GEOLOGICAL SURVEY CIRCULAR 881

Assessment of Undiscovered Conventionally Recoverable Petroleum Resources of the Arabian-Iranian Basin

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By Charles D. Masters, H. Douglas Klemme, and Anny B. Coury

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A resource assessment and a brief description of the petroleum geology, including play distribution, that accounts for the largest accumulation of petroleum in the world.

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ASSESSMENT OF ENERGY RESOURCES

The World Energy Resources Program of the U.S. Geological Survey (USGS) intends to develop reliable and credible estimates of undiscovered petroleum resources throughout the world. Initial program efforts have focused on the major producing areas of the world in order to gain a broad geological understanding of the characteristics of petroleum occurrence for purposes of resource assessment as well as for analysis of production potential. Investigations of production potential are carried out in cooperation with other U.S. Government agencies; specifically, the studies of the main free world exporting nations, of which this study is a part, are carried out in cooperation with the Foreign Energy Supply Assessment Program of the Department of Energy.

The program seeks to investigate resource potential at the basin level, primarily through analogy with other petroleum regions and does not necessarily require, therefore, current exploration information that is commonly held proprietary. In conducting the investigations, we intend to build a support base of publicly available data and geologic syntheses against which to measure the progress of exploration and thereby validate the assessment. Most of these investigations will lead directly to quantitative resource assessments, which, like exploration, to be effective, must be ongoing processes taking advantage of changing ideas and data availability–the results produced are progress reports reflecting on a state of knowledge at a point in time. Because the program is coordinated with the USGS domestic assessment program and because both use similar techniques for assessment, the user can be assured of a thread of consistency permitting comparisons between the various petroleum basins of the world, including the United States, that have been assessed in the overall USGS program.

In addition to resource estimates, the program provides a regional base of understanding for in-country exploration analysis and for analysis of media reports regarding the exploratory success or failure of ventures in studied areas.

Other USGS publications relating to the assessment of undiscovered conventionally recoverable petroleum resources include the following:

Open-File Report 81-0986–Assessment of conventionally recoverable petroleum resources of Persian Gulf basin and Zagros fold belt (Arabian-Iranian basin)

Open-File Report 81-1027–Assessment of conventionally recoverable petroleum resources, Volga-Urals basin, U.S.S.R.

Open-File Report 81-1142–Assessment of conventionally recoverable petroleum resources of Indonesia

Open-File Report 81-1143–Assessment of conventionally recoverable petroleum resources of northeast Mexico.

Open-File Report 81-1144–Assessment of conventionally recoverable petroleum resources of southeastern Mexico, northern Guatemala, and Belize

Open-File Report 81-1145–Assessment of conventionally recoverable petroleum resources of Trinidad

Open-File Report 81-1146–Assessment of conventionally recoverable petroleum resources of Venezuela

Open-File Report 81-1147–Assessment of conventionally recoverable petroleum resources of the West Siberian basin and Kara Sea basin, U.S.S.R.

These reports are available from Open File Services Section, Branch of Distribution, USGS, Box 25425, Federal Center, Denver, CO 80225.

ACKNOWLEDGMENT

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Assessment of Undiscovered Conventionally Recoverable Petroleum Resources of the Arabian-Iranian Basin

By Charles D. Masters,[1] H. Douglas Klemme,[2] and Anny B. Coury[3]

ABSTRACT

The estimates of undiscovered conventionally recoverable petroleum resources in the Arabian-Iranian basin at probability levels of 95 percent, 5 percent, and statistical mean are for oil (in billions of barrels): 72, 337, and 174; and for gas (in trillions of cubic feet): 299, 1792, and 849.

The occurrence of petroleum can be accounted for in five definitive geological settings or plays. The assessment of undiscovered resource potential assumes that the new discoveries will expand the occurrence of petroleum in these basic plays; no additional plays with significant petroleum potential were recognized. The five plays listed by geologic age are: (I) Upper Cretaceous and Tertiary, (II) Lower and Middle Cretaceous sandstone, (III) Lower and Middle Cretaceous limestone, (IV) Jurassic, and (V) Permian. The Permian play, located in the south-central Arabian Gulf region and extending northeast-southwest from southern Iran to the Ar Rub' al Khali in Saudi Arabia, accounts for over four-fifths of the mean estimate of undiscovered gas. The remainder of the gas is divided about equally among the other four plays. The Jurassic play, located on the south side of the Arabian Gulf, accounts for slightly less than one-third of the estimated undiscovered oil, which is split equally between Saudi Arabia and Iraq. The Lower and Middle Cretaceous limestone play is located in the southern Gulf region and accounts for about one-fifth of the undiscovered oil, most of which is located in Saudi Arabia and the remainder in the United Arab Emirates. The Lower and Middle Cretaceous sandstone play is centralized in Kuwait at the head of the Arabian Gulf with significant potential extending to the northwest in Iraq; the play accounts for about one-third of the undiscovered oil, the great majority of which is estimated to be in Iraq with the remainder divided between Saudi Arabia and Kuwait. The upper Cretaceous-Tertiary play is located in the Zagros fold belt of Iran and Iraq and accounts for about one-fifth of the undiscovered oil.

Estimation of the resources in this vast area is hindered by lack of data from certain broad regions, abandoned wells, and several significant dry holes, but the regional geology is well enough reported that geologic projections can be made and inferences from selected wells can be drawn to permit estimation of the resource potential.

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INTRODUCTION

The investigation of the petroleum resource potential of the Arabian-Iranian basin was performed under contract to Weeks Petroleum Corporation (Contract No. 14-08-001-17919) by Dr. H. Douglas Klemme. Sources of data include Petroconsultants Ltd. and published literature. The resource assessment was conducted by the Resource Appraisal Group (RAG) of the USGS, Branch of Oil and Gas Resources, following the standard procedures developed since 1974 for domestic petroleum resource analysis. The technique, briefly, requires study of a given area, paying particular attention to the geologic factors controlling the occurrence, quality, and quantity of the petroleum resource. Standardization of critical elements of the investigations is achieved by the preparation of data forms for each basin, which call for specific volumetric, areal, and rock-quality measurements, as well as the determination of basin analogs for comparison purposes. In addition, finding-rate histories and projections are constructed, when possible. From these data and analyses, various analytical techniques are used to calculate a set of resource numbers.

