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The 1985 Oil Production of 21 Oil Producing Non-OPEC Countries

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The 1985 Oil Production of 21 Oil Producing Non-OPEC Countries

Prepared by
Arthur J. Warner

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FOREWARD

The diversification of oil supply sources is of interest to both crude oil consumer and producer nations. Each has a stake in the future availability of petroleum supplies to world markets and the economic consequences of a narrowing supply base. Thus, the potential future supply status of the marginal oil producing developing countries is of vital interest.

This report presents a point of view regarding the production prospects of twenty-one countries in 1985 and their potential to produce in excess of domestic needs. The analysis examines the prospectiveness of sedimentary basins, inasmuch as they are the primary factors influencing the future availability of crude oil. It is concluded that in the aggregate the 21 countries reported on will continue to have a supply deficit through 1985.

The conclusions of this report are generally those of the author and may not necessarily represent the official position of the Department of Energy.

The author is grateful to Judith Reynolds for editing, and to Dee Sutton for secretarial assistance. The author also appreciates the permission granted by the American Association of Petroleum Geologists for the generous use of their reference maps.

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EXECUTIVE SUMMARY

- o The purpose of this report is to assess the possibility of increased oil production from 21 less developed non-OPEC countries (excluding the Middle East and Mexico) by 1985. The forecast is compared with those prepared by the World Bank, the International Energy Agency, and others.
- o The approximately 60 prospective geological basins within the 21-LDC have been drilled with various degrees of success, including the discovery of approximately 30 giant and possible giant oil fields. Several of the giant fields have been depleted and a few others are in the last phase of depletion. The discovery of a few more giant fields is possible but the vast majority of new discoveries will be small fields.
- o The 21 Latin American, African, and Far East (including Asia) countries 1/ produce 2.5 million barrels of oil per day (BD) or 4.2 percent of world production, and they have 21 billion barrels of proved reserves, or 3.2 percent of the world total.
- o In recent years these countries have consumed 3.1 million BD; some 0.9 million barrels in excess of their production.
- o By 1985, the 21 countries may produce 3.9 million BD, an average annual increase of 5.0 percent; however, demand is expected to increase at an annual rate of 3.5 percent to 4.4 million BD.
- o The net effect is that the 1985 aggregated supply-demand balance will be in deficit, by nearly 560 thousand BD, compared to slightly more than 930 thousand BD in 1976.

1/ Latin America: Argentina, Trinidad, Brazil, Colombia, Peru, Bolivia, Chile, and Barbados.
Africa: Egypt, Angola, Tunisia, Congo, Zaire, Cameroon, Morocco and Senegal.
Far East: Brunei-Malaysia, India, Burma, Pakistan, and Thailand

NOTE: These countries were selected because they are marginal producers with an apparent potential for new discoveries.

- o The countries with the largest export potential by 1985 may be: Brunei-Malaysia (441 thousand BD, an increase from 257 thousand BD), Egypt (437 thousand BD, an increase from 133 thousand BD), and Angola-Cabinda (214 thousand BD, an increase from 92 thousand BD).
- o The largest net importers in 1985 may be: Brazil (1.3 million BD, an increase from 0.8 million BD); India (240 thousand BD, a decrease from 338 thousand BD); and Thailand (240 thousand BD, an increase from 176 thousand BD).
- o The net supply-demand status of the 21 countries may be summarized as follows:
 - Countries likely to have greater supply deficits in 1985 and the approximate change from the current supply-demand balance are:
 1. Brazil (-1,255 thousand BD, up from -806 thousand BD)
 2. Thailand (-240 thousand BD, up from -175 thousand BD)
 3. Morocco (-93 thousand BD, up from -63 thousand BD)
 4. Colombia (-25 thousand BD, up from + one thousand BD)
 5. Pakistan (-89 thousand BD, up from -82 thousand BD)
 6. Barbados (-14 thousand BD, up from -12 thousand BD)
 - Countries likely to have lesser supply deficits in 1985 and the approximate change from the current supply-demand balance are:
 1. India (-243 thousand BD, down from -338 thousand BD)
 2. Chile (-60 thousand BD, down from -65 thousand BD)
 3. Peru (-26 thousand BD, down from -41 thousand BD)
 - Countries likely to have a greater supply surplus in 1985:
 1. Brunei-Malaysia (+441 thousand BD, up from +257 thousand BD)
 2. Egypt (+437 thousand BD, up from +133 thousand BD)
 3. Angola-Cabinda (+214 thousand BD, up from +92 thousand BD)
 4. Trinidad (+167 thousand BD, up from +149 thousand BD)
 5. Tunisia (+98 thousand BD, up from +42 thousand BD)
 6. Zaire (+50 thousand BD, up from +17 thousand BD)
 7. Cameroon (+30 thousand BD, up from -7 thousand BD)
 8. Argentina (+12 thousand BD, up from -54 thousand BD)
 9. Congo (+10 thousand BD, from a supply-demand balance)

- Countries likely to have relatively unchanged supply-demand balances:
 1. Bolivia (+21 thousand BD, from +22 thousand BD
 2. Burma (+2 thousand BD , from a supply-demand balance)
 3. Senegal - its position in the market unclear due to lack of consumption and production data.
- o This report provides a less optimistic forecast of the 21-LDC production in 1985, compared to the forecasts prepared by others, shown in Table III-1.
- o The analysis of the sedimentary basins of the LDC will be completed in greater detail in a separate study under the Foreign Energy Supply Assessment Program (FESAP); currently underway in the Department.

SECTION I

Introduction

The purpose of this report is to forecast the 1985 production possibilities of 21 non-OPEC* marginal oil producing, developing and less-developed countries (LDC), in Latin America, Africa and the Far East (including Asia), and the potential net benefit of such production to the world market. The net benefit is the quantity of oil that may be produced in excess of indigenous demand.

The forecast is based on an analysis of drilling results in geological basins, and pertinent historical production and consumption trends. The extent to which production is expected to increase hinges on the status of existing fields and the quality of recent discoveries. The normal lag-time between pre-concession or pre-drilling exploration, exploration drilling, development drilling, and the installment of production facilities with ancillary transportation and marketing infrastructure, preclude any oil discovery not now undergoing development from being an important supply source in 1985.

In the event national political, social and economic policies rationalize a less than maximum effort to increase production, this forecast becomes moot.

The forecasts of others concerned with the future prospects of many of the same countries that are the subject of this analysis, are included for comparison.

*OPEC = Organization of Petroleum Exporting Countries.

