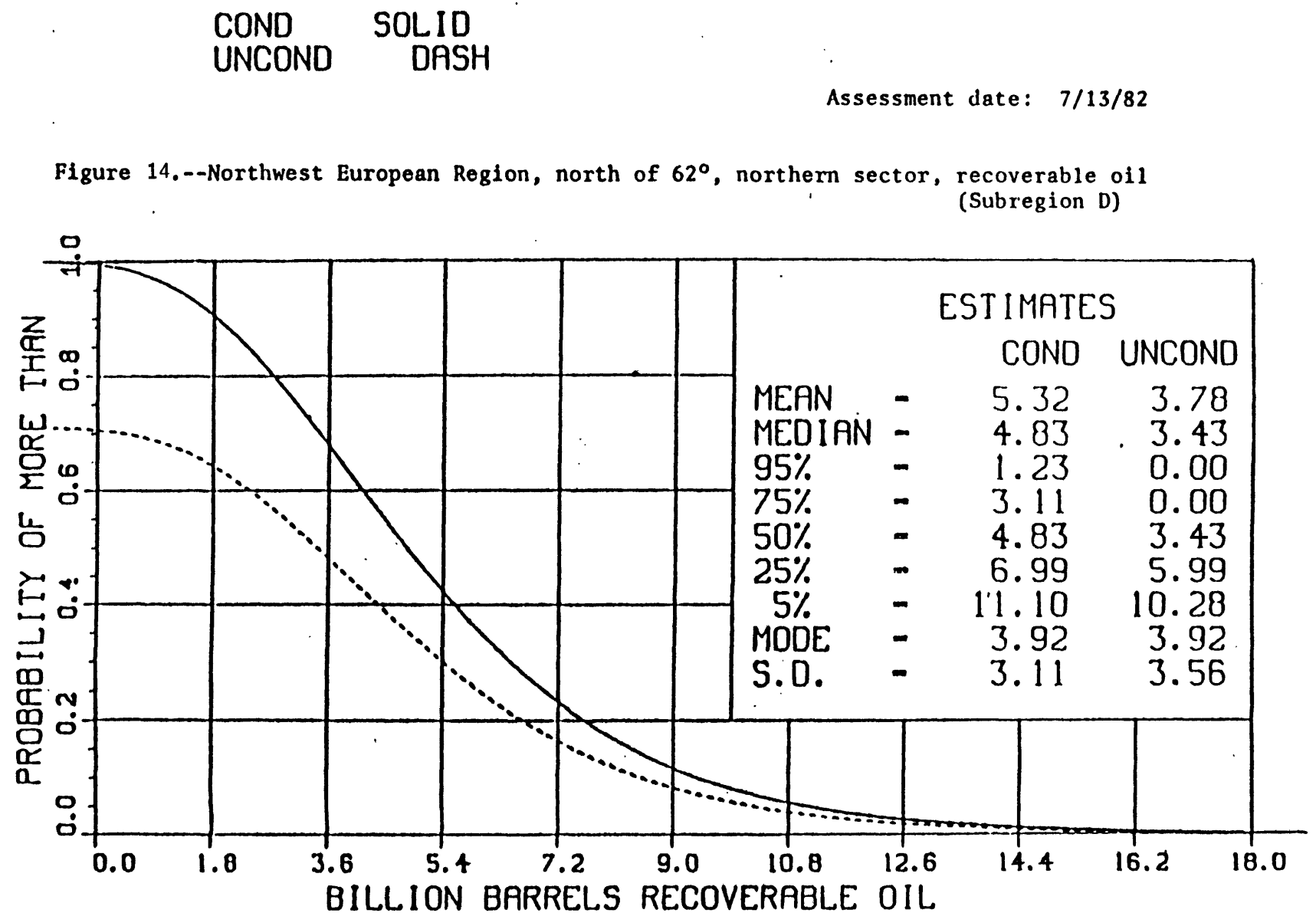


Figure 14.--Northwest European Region, north of 62°, northern sector, recoverable oil (Subregion D)