The assessment process itself is subjective; the results of the geological investigation and of the resource calculations are presented to a team of USGS assessment specialists, who make their personal estimates conditional upon recoverable resources being present. Initial assessments are made for each of the assessed provinces as follows:

(a) A low-resource estimate corresponding to a 95 percent probability of more than that amount; this estimate is the 95th fractile (F_{95}).

(b) A high-resource estimate corresponding to a 5 percent probability of more than that amount; this estimate is the 5th fractile (F_5).

(c) A modal (most likely) estimate of the quantity of resource associated with the greatest likelihood of occurrence.

The individual estimates are then posted and averaged, and the results debated from the perspective of the personal experiences of the individual assessors; a second and third iteration of the procedure may follow depending on consensus. If no commercial oil has been heretofore discovered in the basin, then a marginal probability is subjectively assessed reflecting the probability that any commercial oil will ever be discovered.

The results of the final estimates are averaged, and those numbers are computer processed using probabilistic methodology (Crovelli, 1981) to show graphically the resource values associated with a full range of probabilities and to determine the 95th fractile, the 5th fractile, and the mean, as well as other statistical parameters.

REGIONAL GEOLOGY

The Arabian-Iranian basin lies on the northeast flank of the Arabian craton (fig. 1), which, along with a proximal ocean margin of the Tethys seaway, provided the physical framework that controlled the sedimentary processes during Paleozoic, Mesozoic, and most of Cenozoic time. The tectonic behavior of the area during most of this time was as a modified passive margin. The continental mass, of which the Arabian Shield and associated sedimentary basins were a part, moved from the general South Pole region to the Equator (Scotese and others, 1979). Clearly, in the resultant closing of the Tethys, subduction of the oceanic crust must have taken place north of the advancing Arabian craton, but that process does not appear to have affected the Arabian-Iranian basin sedimentation (except perhaps in whatever role it may have played in the crustal movements that controlled sedimentation) until the Late Cretaceous, at which time ophiolites were obducted in the area of Oman (Glennie and others, 1974, p. 393), and clastic sediment derived from the north and east was deposited as wedges (Murris, 1980, p. 598). In latest Tertiary, coincident with the final closing of this portion of the Tethys, the Zagros Mountains were uplifted and thrust to the south, shedding sediments into a Neogene foreland basin over the earlier accumulated sedimentary rocks on the passive margin of the Arabian-Iranian basin. In the process, the foreland belt of sediments was tightly folded into a series of long linear northwest-trending parallel folds (Murris, 1980).

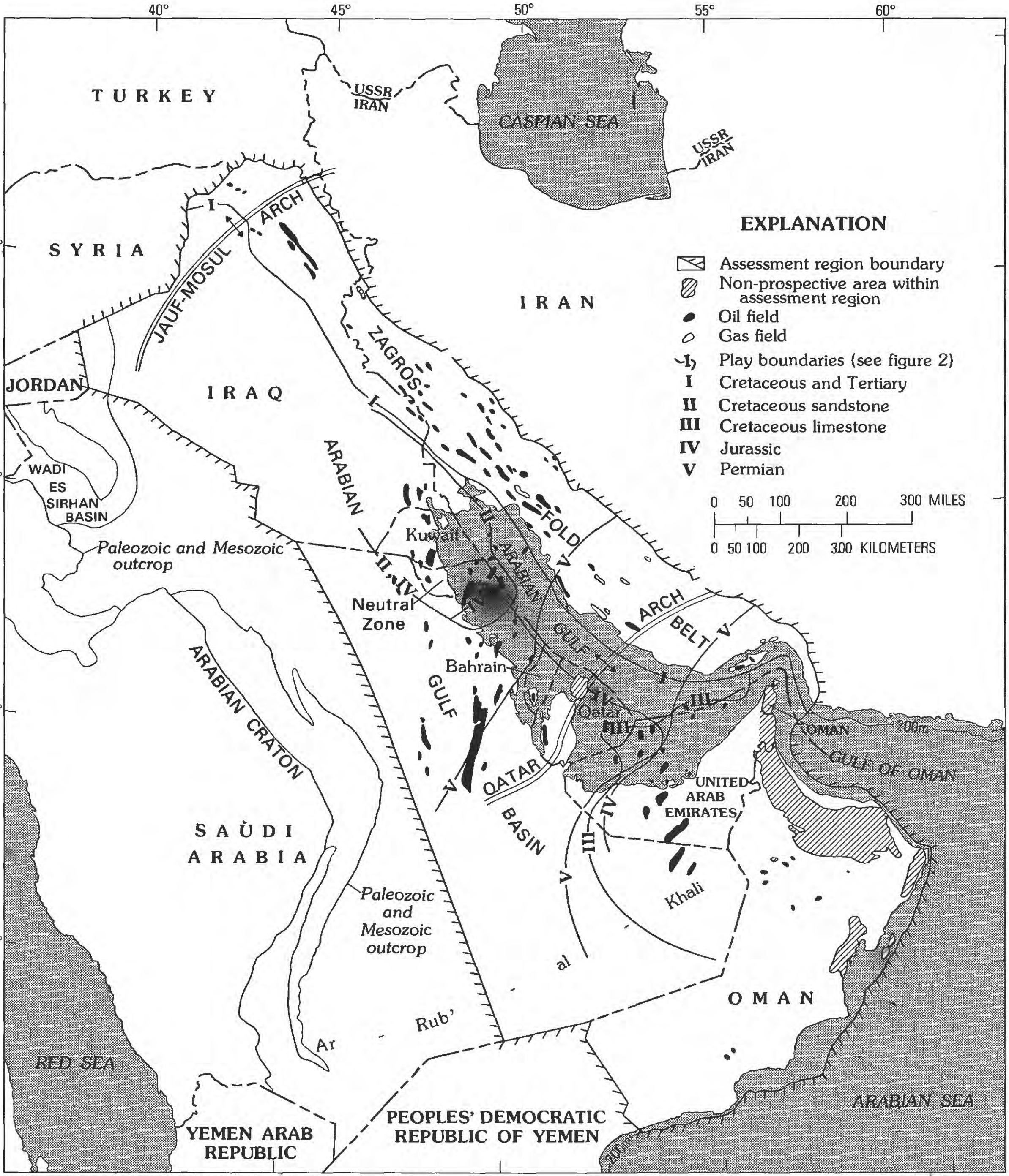
The location of the Arabian craton near the Equator during the Phanerozoic provided optimal environmental conditions for carbonate sedimentation on platform areas and for deposition of organic shales in marginal continental slope and deep water marine environments. Periodically, the dominant carbonate/shale depositional environment received an influx of siliceous clastic sediments from the shield or experienced such restrictions of water movement that evaporite deposition ensued. The combination of favorable depositional conditions for reservoir rock, seals, and source rock, in a tectonic environment of large anticlinal structures caused initially by gentle basement crustal movements and later by continental plate collision, produced the Arabian-Iranian basin petroleum province.