SECTION II

A Perspective of World Production, Proved Reserves, and Ultimately Recoverable Oil Resources

Background - The Disposition of World Oil Supplies

Over 80 percent of the 22 billion barrels of oil produced in the world in 1977, is controlled by 12 countries, as shown in Table II-1. Nine of the leading producers are members of the Organization of Petroleum Exporting Countries (OPEC). The other three dominant producers are the United States, the USSR, and the Peoples Republic of China. The non-OPEC, marginal producing LDC, shown in Table II-2, provide less than 10 percent of the world's production, and they have less than 10 percent of the proved reserves.

The distribution of the world's discovered crude oil supplies, proved reserves, unequivocally portend the sources of crude oil available in the future. The duration that such supplies will be available depends on the rates of depletion. Inasmuch as the OPEC controls over 60 percent of the nearly 650 billion barrels of proved reserves, they will continue to be the dominant source of supply in 1985. The current proved reserves of the LDC indicate that in the aggregate their potential as producers in 1985 will be nearly as limited as it is today.

The dominance by a comparatively few political entities over the world's oil supplies is the result of a geological phenomenon. Nearly 80 percent of the known recoverable oil, proved reserves plus cumulative production, has been found in less than one percent of the discovered oil fields. ^{1/} Also the great majority of these fields are concentrated in a few of the 600+ sedimentary basins that exist in the world. Most of the unique production basins are located in the Middle East. Table II-3 shows the quantity of known recoverable oil in the giant and super giant fields. ^{2/} Of the 425+ known and potential giant fields, 45 are located among the LDC; nearly one-third are in Mexico and Egypt. Figure II-1 shows the importance of the giants as the source of new discoveries.

^{1/} Richard Nehring, Giant Oil Fields and World Oil Resources, Rand Corporation, June 1, 1978.

^{2/} A super giant field is one which has an ultimate recoverable supply of at least one billion barrels and a giant field's recoverable supply is 0.5 billion barrels. (Nehring definition)

TABLE II-1--World Petroleum Production and Reserves

World Production - 1977 (21.73 Billion Bbls.)

World Reserves - 1977 (645.8 Billion Bbls.)

	Production		Reserves		
	Billion Bbls.	% of World	Billion Bbls.	% of World	Reserve/Prod Ratio
1. USSR	4.00	18.4	75.0(2)	11.6	19
2. Saudi Arabia**	3.27	15.0	150.0(1)	23.2	46
3. USA	3.01	13.8	29.5(6)	4.6	10
4. Iran*	2.06	9.5	62.0(4)	9.6	30
	12.34	56.7	316.5	49.0	
5. Venezuela*	.83	3.8	18.2(11)	2.8	22
6. Iraq**	.78	3.6	34.5(5)	5.3	44
6. Nigeria*	.78	3.6	18.7(10)	2.9	24
8. Libya**	.75	3.4	25.0(8)	3.9	33
9. China	.66	3.0	20.0(9)	3.1	30
10. Kuwait**	.62	2.9	67.0(3)	10.4	108
11. Indonesia*	.62	2.8	10.0	1.5	16
12. Abu Dhabi*	.61	2.8	31.0(7)	4.8	51
	5.65	25.9	224.4	34.7	
13. Canada	.50	2.3	6.0	.9	
14. Algeria**	.36	1.7	6.6	1.0	
14. Mexico - LDC	.36	1.7	14.0	2.2	
16. United Kingdom	.28	1.2	19.0	2.9	
17. Egypt - LDC	.16	.7	2.5	.4	
18. Argentina - LDC	.16	.7	2.5	.4	
19. Australia	.16	.7	2.0	.3	
20. Brunei-Malaysia LDC	.15	.7	4.6	.7	
	2.13	9.7	57.2	8.8	
21. Neutral Zone	.13	.6	6.2	.9	
22. Oman - LDC	.13	.6	5.7	.8	
23. Qatar**	.13	.6	5.6	.8	
24. Dubai*	.12	.6	1.4	.2	
25. Norway	.10	.5	6.0	.9	
26. Trinidad - LDC	.08	.4	0.7	.1	
27. Gabon*	.08	.4	2.1	.3	
	.77	3.7	27.7	12.1	
Grand Total		96.0		96.5	

* OPEC Countries -- also Ecuador, Sharjah (UAE)

Total production - 11.26 billion bbls. (52%)

Total reserves - 366.5 billion bbls. (57%)

** OAPEC Countries -- also Sharjah (UAE)

Total production - 6.16 billion bbls. (28%)

Total reserves - 224.5 billion bbls. (35%)

Source: Oil & Gas Journal.

TABLE II-2--Non-OPEC Developing and Less Developed
Countries - Production and Reserves

		Production - 1977			Proved Reserves
		(Million Bbls.)			end 1977
					(Million Bbls.)
1.	Mexico	361			14,000
2.	Egypt	164			2,450
3.	Argentina	161			2,503
4.	Brunei-Malaysia	145			4,050
5.	Oman	128			5,650
6.	Trinidad	84			650
7.	India	73			3,000
8.	Syria	73			2,150
9.	Angola-Cabinda	71			1,160
10.	Brazil	59			880
TOTAL (10)		1,319	6.1%	1/	36,493
					5.7%
11.	Colombia	51			960
12.	Peru	33			730
13.	Tunisia	32			2,670
14.	Turkey	24			370
15.	Bahrain	20			1
16.	Congo	13			360
17.	Bolivia	13			350
18.	Zaire	9			150
19.	Burma	8			55
20.	Chile	8			440
21.	New Zealand	5			105
22.	Pakistan	4			280
23.	Taiwan (ROC)	2			12
24.	Morocco	1			150
25.	Barbados	1			1
26.	Thailand	1			1
27.	Afghanistan	1			84
TOTAL (16)		218	1.0%		6,718
GRAND TOTAL (26)		1,537	7.1%		43,211
					6.7%

1/ Percentage of total world production and proved reserves.

TABLE II-3

THE DISTRIBUTION OF KNOWN RECOVERABLE OIL RESOURCES OF THE WORLD BY FIELD SIZE
AS OF DECEMBER 31, 1975

Field Size (In millions of barrels)	Number	Amount (In bil- lions of barrels)	Percent of Total
Super-giants (5000 +) ^a	33	512.6	50.7
Large giants (2000-5000) ^a	31	89.3	8.8
Medium giants (1000-2000) ^a	70	90.2	8.9
Small and combination giants (500-1000)	138	84.0	8.3
Potential giants ^{a,b}	153(+)	43.1(+)	4.3(+)
Large non-giants (100-500) ^{b,c}	483(+)	75.2(+)	7.4(+)
Other non-giants (less than 100) ^c		117.1(-)	11.6(-)
Total ^c		1,011.5(+)	

^aBecause no estimates of total recovery are available for 30 of the potential giants and some estimates available for the others are likely to be substantially understated, the actual amount in potential giant fields could easily be 25%-50% greater than that shown here.