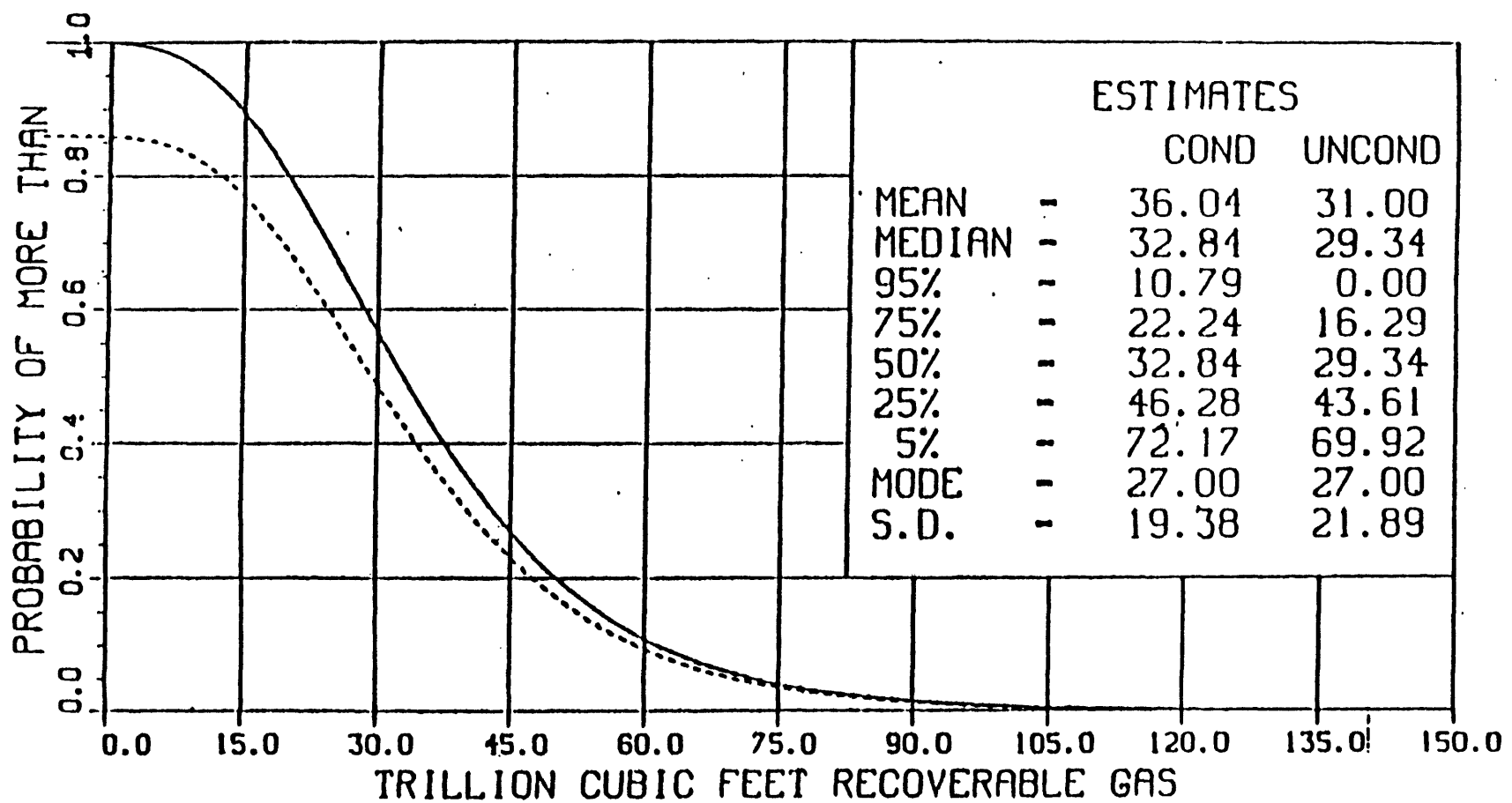


Figure 15.--Northwest European Region, north of 62°, northern sector, recoverable total gas (Subregion D)

Table 3.--Supplementary and comparataive data relative to the resource assessment of the northwest European assessment region[1/]

Crude oil (BB)		Natural gas (Tcf)	
Cumulative production to 12/31/81		Cumulative production to 12/31/81	
3.8		40	
Identified reserves to 1/1/82 [2/]		Identified reserves to 1/1/82 [2/]	
Demonstrated	23.6	Demonstrated	222
Inferred	+ [3/]	Inferred	+ [3/]
Original recoverable resources (ultimate)			
Cumulative production	3.8		40
Identified reserves	23.6		222
Undiscovered resources (mode)	15		162
	42.4		424
			BBOE = 72

Total oil and gas (mode) = 114 BBOE

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

[2/] Following terminology outlined in USGS Circular 860. Demonstrated is equivalent to API Proved and Indicated Additional. (For natural gas, indicated additional is zero.) Inferred represents anticipated field growth in existing fields.

[3/] Quantity positive but data not available.

COMMENTS

- The dominant analogue used in volumetric calculations was the Klemme type 3 rift basin (Klemme, 1980). Some basins to the west of the British Isles and to the northwest of Norway north of 62° N latitude did not possess the two sided rift characteristic and were classified as Klemme type 5 pull-apart basins.

- The southern North Sea basin is geologically completely different from the rest of the North Sea and appears to be a Klemme type 2A complex basin; specific basin analogues include the Ergs Oriental and Occidental in Algeria and the West Siberian basin in the USSR.

- In both the Viking and Central grabens and in the southern North Sea basin, a number of discoveries are under evaluation—some 36 in the former and 45 in the latter. In the assessment, we assume that most of these discoveries represent a marginal economic field-size potential, and their exclusion from the discovered reserves does not significantly affect the estimate of undiscovered resource potential.

- Broad areas for which there are little data, lying between and west of the British Isles, are included in the assessment, but regional analysis suggests that those regions have lesser potential as compared with the heart of the North Sea. To the south, this would appear to be owing to facies changes in the prime Jurassic source rock and possibly to inadequate burial depth. To the northwest, however, due west of the Shetland Islands, a giant field has been discovered on the Rona Ridge (approximately 4×10^9 bbls in place), but the oil is heavy, 22°–25° API, resulting in recovery percent being limited, and the relatively shallow depth of burial poses difficult production problems. Exploration undoubtedly will continue in this area, however.

- The assessment area extends marginally into the area that probably geographically belongs to the Barents Sea. The geological characteristics that make the North Sea-proper productive do not extend significantly into the Barents Sea; hence, the assessment for that area is minimal.

- Prime areas of undiscovered potential appear to heavily favor Norway, considering the as yet modest exploratory effort in the Northeast Viking graben area, the Bergen high, and the Horda basin. The very large off-shore region to the north of 62° N latitude suffers from increasing water depth (optimum geology would appear to lie between 600 and 1,200 ft of water depth) and excessive source rock depth of burial; both factors decrease economic potential, the one because of increasing costs and the other because the area is rendered gas prone. The two discoveries to date have been gas and gas condensates. The Bergen high and Horda basin may suffer from either absence or immaturity of source rock.

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* Klemme, H. D., 1980, Petroleum basins—classifications and characteristics, Journal of Peteroleum Geology, v. 3, no. 2, p. 187-207.

Areas of petroleum potential were estimated, assuming normal to slightly above-normal temperature gradients. Because we think the temperature gradient may in fact have been higher, we consider that assumption to have biased the estimate slightly toward oil.