PETROLEUM GEOLOGY

The Arabian-Iranian basin is the richest petroleum province in the world. Other basins, such as the Los Angeles basin, are richer per unit volume, but their volumes are relatively small. The individual factors that have contributed to this great accumulation are well known, but just how they all fit together to result in such extraordinary quantities of trapped, recoverable petroleum can only be hypothesized.

Essential factors in petroleum occurrence and entrapment are reservoir rock, source rock, trap, seal, and the timing and geometry of their interrelationship. Major oil and gas occurrence in the Arabian-Iranian basin is associated with five time periods during which the relationship between essential geologic factors was satisfactory for significant oil generation and entrapment; it is possible to define five discrete plays that account for most of the petroleum occurrence: (I) Upper Cretaceous and Tertiary, (II) Lower and Middle Cretaceous sandstone, (III) Lower and Middle Cretaceous limestone, (IV) Jurassic, and (V) Permian (fig. 2). Each of the plays is geographically restricted to areas where all of the essential factors were present, and for the most part the boundaries of these areas are predictable.

The Upper Cretaceous and Tertiary play (I) is concentrated in the Zagros fold belt of Iran and



The boundary lines on this chart are for purposes of illustration only, and do not necessarily reflect the position or views of the United States with respect to the boundaries involved.

Modified from Petroconsultants

FIGURE 1.–The Arabian-Iranian basin assessment region including the locations of most oil and gas fields and petroleum play limits.

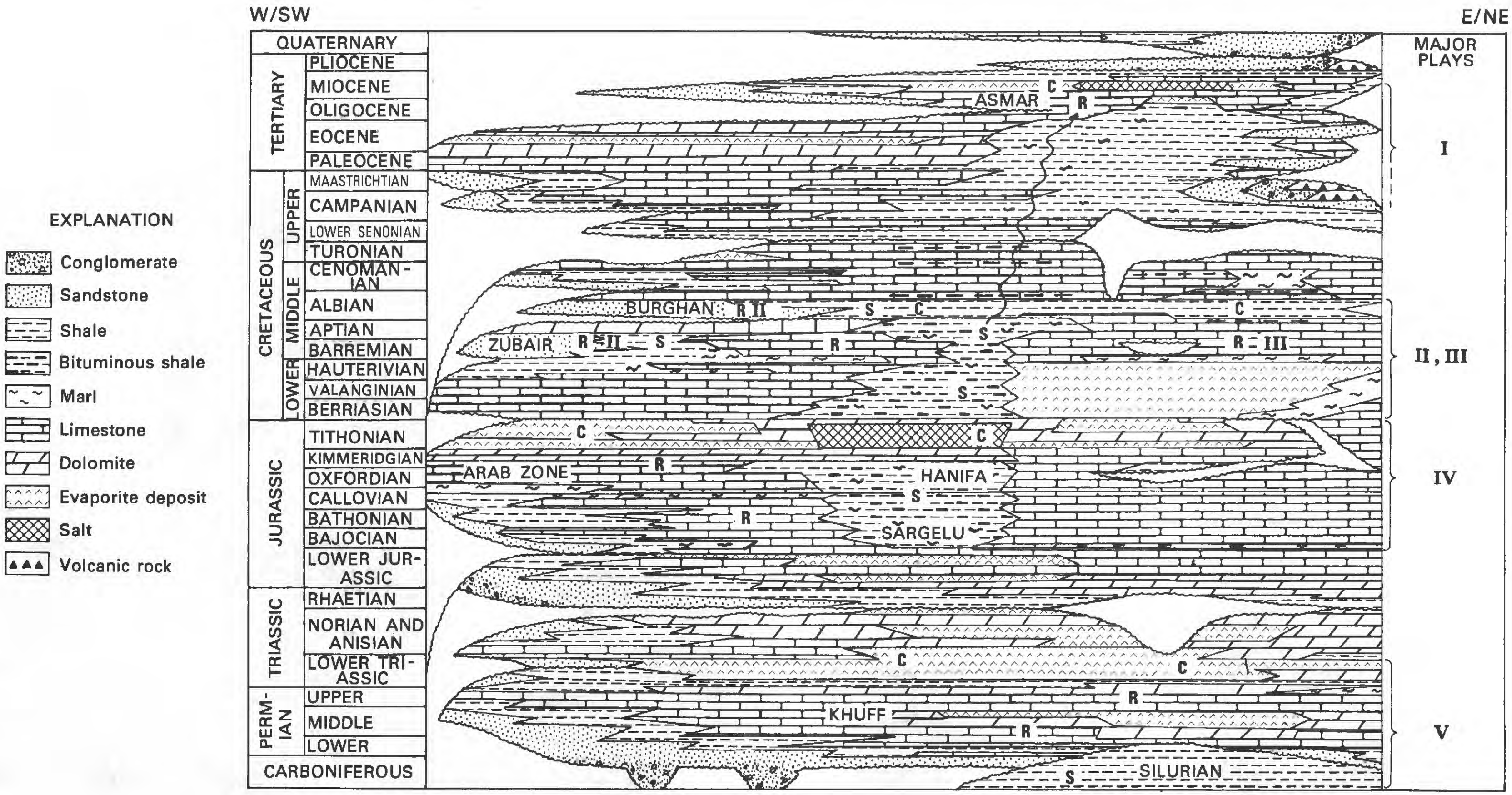


FIGURE 2.—Generalized stratigraphy of Arabian-Iranian basin showing position of five major plays (Roman numerals I-V) and their associated reservoir rock (R), cap rock (C), and source rock (S). Note source rock for play V is Cretaceous and Jurassic. (Modified from Murris, 1980, p. 598.)