^bBecause some of the potential giants are likely to prove to be merely large non-giant fields, the amount in large non-giants is somewhat greater than indicated here.

^cNo information on large non-giant fields in China, Eastern Europe, and the Soviet Union could be obtained for this report. The amounts in these fields are therefore included in the amount in other non-giant fields. Transferring them to the large non-giant category would probably increase the amount in large non-giants by 15 to 20 billion barrels and decrease the amount in other non-giants by a similar amount.

SOURCES: See Appendix A, particularly Tables A.1, A.6, A.16, A.28, A.37, A.48, and A.63.

Source: Giant Oil Fields and World Oil Resources,
Richard Nehring, Rand, June 1978.

Figure II-1 -- Crude Oil Discoveries in
the Giant Fields Worldwide
and the Middle East Through 1975.

Source: Giant Oil Fields and World Oil Resources,
by Richard Nehring, Rand Corporation, June 1978.
(composite of two graphs).

During the last quarter-century nearly three-fourths of new proved reserves have been found in giant and super giant fields. The preponderance of these fields is in the Middle East, as shown in Table II-4.

Of the approximate 0.8 trillion barrels of oil discovered in the giant fields, one-third has been produced; the remaining quantities are proved reserves. The most extensive depletion of giant fields has occurred in the United States. A total of 59 billion barrels of oil have been discovered in the LDC giant fields, of which only one-fourth has been produced. 3/

There are approximately 600 sedimentary basins in the world; about 200 have had little or no exploration. Of the 400 basins that have been explored intensively, 240 have yielded no commercial hydrocarbons. However, 25 of the 160 basins have resulted in discoveries of at least 10 billion barrels each. These premium basins account for 86 percent of the total hydrocarbons discovered. One basin alone, the Persian Gulf, contains 40 percent of all the hydrocarbons discovered. Six sedimentary basins have had discoveries of at least 50 billion barrels each, and they contain nearly 65 percent of the total petroleum discovered worldwide. 4/

3/ Egypt and Mexico have nearly one-half of the LDC giant field production, and one-third of LDC giant field proved reserves.

4/ World Petroleum Availability, by D.H. Root and E.D. Attanasi, USGS, 1979.

TABLE II-4 --Distribution of Giant Oil Fields by
Political Regions

	Giants		Discovered Oil (Billion Barrels) <u>1/</u>
	Known	Potential	
OPEC	126	79	605.6+
CPE's	40	24+	85.2+
USA and Canada	68	28	75.4+
Developed Countries	17	14	18.6
LDC's and Developing Countries			
Latin America	12	3	16.0
Africa	6	6	7.5
Far East	6	5	7.9
Mid East	5	3	5.5
TOTAL	280	162	821.70

1/ Discovered oil is cumulative production plus proved reserves.

Source: Giant Oil Fields and World Oil Resources, Richard Nehring, June 1978, pages 32 and 33.

The Uncertain Future - Undiscovered Recoverable Resources

The known proved reserves of the 21 LDC are inadequate by themselves to sustain the historic production rates through 1985. Therefore, new reserve additions related to the development of existing discoveries must increase annually to provide the expanded production for 1985. Furthermore, the future importance of these countries as producers beyond 1985 is contingent on the quantity of oil resources that remain to be discovered. Thus, greater exploration efforts and further development is essential. However, the supply response, or the rate that new reserves can be found and developed into production capacity, depends on the quality of the geological prospects available.

Estimates of the quantity of ultimate recoverable petroleum resources within the individual countries, or the LDC in toto, are poorly documented. There are only a few countries for which resource estimates are available, and seldom do the estimates incorporate probability factors to qualify, or provide a rationale to support the value. In general, those which are available are largely "naked numbers," devoid of any supportive documentation. One is expected presumably to believe those numbers on the basis of the credentials of the experts, individually or organizationally, who make such estimates.^{5/}

Tables II-5 and II-6 are examples of the extent that undiscovered recoverable oil resource estimates are disaggregated.

Consensus of Ultimately Recoverable Oil Resources

During the last decade there have been at least 18 published estimates of the quantity of crude that may be ultimately recovered throughout the world. Table II-7 shows the range of estimates prepared by the US Geological Survey (Department of the Interior), the National Academy of Sciences, petroleum consultants, and private companies. The conclusions are substantially similar, particularly when like areas are compared. The average estimate is about 2 trillion barrels. Of this quantity, approximately 0.4 trillion barrels of oil have been depleted (produced). More than one-third of the

^{5/} loc cit, "Giant Oil Fields, etc," page 2.

TABLE II-5

Ultimate Recoverable Resources of Oil
(Billions of barrels)

Country	Low Estimate	Medium Estimate	High Estimate
U.S.S.R., Eastern Europe and China	369	381	530
United States and Canada	134	183	274
Middle East and North Africa	473	713	1,028
Africa South of Sahara	31	62	98
Western Europe	73	78	149
Latin America	92	146	226
Far East and Oceania	48	95	157
Total Conventional	1,220	1,658	2,457
Deep Offshore and Polar Areas	20	148	653
Total	1,240	1,806	3,110

Source: World Energy Conference, Conservation Commission Report on Oil Resources, 1985-2020, Executive Summary. August 15, 1977.

TABLE II-6--World Estimated Ultimate Crude Oil Recovery as of January 1, 1976
(Billions of barrels of oil)

	Fields Discovered			Undiscovered Potential - Resources		Total Recovery 1/
	Cumulative Production through 1973	Proved & Prospective Reserves	Ultimate Production	Expected Value	Range	
Russia & China, <u>et al.</u>	46	104	150	350	100-900	500
North America						
United States	103	51	154	76	23-174	230
Canada	7	7	14	71	18-152	85
Total North America	110	58	168	147	41-326	315
Middle East	69	430	499	131	50-500	630
Other Foreign						
North Sea	--	20	20	30	10- 90	50
Western Europe	3	1	4	15	4- 35	19
North Africa	13	33	46	38	10- 89	84
Gulf of Guinea	3	24	27	25	10- 50	52
Other Africa	--	4	4	23	2- 47	27
N.W. Latin America	35	32	67	53	12-110	120
Other Latin America	9	7	16	38	10- 89	54
Indonesia, et al.	7	22	29	45	15- 80	74
Other Far East	2	5	7	48	10- 75	55
Antartica				20	1-100	20
Total Other Foreign	72	148	220	335	90-800	555
Total Worldwide	297	740	1,037	963	280-2,200	2,000

1/ Total Recovery equals the Ultimate Production in Discovered Fields plus the Expected Value of Undiscovered Potential Resources.