Iraq. Structures that derive from the collision tectonics associated with the closing of the Tethys trend are arrayed northwest-southeast in the area northeast of the Arabian Gulf and the Euphrates River valley. More than three-fourths of the petroleum potential lies in Iran. The reservoir rock distribution is controlled by fractures associated with the Zagros folding. Regional evaporites effectively seal the traps. The major reservoir rock unit is the Asmari limestone of Oligocene to early Miocene age. The Asmari is a neritic limestone, with shelly intercalations, that is locally altered to dolomite and anhydrite. The degree of permeability of the reservoir rocks is due entirely to fracturing; porosity ranges from 9 to 14 percent. The Asmari is 100 to 1,500 ft thick, and its productive section commonly comprises 25 to 75 percent of the overall thickness. The Asmari is absent in the southern fold belt owing to facies change or nondeposition, but, there, other fractured Tertiary limestones provide substitute reservoirs. The source rocks are the same Cretaceous and possibly Jurassic shales that sourced the Arabian platform facies. Here, the oil has migrated vertically through fractures to a zone of principal concentration in the Asmari. To the southeast, the source rocks are absent because of facies change or nondeposition, just as is the Asmari limestone. Throughout the fold-belt region, large structures are pervasive; hence a principal limitation on oil occurrence appears to be source rock distribution. In the southern Zagros, however, where Jurassic and Cretaceous source rock are absent, the lower Paleozoic source rocks have generated large quantities of natural gas, but the gas fields are yet to be developed.

The Lower and Middle Cretaceous sandstone play (II) is located centrally in the Arabian-Iranian basin; Kuwait and the giant field Burgan are in the middle of the play area. The boundaries of the controlling reservoir sandstone facies extend through the Neutral Zone into Saudi Arabia, northwest into Iraq and northeast into the fold belt of Iran. The reservoir rock consists of pure quartz sandstone, clean, well sorted, medium- to coarse-grained, commonly glauconitic, with minor secondary cementation and shale interbeds. Porosities range from 10 to 30 percent, and permeabilities are commonly in excess of one darcy. Thickness of the delta sandstone wedge varies from 200 to 1,200 ft. Source rocks are most likely facies equivalent, prodelta shales deposited seaward (east) of the delta. Traps are found in upward continuations of the same structural lineaments responsible for oil accumulation in the Jurassic play in Saudi Arabia. They are basement controlled, generally north-south oriented, and commonly enhanced by salt flowage. The limiting factor in Cretaceous oil occurrence appears to be the distribution of reservoir facies and structural lineaments. Though the present producing delta facies appears to have been delineated, it is possible that the poorly explored regions to the northwest in Iraq could contain one or more deltas; it is not known from the literature on Iraq available to us whether or not anticlinal traps exist in this region of Iraq.

The Lower and Middle Cretaceous limestone play (III) is concentrated in southeastern Saudi Arabia, the United Arab Emirates, and in northern Oman. The reservoir rock consists of mixed carbonate facies, including packstone, wackestone, lime mudstone, and bioclastic fore-reef debris deposited under general cyclic conditions between slope and carbonate platform edge localities. The reservoir units, up to 3,000 ft thick, generally have been recrystallized and possess 10 to 20 percent porosity and 0 to 500 md permeability. The age of the source rocks is uncertain, but the petroleum probably was generated in shale facies that are equivalent in age to the reservoir rock. Traps are associated with salt diapirs. Cap rocks consist of shale and evaporite that are common throughout the area. Petroleum occurrence is strongly facies and structure controlled. Field sizes are modest by Middle East standards and are limited generally by trap size.

The Jurassic play (IV) occupies a large area in northeast Saudi Arabia, extending northeast to approximately the Iranian border, southeast to the United Arab Emirates, and north to Kuwait (fig. 1). The reservoir rocks, principally in the Upper Jurassic Arab zone (fig. 2), are commonly poorly cemented bioclastic, oolitic, limey sandstones with high porosity (20–30 percent) and permeability (several hundred millidarcies). Off structure, these same units are strongly altered by recrystallization to dolomite and anhydrite. Pay zones range from 30 to 200 ft, averaging 90 ft. The Arab D zone contains the principal reserves of the Jurassic section. Production per well averages 12,000 b/d. Source rocks include the Hanifa and Sargelu formations of Middle and Late Jurassic age. The source rocks interfinger with the reservoir rocks at the southern end of their distribution, but for the most part they were deposited to the northeast beyond the edge of the platform carbonate bank; the oil migrated updip to the south and west into the early formed structures that controlled reservoir deposition. The Qatar-south fars arch was probably a limiting factor in migration to the south. The dominant traps for Upper Jurassic oil are north-trending, broad anticlinal structures that are controlled by gentle basement block movements, some of which are enhanced by salt movement. The size of the traps and the fact that their early growth contributed to favorable reservoir rock sedimentation have resulted in a close grouping of the largest oil fields in the world. The largest of these fields is Ghawar with original reserves in excess of 80 billion barrels of oil (BBO). Another significant factor in Jurassic oil occurrence is an overlying regional evaporite seal of Late Jurassic age, the Hith formation (fig. 2). Limiting factors in Jurassic oil occurrence are reservoir facies distribution, structure size, and migration paths from principal source rock areas.

The Permian play (V) is located in the south-central Arabian Gulf region and extends in a southwest-northeast direction from the Arabian platform to the Zagros fold belt (fig. 1). Reservoir rocks are in the Khuff formation, a platform carbonate with interbedded evaporite deposits and a basal conglomerate (fig. 2). Thicknesses of the Khuff range up to 2,000 ft. Reservoir rocks in the Zagros fold belt are fractured. The source rocks are unconformably underlying widespread Ordovician and Silurian graptolitic shales, up to 3,000 ft. thick, which have been deeply buried and thermally matured to the gas generation stage. The distribution of the Hercynian unconformity that permits juxtaposition of lower Paleozoic source rock with upper Paleozoic reservoir rock controls the play boundaries. In general, the critical uncomformity distribution follows the Qatar-south fars arch (fig. 1). The traps on the shield are basement-controlled anticlines trending north, and some are enhanced by the movement of Cambrian salt. The traps in the Zagros fold belt are long, linear anticlines. Seals are provided by the interbedded Permian evaporite deposits as well as by regional Triassic evaporite deposits (fig. 2). Limiting factors in the play appear to be (1) the distribution of the critical unconformity that brings source and reservoir in juxtaposition, (2) structure size, and (3) drilling depth.

RESOURCE ASSESSMENT

Introduction.–The location of the Arabian-Iranian basin assessment region is shown in figure 1. U.S. Geological Survey (USGS) estimates of oil and gas resources in this region are given in table 1 and figures 3 through 16. Supplementary data of interest in analyzing these estimates are supplied in table 2.