Source: Moody, J. D. An Estimate of the World's Recoverable Crude Oil Resources, Panel Discussion 6, Preprint of the Proceedings of the 9th World Petroleum Congress, 1975. Published by Applied Science Publishers, Ltd., Barking Essex, England.

TABLE II-7--Estimates of Ultimately Recoverable
Oil Resources

Author			
L.G. Weeks	Standard Oil Co. (N.J.)	1,500	Weeks, 1958
L.G. Weeks	Standard Oil Co. (N.J.)	2,000	Weeks, 1959
M. King Hubbert	Nat'l Academy of Sciences	1,250	Hubbert, 1962
T.A. Hendricks	US Geological Survey	2,480	Hendricks, 1965
W.P. Ryman	Standard Oil Co. (N.J.)	2,090	Cited in Hubbert, 1969 Tbl. 8.2
-----	Shell	1,800	Warman, 1971
L.G. Weeks	Consultant	1,870*	Weeks, 1968a,b
M. King Hubbert	Nat'l Academy of Sciences	1,350-2,000	Hubbert, 1969
J. D. Moody	Mobil Oil Corporation	1,800	Moody, 1970
H.R. Warman	British Petroleum co. Ltd.	1,200-2,000	Warman, 1971
L.G. Weeks	Lewis G. Weeks Assoc. Ltd.	1,950**	Weeks, 1971
J.D. Moody and H.H. Emmerick	Mobil Oil Corporation	1,800-1,900	Moody and Emmerick, 1972
Richard L. Jodry	Sun Oil Company	1,952	Cited in Hubbert, 1974 Tbl. 9
H.R. Warman	British Petroleum Co. Ltd.	1,800	Warman, 1972
Wim Vermeer	Shell	1,930	Vermeer, 1973
H.R. Warman	British Petroleum co. Ltd.	1,915	Warman, 1973
J.D. Moody and R.W. Esser	Mobil Oil Corporation	2,000	Moody and Esser, 1974
M. King Hubbert	US Geological Survey	2,000	Hubbert, 1974 p. 185; fig. 68

* 85 percent of estimate of $2,200 \times 10^9$ bbl for petroleum liquids.

** 85 percent of estimate of $2,90 \times 10^9$ bbl for petroleum liquids.

Source: M. King Hubbert, "World Oil and Natural Gas Reserves and Resources", in:
Project Interdependence U.S. and World Energy Outlook Through 1990.
Library of Congress, Washington, D. C. 1977.

remaining 1.6 trillion barrels, have been discovered and are classified as proved reserves. Thus, less than 1 trillion barrels of oil remain to be discovered.6/

In a poll conducted by the World Energy Conference, most of the respondents expressed the view that 60 percent of the oil remaining to be discovered will be found in the 160 sedimentary basins that are producing.7/ This implies that minimal quantities of oil are likely to be found within the 440 basins that are located outside of major producing areas as we know them today.

Despite the fact that most of the 440 sedimentary basins not regarded to be prospective have had little drilling, they are not geological mysteries. Sufficient reconnaissance geophysical (exploration) work has been done to indicate the size, the characteristics of the sediments, and the gross structural features of these basins.8/

It is estimated that the areal limits of the sedimentary basins of the world comprise 28 million square miles, excluding Alaska. The prospective lands are distributed regionally, as shown in Table II-8.9/ The LDC in Latin America, Africa, and the Far East contain over one-third of the prospective areas of the world; 9.6 million square miles. Some 3.7 million square miles are located in LDC without oil production.

6/ The Department of Energy, International Affairs, with the assistance of other DOE offices and the U.S. Geological Survey, is developing a series of individual country reports which will provide recoverable resource estimates; the program is identified as Foreign Energy Supply Assessment Program (FESAP).

7/ "Comments on Oil and Gas Potential in Developing Countries" by Philip R. Woodside, U.S. General Accounting Office, presented to the Energy Section of the Office of the Under-Secretary General, U.N. in New York, November 20, 1978.

8/ "Acceleration in Global Exploration," by M. Halbouty, AAPG Bulletin, May 1978.

9/ Prospective area is defined as having at least 1,000 feet of sedimentary deposits which could contain petroleum: Based on data in "Window on Oil," B. Grossling, published by the Financial Times, 1976.

TABLE II-8--Regional Distribution of Productive Areas
and Discovered Oil

Region	Prospective Area <u>1</u> / (1,000 sq.mi.)	% of Producing Areas	Discovered oil <u>2</u> / (Billion bbls.)	% of Discovered Oil	Bbls/Sq.Mi. (1,000 bbls.)
U.S.-Canada <u>3</u> /	4,991.4	17.8	171.6	16.8	34.4
Europe <u>4</u> /	4,874.0	17.4	168.2	16.5	34.5
Middle East	1,344.8	4.8	467.0	45.8	347.5
Far East and Asia <u>5</u> /	6,923.0	24.7	39.8	3.9	5.7
Africa	5,034.6	18.0	82.5	8.1	16.4
Latin America	4,804.6	17.2	89.8	8.8	18.7
Total	27,972.4		1,018.9		36.4 (avg.)

1/ Based on Window on Oil by Grossling, Financial Times, 1976.

2/ Discovered Oil = cumulative production + proved reserves through 1977.

3/ Excludes Alaska.

4/ Includes USSR.

5/ Includes Peoples Republic of China.

The Historical Results of Exploration and Development

Approximately three and one-half million wells have been drilled in the search and development of over one trillion barrels of oil, as shown in Table II-9. One-third of the discoveries are in the developed areas of North America and Europe (including the USSR), where nearly 15 out of every 16 wells have been drilled. Two-thirds of the discovered oil has been found in Latin America, Africa, the Middle East, and the Far East (including Asia), where only one-sixteenth of the wells have been drilled.

The quantity of oil discovered in the world per square mile of prospective area (SMPA) averages 36.4 thousand barrels. The U.S. and Canada combined average 34.4 thousand barrels per SMPA; the average for Europe-USSR is virtually identical. The average yield per SMPA in the Middle East is 10 times greater than either of the above regions.