At the time of the assessment, the country-by-country distribution of resources was estimated on the basis of play distribution by country and on the proportion of total estimated resources assigned to each play (table 3). This estimate was considered to be an allocation of the mean quantity of resources, and a curve was fitted using the mean estimate to determine the resource values associated with a full range of probabilities for each country from which we selected, for reporting, a 95 to 5 percent probablility range and a statistical mean, standard deviation (S.D.), median, and mode (see figs. 3–16).

Commodities assessed.–The assessment of undiscovered conventionally recoverable petroleum resources includes those resources that can be extracted using conventional methods assuming a continuation of present economic and technologic conditions (Dolton and others, 1981). The assessment does not include inferred resources, which may yet be found in new pay zones or extensions of existing fields. Also excluded from the assessment, even if present, are unconventional resources such as heavy oil deposits, tar deposits, and oil shales, as well as gas in low permeability (tight) reservoirs, gas occluded in coal, gas in geopressured reservoirs and brines, and natural gas hydrates.

Factors in the assessment.–Assessing petroleum resources in the Middle East is limited by the lack of analog basins that can be used for comparison. Considering the quantity of petroleum, there is no comparable area on the face of the Earth. Given the absence of analogs, one must rely on judgments as to maturity of exploration, but this method is limited by the paucity of published data on dry holes and the uncertainty of reserve data. Nonetheless, much pertinent data have been published, and broad levels of field sizes can be determined. Furthermore, because large fields are so dominant, some judgments as to exploration maturity for giant and supergiant fields can be considered. Clearly, there is another lower level of field sizes not included in assessment

TABLE 1.—*Assessment of undiscovered conventionally recoverable petroleum resources of the Arabian-Iranian basin*

[Resource assessment by USGS as of 4/1/81; see also figures 3 through 16.]

	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
Estimate	72	337	174	Tcf	299	1,792	849
				BBOE	50	299	142

Distribution by country of undiscovered conventionally recoverable petroleum resources in Arabian-Iranian basin[2]

	Crude oil (BB)			Natural gas (Tcf)		
	Low F_{95}[1]	High F_5[1]	Mean	Low F_{95}[1]	High F_5[1]	Mean
Saudi Arabia	24	111	57	71	423	201
Iran	11	50	26	197	1183	560
Iraq	32	150	78	11	66	31
UAE	2	13	7	13	80	38
Kuwait	2	9	4	4	23	11
Oman	1	4	2	3	17	8
Qatar			<1[3]			<1[3]
Bahrein			0			0
	72	337	174	299	1792	849

[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] Neutral Zone potential of 2.2 BB of oil and 17 Tcf of gas is equally divided between Kuwait and Saudi Arabia.
[3] Not included in totals.

TABLE 2.—*Supplementary and comparative data supporting this resource assessment of the Arabian-Iranian basin*[1]

	Crude oil in billions of barrels (BB)		Natural gas in trillions of cubic feet (Tcf)
Cumulative production to 1/1/79			
102–108			+[2]
Identified Reserves to 1/1/79[3]			
Demonstrated	356		517
Inferred	59		563
	415		1,080
		BBOE	180

Original recoverable resources (ultimate) of the basin

	Oil		Gas (BBOE)
Cumulative production	108		+[2]
Identified reserves	415		1,080
Undiscovered resources	174		849
	697		1,929+
		BBOE	322+
Total oil and gas	1,019+BBOE		

Basin richness

$$\frac{\text{Original resources}}{\text{Basin volume}} \quad \frac{1{,}019+\text{BBOE}}{1{,}700{,}000\ \text{mi}^3} = 5600{,}000\ \text{BOE/mi}^3$$

[1] *Cumulative production* and reserves are composited estimates from various sources.
[2] Quantity positive but data unavailable.
[3] Follows terminology outlined in USGS Circular 831. *Demonstrated* is equivalent to API *Proved* plus *Indicated additional. Inferred* represents anticipated reserves growth in existing fields.

TABLE 3.—*Mean estimated undiscovered conventionally recoverable resources by country considering only that portion of a country included in the Persian Gulf basin and Zagros fold belt (Arabian-Iranian basin)* [1]

Plays	OIL in billions of barrels (BB) Mean estimate from this study: 174 BB				GAS in trillions of cubic feet (Tcf) Mean estimate from this study: 849 Tcf			
	Percentage distribution by play	Distribution of mean estimation by play	Percentage distribution by country[2]	Distribution of mean estimation by country	Percentage distribution by play	Distribution of mean estimation by play	Percentage distribution by country	Distribution of mean estimation by country
I. Upper Cretaceous and Tertiary.	20	35	In 75	26.3	4	34	In 75	25
			Iq 25	8.7			Iq 25	9
II. Lower and Middle Cretaceous (sandstone).	32	55	Iq 80	44.0	3	25	Iq 90	22
			On 3	1.6			On 3	1
			SA 9	5.0			SA 7	2
			K 8	4.4			Q< 1[3]	< 1[3]
			(NZ 4)	(2.2)				
III. Lower and middle Cretaceous (limestone).	19	33	SA 80	26.4	4	34	SA 80	27
			UAE 20	6.6			UAE 20	7
IV. Jurassic	28	49	Iq 50	24.5	5	43	SA 60	26
			SA 50	24.5			UAE 40	17
V. Permian	1	2	SA 80	1.6	84	713	In 75	535
			On 20	.4			SA 20.5	146
							UAE 2	14
							K 1.5	11
							Q< 1[3]	< 1[3]
							On 1.0	7
							(NZ 2.0)	(17)
	100	174		174	100	849		849

[1] Neutral Zone (NZ) potential is equally divided between Kuwait and Saudi Arabia and is included in those totals.
[2] SA=Saudi Arabia, On=Oman, Iq=Iraq, UAE=United Arab Emirates, In=Iran, Q=Qatar, NZ=Neutral Zone, K=Kuwait.
[3] Not included in totals.

thinking today that will likely sustain Middle East energy needs for decades to come; the geology relating to possible smaller field sizes is insufficiently understood for those resources to be knowingly included in this assessment. It does not follow that the assessed quantities of oil and gas necessarily will change significantly with new data on smaller fields, because the quantities of oil and gas contained in the large fields still will dominate the estimates.