In the aggregate, the LDC of Africa have the lowest drilling density among the three LDC regions, one well per 283 SMPA. Nevertheless, they have the highest average yield, 9,420 barrels per SMPA (shown in Table II-10). Latin America-LDC have the greatest drilling density, one well per 68 SMPA, but they have the lowest average yield, 4,240 barrels per SMPA. The greater number of wells in Latin America is largely the result of an early exploration history, which predates such activities in Africa by over half a century. At that time drilling sites were selected without the benefit of sophisticated geophysical technology. The relatively favorable yield in Africa, compared with Latin America, simply indicates the superiority of the African geological prospects and effective selection of drill sites based in part on geophysical exploration.

TABLE II-9--Estimated Petroleum Drilling Activity
Through 1978
(1000 Wells)

Region	Number of Wells Drilled (Thru 1978)	Percent of Total Wells Drilled
US - Canada	2,676.6	77.8
Europe <u>1/</u>	580.0	16.9
Middle East	12.2	0.4
Far East (Including Asia)	31.2	0.9
Africa	17.0	0.5
Latin America	<u>124.2</u>	3.6
TOTAL	3,441.2	

1/ Includes USSR

Source: Data: through 1975, Grossling; through 1978, World Oil
and Energy Information Administration, Department of
Energy.

TABLE II-10.-Twenty One Oil Producing NON-OPEC LDC
(Historical Development Data)

Country	Prospective Area (PA) Sq.Mi.1/ (1,000)	Total No. of Wells Drilled thru 1977	No. of Wells Producing (7-1-77)	Cumulative Production thru 1977 (10 ⁶ Bbls)	Proved Reserves as of 1/78 (10 ⁶ Bbls)2/	1977 Daily Average Well Production2/ 2/	Yield: Bbls/per SMPA 3/ (1,000 Bbls)	Average SMPA/Well Drilled
Region - Latin America	3,685.8	54,448	15,568	9,128	6,514	76.7	4.24	67.7
Argentina	790	23,676	5,697	2,926	2,503	77.2	6.87	33.4
Trinidad	13	9,121	3,083	1,715	650	27.1	181.92	1.4
Brazil	1,840	4,751	1,441	978	880	112.4	1.01	387.3
Colombia	326	4,154	2,118	2,041	960	66.1	9.21	78.5
Peru	399.5	10,015	2,495	1,003	730	36.1	4.34	39.9
Bolivia	254	869	283	214	350	123.7	2.22	292.3
Chile	63	1,833	436	231	440	50.5	10.65	34.4
Barbados	0.3	29	15	20	1	20.0	70.00	10.3
Region - Africa	972.4	3,436	752	2,307.7	6,850.2	1,053.3	9.42	283.0
Egypt	324.5	1,436	401	1,426	2,450	112.2	11.94	225.0
Angola-Cabinda	45	645	157	460	1,160	1,242.0	36.00	69.8
Tunisia	82.9	308	73	310	2,670	1,191.8	35.95	269.2
Congo	30.5	166	97	78	360	360.8	14.36	183.7
Zaire	270.4	34	12	17.4	150	2,000.0	0.62	7,952.9
Cameroon	10.1	127	4/8	0.25	60	86.2 est.	5.97	79.5
Morocco	144	657	4	16	0.2	100	0.11	219.1
Senegal	65	63	0	0.03	N.A.	0	N.A.	1,031.8
Region - Far East & Asia	1,161.7	9,966±	2,684	3,521	7,385.3	234.8	9.39	116.6
Brunei-Malaysia	167.2	2,004	648	2,123	4,050	612.7	36.92	83.4
India 5/	469	1,850±	1,600	777	3,000	125.0	8.05	253.5
Burma 5/	153	5,374	407	533	55	56.5	3.84	28.5
Pakistan	152.5	613	17	87	280	588.2	2.41	248.8
Thailand	220	125	12	1	0.3	6/16.7	0.01	1,760.0
Grand Total	5,819.9	67,850	19,004	14,956.7	20,749.5	137.7	6.14	85.8

N.A. - Not Available EST. - Estimated

1/ Based on Window on Oil by Bernardo Grossling.

2/ Source: Oil and Gas Journal.

3/ Cumulative Production plus proved reserves divided by square miles of prospective area (SMPA)

4/ American Association of Petroleum Geologists, October 1977 Bulletin, reported as development wells completed.

5/ Well statistics incomplete.

6/ No production by end of 1977.

Analysis which attempts to correlate the relationship between drilling densities and oil discoveries may be misleading, because of the variations in the quality and the quantity of oil-bearing geological structures within sedimentary basins. The lack of uniformity is illustrated partly by the variable number of wells required to find and produce like quantities of oil in prospective areas of similar size. Also, the fact that relatively few wells are required to find and produce sizeable quantities of oil in some prospective areas further emphasizes the significance of the quality aspect of geological prospects or oil fields. Examples of this point may be made by comparing the U.S.-Canada prospective areas to that of Europe-USSR, which are similar in size and yield per SMPA, and yet, one-fourth as many wells have been drilled in Europe-USSR than in U.S.-Canada. Conversely, the Middle East with less than one-third the prospective area of either of the above regions, has 10 times the yield per SMPA, but fewer than two percent of the number of wells drilled in Europe-USSR, and less than one-half of one percent of the wells drilled in U.S.-Canada.

It should be noted that the U.S., with nearly three-fourths of wells drilled in the world, is not the most desirable model for comparing effective drilling densities. Approximately 35 to 50 thousand wells are drilled each year in the U.S. and in the aggregate, as shown in Figure II-2, the yield per foot of exploratory well drilled is declining.^{10/} In addition, the average well in the U.S. produces approximately 16 barrels of oil per day. This is nearly one-tenth of the 21 LDC average. The reason wells are drilled in the U.S., despite increasingly marginal results, has a great deal to do with traditional attitudes and policies relating to risk-taking, tax laws, leasing laws, etc. Also, the private ownership of minerals, including oil and gas, and the ability to either explore or to lease exploration rights, have created a broad-based industry with numerous drilling opportunities.

^{10/} "U.S. Oil Resources: The Critical Years" by Charles D. Masters, USGS, Petroleum Engineer, December 1977.

Figure II-2 -- Oil and Gas Discoveries
Per Foot of New Field Wildcat Drilled

Source: C. D. Masters, Chief, Office of Energy Resources,
U.S. Geological Survey. Available from Petroleum
Engineer, International, December 1977.