Though most areas in the Arabian-Iranian basin region have been significantly explored, vast areas still remain almost undrilled, especially to the south in the Ar Rub' al Khali and to the north in southern Iraq. In addition, deep target objectives have not been adequately tested in several areas. We believe, however, that enough is known of regional geology to make reasoned projections. To the south, in the Ar Rub' al Khali, we assume the potential for some extension of the Jurassic limestone play and for significant discovery of Permian gas. We are concerned, however, and have factored into the assessment probability considerations relative to the changing reservoir facies, the lack of known structures, and the increasing depth of the play. In Iraq, we are concerned about the absence of known reservoir facies and structure required for a continuation of the Lower and Middle Cretaceous sandstone play but assume that the probabilities are good for play extension. Because of the limited data available in Iraq, we possibly have underestimated the deep-gas possibilities, but it is not likely that gas fields, if present, will be developed any time soon. A final problem area in Middle East assessment is inferred gas reserves. We have excluded them from the assessment of undiscovered resources but consider that the potential for undeveloped Permian gas on Ghawar and other major fields in appropriate areas is of supergiant proportions and must be clearly considered in any analysis of future gas supply in the area.

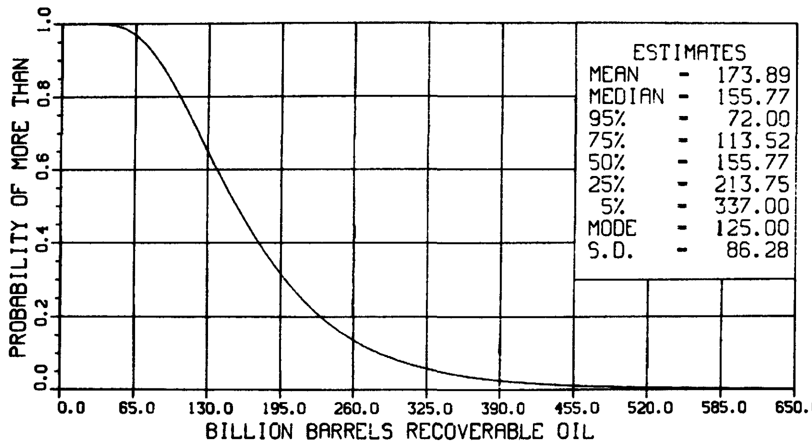


FIGURE 3.—Arabian-Iranian basin recoverable oil as assessed April 1, 1981.

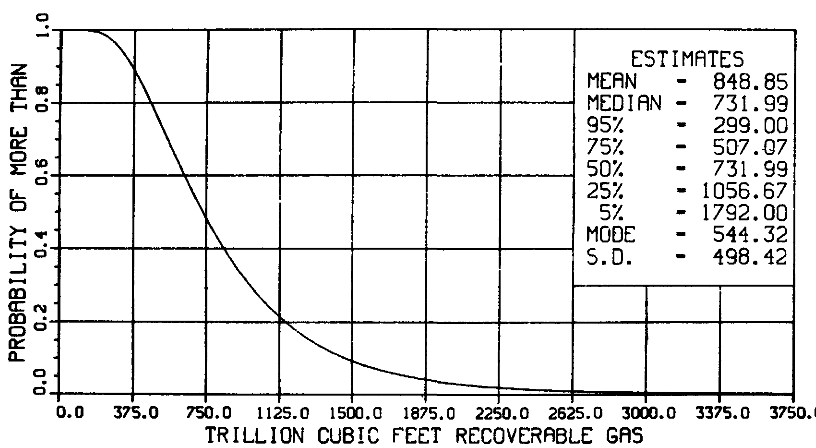


FIGURE 4.—Arabian-Iranian basin recoverable total gas as assessed April 1, 1981.

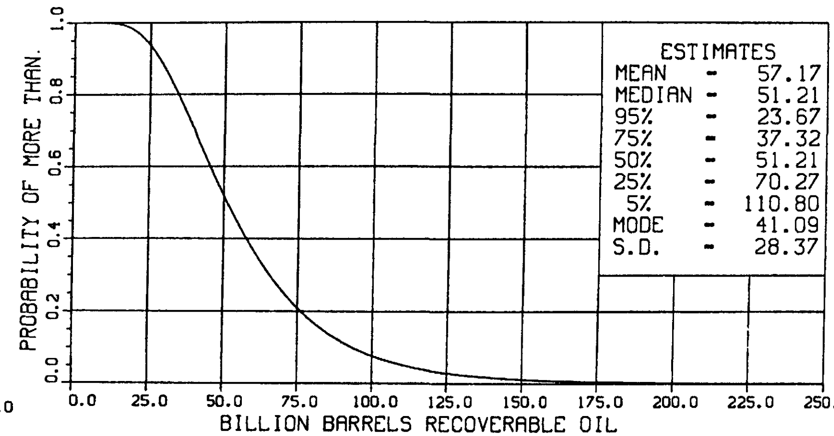


FIGURE 5.—Arabian-Iranian basin—Saudi Arabia recoverable oil as assessed April 13, 1981.

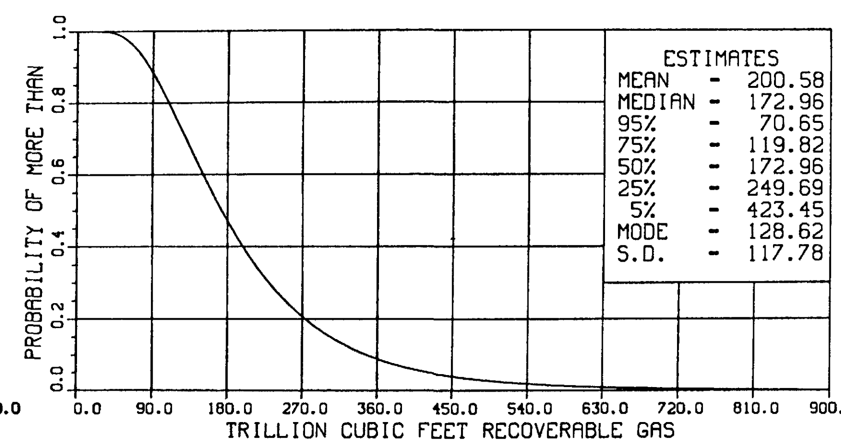


FIGURE 6.—Arabian-Iranian basin—Saudi Arabia recoverable total gas as assessed April 13, 1981.