The U.S. private and public policies have nurtured a sizeable oil industry. The U.S. history of oil exploration and development is replete with examples of multiple ownership of geological prospects and the excessive drilling of such structures. The principle of the "law of capture"^{11/} encouraged practices which, in retrospect, resulted in the drilling of many unnecessary wells. In recent years, most states, and even the federal government, have adopted policies which discourage excessive drilling.

The more recent efforts to find and develop foreign oil resources have the advantage of improved exploration technology and better understanding of geological forces and reservoir mechanics. Thus, fewer exploratory and development wells are required. Usually the development of an oil field can be accomplished with much wider spacing between wells, if the field is entirely within the control of a single concessionaire; this is more common in foreign operations than it is in the U.S.

^{11/} The legal principle of the "law of capture" essentially encouraged wells to be drilled by offsetting interests as quickly as possible once a discovery was made; the rights to the oil belonged to whomever was able to capture or produce it.

SECTION III

Summary

Most of the 21 LDC have adopted policies which should encourage exploration and development of their petroleum resources. The initiatives in some instances reflect efforts to reduce the economic impact of costly imported oil. In other instances, the motive is the economic opportunity of a sellers market. As the world price for crude oil increases, greater efforts will be made to search for and develop marginal oil deposits.

The Production Forecast for 1985

There will not be a one million-barrels-of-oil-per-day producer among the 21 LDC by 1985. However, Egypt has the potential to reach that level. As shown in Table III-1, it is expected that Egypt may produce approximately three-quarters of a million BD by 1985. Three countries are expected to produce around one-half million BD (Argentina, Brunei-Malaysia, and India); three countries may produce approximately one-quarter of a million BD (Trinidad, Brazil, and Angola-Cabinda); and another three will produce at least 100 thousand BD (Colombia, Peru, and Tunisia) by 1985. The production of the 21 LDC will increase from 2.5 million BD to 3.9 million BD, an average annual growth rate of 5.0 percent, from 1977 to 1985.^{1/}

The lack of suitable prospective geological structures precludes most countries from achieving greater production rates in the short term. The few countries which have had recent giant field discoveries have the potential to produce at much greater rates than indicated by the forecast, but whether they have an adequate infrastructure to rationalize a substantially greater production rate is uncertain. The political-economic-social factors may sway in favor of a relatively conservative production expansion program. The disparity among the forecasts prepared by other agencies, and with the forecasts of the 21 LDC reported herein, is shown in Table III-1.

^{1/} An estimate based on historic production capabilities, the reserve-to-production ratio, and new field discoveries made in recent years capable of expanding production.

TABLE III-I. -- 1985 Production Forecasts for
Twenty-one Less Developed Countries
(1,000 Barrels per Day)

Country	1977 Actual Production	(Prepared in 1978)					
		Warner (Estimate)	CIA	IEA	World Bank	PetroCan	Texaco
Latin America:	1,109.8	1,369	1,629	1,973	1,961	2,000	
Argentina	431.8	507	430	575	548	600	470
Trinidad	229.1	258	200	235	180	300	-
Brazil	166.4	228	505	610	753	600	625
Colombia	136.4	148	155	175	137	100	-
Peru	91.6	116	200	220	192	200	-
Bolivia	34.8	55	100	115	110	100	-
Chile	19.5	55	39	43	41	100	-
Barbados	0.3 e/	NS	-	-	-	-	-
Africa:	731.9	1,356	1,570		1,743		
Egypt	414.8	767	1,000	1,000	1,233	1,000	476
Angola-Cabinda	171.1	234	200	235	220	500	-
Tunisia	87.8	175	150	145	151	100	-
Congo	34.4	70	70	125	16	-	-
Zaire	22.6	70	50	80	96	-	370
Cameroon	-0.7	40	100	-	27	-	-
Morocco	0.5	NS	-	-	-	-	-
Senegal	0	NS	-	-	-	-	-
Far East (including Asia):	663.4	1,153	1,230		1,096		
Brunei-Malaysia	396.3	600	610	625	521	-	492
India	230.0	493	500	575	493	500	427
Burma	27.8	29	70	-	41	-	-
Pakistan	10.1	31	50	-	41	-	-
Thailand	0	NS	-	-	-	-	-
GRAND TOTAL	2,505.1	3,876					

e/ Estimated NS - Not Significant.

IEA - International Energy Agency
CIA - Central Intelligence Agency

An analysis of the forecast on a regional basis, shown below, indicates that production from the African-LDC and the Far East-LDC will increase at a much greater rate and in absolute terms, than the production from the Latin American-LDC.

<u>Region</u> 21-LDC	1977 Production (1000 BD)	1985 Production (1000 BD)	Percent Avg. Annual Growth Rate	Percent Change
Latin America	1,110	1,370	+2.6	+23
Africa	732	1,360	+8.0	+85
Far East (Asia)	663	1,150	+7.1	+74
TOTAL	2,505	3,880	+5.0	+55

The Net Benefit

The net benefit of the 1985 production of the twenty-one countries to world supplies will depend on their domestic needs. The demand for oil among the 21 LDC is expected to increase from 1976 to 1985 at an average annual rate of 3.5 percent. This is less than the forecast production growth rate of 5.0 percent.

The regional demand analysis shown below indicates that the largest growth in demand will occur among the African-LDC, but in absolute terms the Latin American-LDC show the largest incremental increase.

<u>Region</u> 21-LDC	1976 Demand (1000 BD)	1985 Demand (1000 BD)	Percent Avg. Annual Growth Rate	Percent Change
Latin America	1,872	2,550	+3.5	+36
Africa	359	610	+6.1	+70
Far East (Asia)	915	1,280	+3.8	+40
TOTAL	3,146	4,440	+3.5	+41

Table III-2 shows the historic 1976 and forecast 1985 supply-demand balances for the 21 LDC. Only four countries are expected to change their status by 1985 as exporters or importers. Argentina may reach an equilibrium in their supply-demand balance and cease being importers; Colombia may become an importer; the Republic of Congo may become an exporter; and Cameroon may shift from an importer to an exporter.

Trinidad, Egypt, Angola-Cabinda, Tunisia, Zaire and Brunei-Malaysia all may become more important exporters of petroleum by 1985. However, Brazil, Colombia, Morocco and Thailand, may become greater importers by 1985.

The regional supply-demand balances shown below indicate that the Latin American-LDC deficits of oil in 1985 will be greater than it was in 1976 (the last year demand data are available).

Region 21-LDC	1976 S/D Balance +/- 1000 BD*	1985 S/D Balance +/- 1000 BD	Percent Avg. Annual Rate of Change
Latin America	-806	-1,180	- 4.3
Africa	+213	+ 747	+15.0
Far East (Asia)	-339	+ 186	+11.7
TOTAL	-932	- 559	+ 5.8

* The negative value implies import requirements, offsetting supply shortfalls, to meet domestic needs. The positive value implies export potential; production in excess of domestic needs.

TABLE III-2 -- The 1976 and 1985 Supply-Demand
for Twenty-one LDC

Region: Country	Production (1,000 BD)	Production Percent Growth Rate 1/ (No. of Years)	Demand (1,000 BD)	Demand Percent Growth Rate 1/ (No. of Years)	1976 Production (1,000 BD)	1985/1976 Net Supply-Demand Balance 2/ (1,000 BD)
<u>Latin America</u>						
Argentina						
Future: 1985	507	+ 1.8 (8)	495	+ 1.0 (9)		+ 12
Historic: 2/	432.8	+ 1.4 (7)	453	+ 1.2 (6)	399	- 54
Trinidad						
Future: 1985	258	+ 1.5 (8)	91	+ 4.0 (9)		+167
Historic	229.1	+10.0 (6)	64	+ 7.8 (4)	213	+149
Brazil						
Future: 1985	228	+ 4.0 (8)	1,483	+ 4.8 (9)		-1,255
Historic	166.4	- 2.2 (3)	973	+11.0 (9)	167	-806
Colombia						
Future: 1985	148	+ 1.0 (8)	173	+ 1.9 (9)		-25
Historic	136.4	- 7.0 (7)	145	+ 7.1 (10)	146	+ 1
Peru						
Future: 1985	116	+ 3.0 (8)	142	+ 2.0 (9)		-26
Historic	91.6	6.7 (6)	118	+ 5.1 (4)	77	-41
Bolivia						
Future: 1985	55	+ 5.9 (8)	34	+ 6.5 (9)		+21
Historic	34.7	-10.9 (3)	19	+ 9.2 (6)	41	+22
Chile						
Future: 1985	55	+13.9 (8)	115	+ 3.4 (9)		-60
Historic	19.5	- 7.5 (9)	88	- 5.7 (4)	23	-65
Barbados						
Future: 1985	NS	-	14	+ 2.2 (9)		-14
Historic	0.3	NS	12	Erratic 3/	0.3	-12

TABLE III-2 -- The 1976 and 1985 Supply-Demand
for Twenty-one LDC (cont'd)

Region: Country	Production (1,000 BD)	Production Percent Growth Rate 1/ (No. of Years)	Demand (1,000 BD)	Demand Percent Growth Rate 1/ (No. of Years)	1976 Production (1,000 BD)	1985/1976 Net Supply-Demand Balance 2/ (1,000 BD)
<u>Africa</u>						
Egypt						
Future: 1985	767	+ 8.0 (8)	330	+ 6.0 (9)		+437
Historic	414.8	+ 36 (3)	195.5	+12.3 (7)	329	+133
Angola-Cabinda						
Future: 1985	273	+4.0 (8)	20	+ 9.6 (9)		+214
Historic	171.1	Erratic	8.7	Erratic	101	+ 92
Tunisia						
Future: 1985	151	+ 9.0 (8)	77	+ 8.9 (9)		+ 98
Historic	87.8	Erratic	36	+ 8.7 (10)	78	+ 42
Congo						
Future: 1985	70	+ 9.3 (8)	60	+ 4.9 (9)		+ 10
Historic	34.4	Erratic	39	+11.9 (6)	39	0
Zaire						
Future: 1985	44	+15.1 (8)	19	+10.3 (9)		+ 50
Historic	22.6	Recent 4/ (2)	7.7	Erratic	25	+ 17
Cameroon						
Future: 1985	40	+ 65 (8)	10.1	+ 4.0 (9)		+ 30
Historic	0.7	Recent (1)	7.1	Erratic	0	- 7
Morocco						
Future: 1985	NS	NS	93	+ 4.3 (9)		- 93
Historic	0.5	Depleting 5/	64	+ 8.6 (10)	0.1	- 63
Senegal						
Future: 1985	NS	NS	NA	NA		NA
Historic	0	NS	NA	NA	0	NA

TABLE III-2 --The 1976 and 1985 Supply-Demand
for Twenty-one LDC (cont'd)

Region: Country	Production (1,000)	Production Percent Growth Rate 1/ (No. of Years)	Demand (1,000)	Demand Percent Growth Rate 1/ (No. of Years)	1976 Production (1,000)	1985/1976 Net Supply-Demand Balances 2/ (1,000)
Far East (Asia)						
Brunei-Malaysia						
Future: 1985	600	+ 5.3 (8)	159	+ 3.8 (9)		+441
Historic	396.3	+17.1 (9)	113	+ 4.2 (3)	370	+257
India						
Future: 1985	493	+10.0 (8)	733	+ 4.0 (9)		-240
Historic	230.0	+ 8.1 (11)	515	+ 7.9 (9)	177	-338
Burma						
Future: 1985	29	+ 0.5 (8)	33	+ 2.3 (9)		+ 2
Historic	27.8	+ 6.5 (11)	22	Erratic	22	0
Pakistan						
Future: 1985	31	+15.0 (8)	120	+ 3.4 (9)		- 89
Historic	10.1	Erratic	89	Erratic	7	- 82
Thailand						
Future: 1985	NS	NS	240	+ 3.5 (9)		-240
Historic	0	Depleting	176	+ 7.8 (10)	0	-176

NA - Not Available. NS - Not Significant.

1/ The most apparent representative duration was selected to determine growth rates of historic production and demand.

2/ Future year 1985 is compared with the supply-demand balance in 1976. The historic data includes 1976 demand and 1977 production.

3/ No specific trend apparent from which to project.

4/ Little to no production history.

5/ Not likely to maintain production trend.

The forecast supply-demand balance suggests that in the aggregate the 21 LDC will improve their supply position by approximately 400 thousand BD, thereby reducing their dependency on imported oil by nearly one-half.

The forecast is heavily skewed by the current status of each country's proved reserves, the quality of oil fields discovered within the sedimentary basins, and the supply-demand balances. The country profiles which follow discuss such data in greater detail.

A Postscript--Non-Producing LDC

There are 56 LDC identified in Table III-3, which have no oil production or commercial discoveries. A few of the countries have been explored and in some instances, marginal discoveries may have been made. It is likely that in the future commercial oil deposits will be found and developed within many of these countries, but they will not be important sources of oil by 1985.