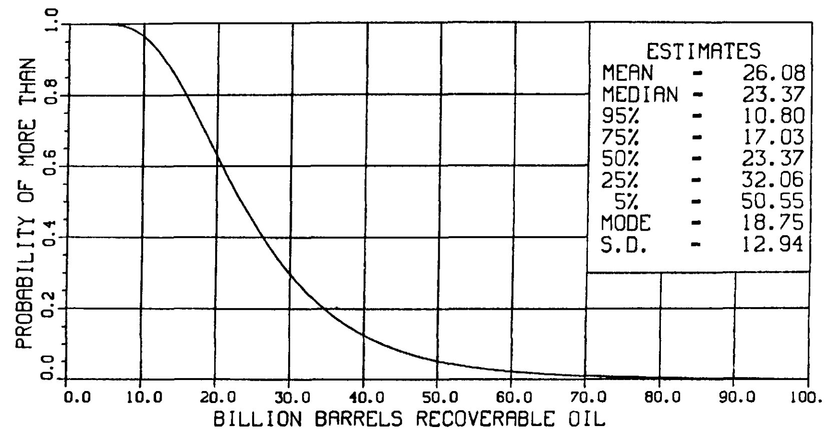


FIGURE 7.—Arabian-Iranian basin—Iran recoverable oil as assessed April 13, 1981.

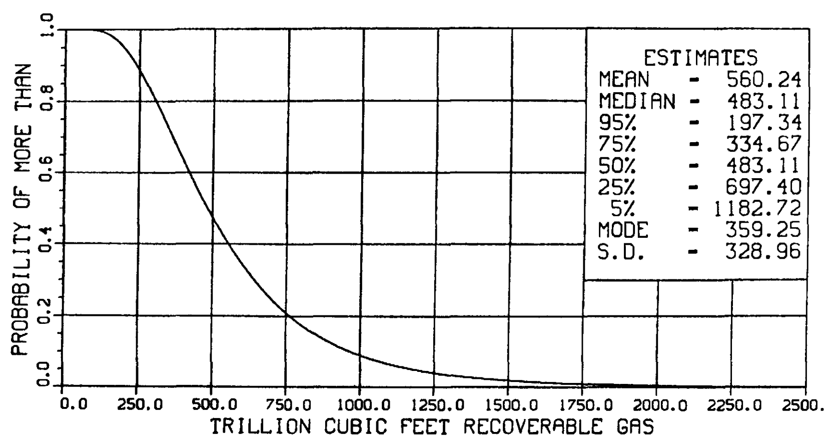


FIGURE 8.—Arabian-Iranian basin—Iran recoverable total gas assessed April 13, 1981.

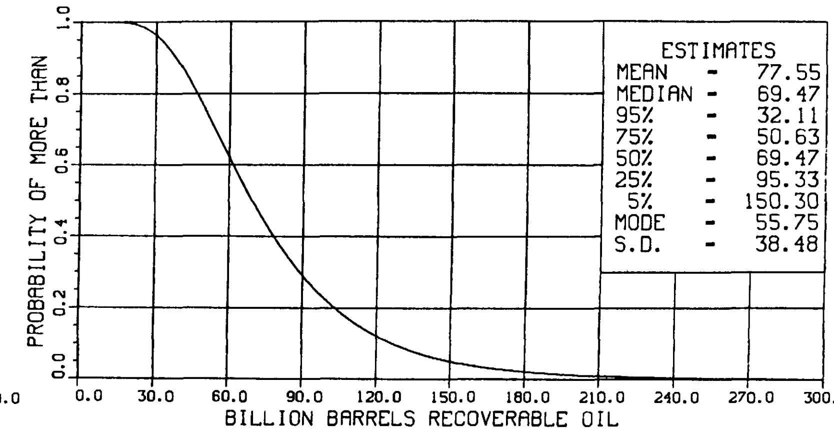


FIGURE 9.—Arabian-Iranian basin—Iraq recoverable oil as assessed April 13, 1981.

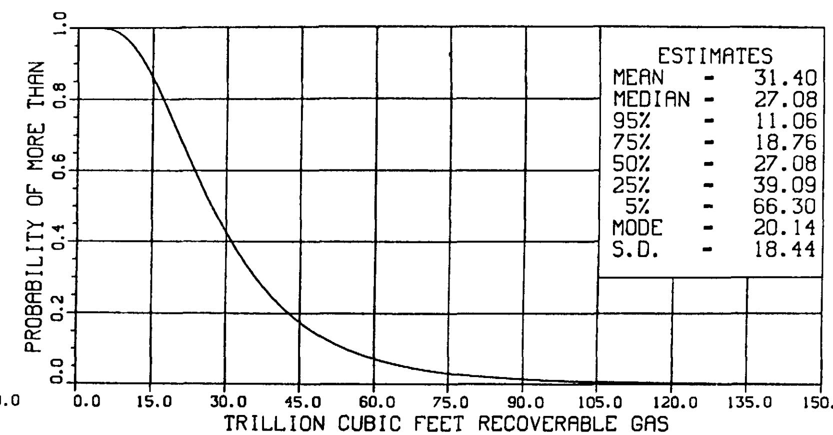


FIGURE 10.—Arabian-Iranian basin—Iraq recoverable total gas as assessed April 13, 1981.

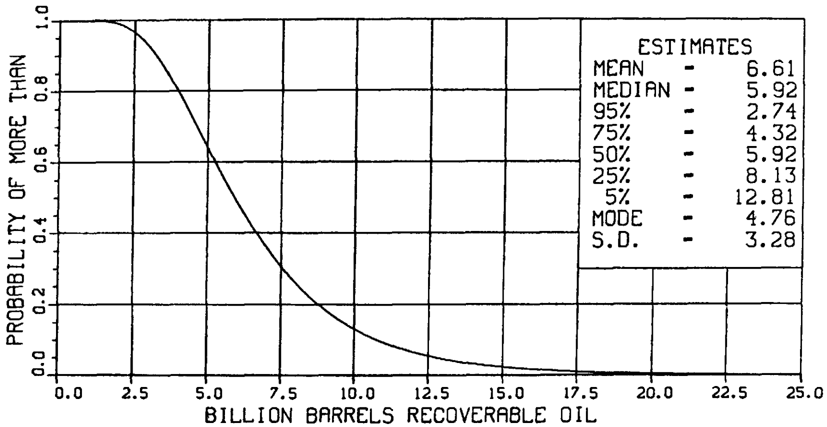


FIGURE 11.—Arabian-Iranian basin—United Arab Emirates recoverable oil as assessed April 13, 1981.

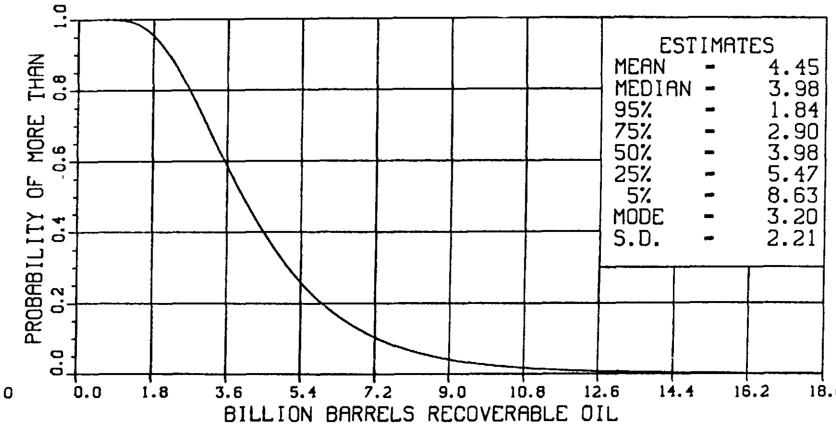


FIGURE 13.—Arabian-Iranian basin—Kuwait recoverable oil as assessed April 13, 1981.

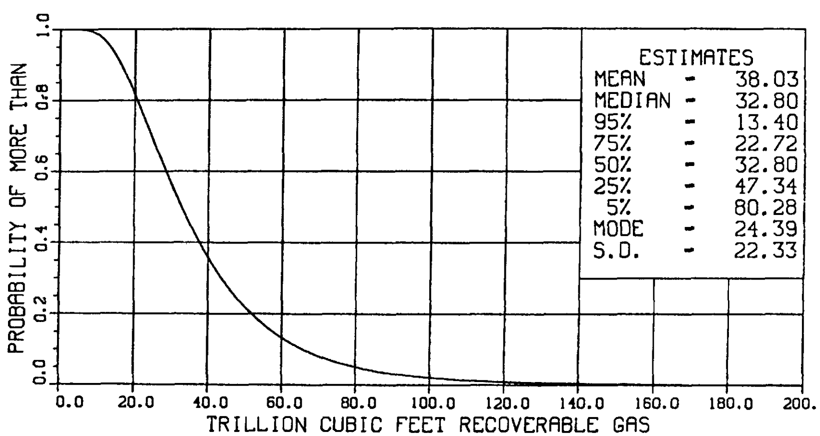


FIGURE 12.—Arabian-Iranian basin—United Arab Emirates recoverable total gas as assessed April 13, 1981.

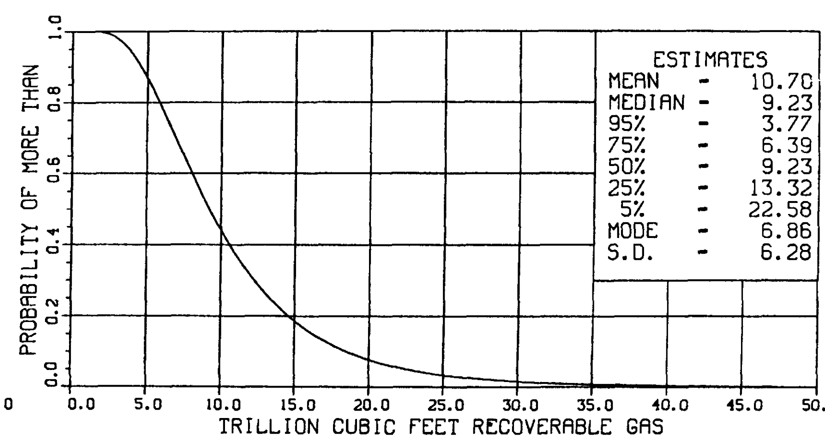


FIGURE 14.—Arabian-Iranian basin—Kuwait recoverable total gas as assessed April 13, 1981.

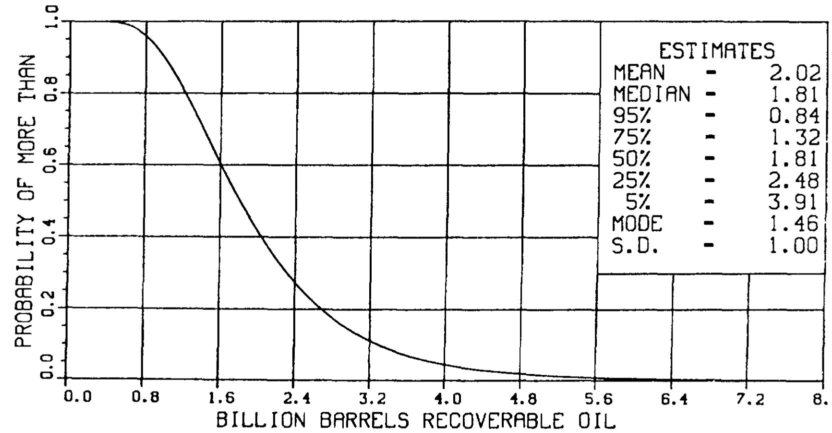


FIGURE 15.—Arabian-Iranian basin—Oman recoverable oil as assessed April 13, 1981.

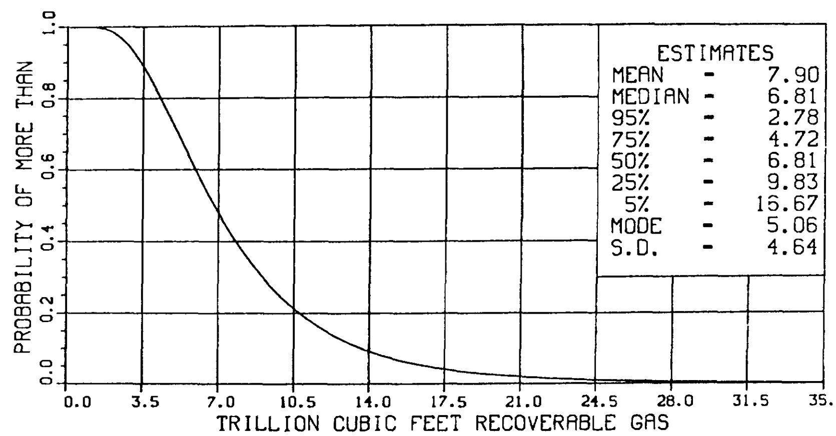


FIGURE 16.—Arabian-Iranian basin—Oman recoverable total gas as assessed April 13, 1981.

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