TABLE III-3--Non-Oil Producing LDC Countries

Country	Prospective Area 10 ³ Sq.Mi.	Total Wells Drilled thru 12-77	Well Density Sq.Mi./Well
Region - Latin America	463.8	247	1,878
Surinan	14.5	33	439
Guyana	27.5	12	2,292
French Guiana	25.0	0	0
Paraguay	95.0	34	2,794
Uruguay	57.0	2	28,500
Belize	12.6	35	360
Honduras	50.5	9	5,611
Nicaragua	48.0	25	1,920
Panama	34.0	15	2,267
El Salvador	6.5	0	-
Costa Rica	8.8	19	463
Dominican Republic	24.0	18	1,333
Jamaica	19.6	10	1,960
Haiti	9.0	9	1,000
Guatemala	31.8	26	1,223
Region - Africa	2,641.3	558	4,734
Niger	390.0	9	43,333
Mauritania	307.0	10	30,700
Sudan	258.6	9	28,733
Mali	250.0	4	62,500
Ethiopia	238.0	30	7,933
Chad	220.0	11	20,000
Somalia	187.0	51	3,667
Mozambique	158.0	52	3,038
South Africa	150.0	134	1,119
Malagasy Republic	111.0	52	2,135
Spanish Sahara	84.0	72	1,167
Kenya	50.5	15	3,367
Tanzania	44.0	18	2,444
Namibia (South West Africa)	35.0	8	4,375
Guinea - Bissau	24.8	10	2,480
Guinea - Republic	24.3	1	24,300
Ivory Coast	15.0	18	833
Sierra Leone	14.2	0	-
Ghana	20.1	27	744
Rhodesia	9.0	0	-
Liberia	7.5	4	1,875
Dahomey (Benin)	7.2	11	655
Gambia	6.2	2	3,100
Lesotho	6.0	0	-

TABLE III-3 -- Non-Oil Producing LDC Countries (Continued)

Country	Prospective Area 10 ³ Sq.Mi.	Total Wells Drilled thru 12-77	Well Density Sq.Mi./Well
Region - Africa (cont.)			
Swaziland	5.4	0	-
Central African Republic	5.0	0	-
Equatorial Guinea	5.0	7	714
Upper Volta	5.0	0	-
Togo	3.5	3	1,167
Region - Far East	433.1	380	1,140
Kmer Republic	76.4	0	-
Bangladesh	44.0	46	957
Laos	55.0	0	-
Nepal	11.0	0	-
Sri-Lanka	7.5	4	1,875
Bhutan	2.0	0	-
Papua-New Guinea	109.0	67	1,627
Philippines	90.2	263	343
New Guinea	38.0	0	-
Total (3 Regions)	3,538.2	1,185	2,986

SECTION IV

21 LDC Profiles

The following briefly discusses statistical data which are relevant to the history and the future of oil production in the 21 LDC. The discussion of the basins and the reserve finding rates emphasize the key elements which must be analyzed if understanding of the short-term prospects of these countries is to be attained. It is recognized that greater analytical work is essential for making longer term forecasts; the DOE/USGS Foreign Energy Supply Assessment Program may satisfy that need.

Argentina

- Argentina may have the greatest future potential among the eight Latin American (LA) LDC.
- The principal control of prospective lands is held by the State agency, Yacimientos Petroliferos Fiscales (YPF).
- The YPF directly controls over 90 percent of the production.
- Recently (April 1978), South Atlantic offshore exploration concessions were granted to private companies.
- Statistics (See Table II-10):
 - Argentina has one-fifth of prospective area (PA) among the LA-LDC:
 - Nearly one-half of total wells drilled among the LA-LDC:
 - Over one-third total producing wells among the LA-LDC:
 - Average daily well production is equivalent to 77 BD, approximately equal to the LA-LDC average;

- 90 percent of producing wells are on pump;
- The yield to date of 6,870 barrels of oil per SMPA is twice as high as the LA-LDC average;
- Highest well density among the LA-LDC - one well per 33 SMPA; and
- Approximately 40 to 50 oil fields produce an average of less than 1,000 BD, plus 15 to 20 fields less than 10 thousand BD, and 3 fields less than 50 thousand BD.

- Discussion of Sedimentary Basins:

- San Jorge Basin (No. 1, Figure IV-1). Production began in 1907. Three fields in this Basin produce about 219 thousand BD, or over half of the national production. Offshore prospects are highly regarded.
- Salado and Colorado Basin (Nos. 2 and 3, Figure IV-1). Like San Jorge, these Basins are prospective offshore; however, the onshore areas have limited prospects.
- The Neuquen Basin (No. 4, Figure IV-1), is of importance for historical reasons. It has the largest number of fields, notably small; approximately half of the total number of fields in Argentina, 35[±]. All but three fields produce less than 10 thousand BD, most produce less than 1,000 BD.
- The potential of the Tajita Basin (No. 5, Figure IV-1) is good and has had several recent discoveries.
- The Magellan Basin (Austral)* (No. 6, Figure IV-1)-- the southern tip of Argentina has approximately fifteen fields; two-thirds produce less than 1,000 BD.

- Summary:

The six principal sedimentary basins in Argentina produce virtually all of Argentina's oil (and condensate). It is expected that additional oil

* Nomenclature of Basins has not been standardized, thus several names for the same area are not uncommon.

Figure IV-1: Latin America Sedimentary Basins

Source: US Geological Survey, Map of Prospective Hydrocarbon Provinces of the World.

may be developed from the coastal basins and a number of smaller basins located in the Andes.

During the last 11 years, over 1,200 exploratory wells have been drilled, most by the State company. In addition, several hundred development wells have been drilled each year during this period. In 1977 alone, 504 development wells were drilled. Despite this effort, there has not been any significant improvement in production over the last five years, although the downward production trend was reversed in 1977. Argentina continues to import approximately 15 to 20 percent of its crude requirements.

Prospects of increasing Argentina's production by 1985 appear favorable, although modest. Even though Argentina's present reserve to production ratio (R/P) is nearly 16 to 1, there is an increasing need to import. Thus, there is little to no capability to increase production from existing facilities. Many of the important producing fields are pre-World War II discoveries, and most producing wells are on pump. The rate of finding new oil will have to accelerate significantly to support a substantial increase in production.

Production in 1977 of 432 thousand BD was an upturn after 4 years of decline from the peak of 434 thousand BD in 1972. An average annual production growth rate of 3 percent would be necessary to increase 1985 production to 547 thousand BD, as expected by some forecasts shown in Table III-1. In order to achieve this level of production and continue to maintain a minimal 16 to 1 R/P ratio, new reserve must be found at a rate of 267 million barrels per year. This is equivalent to 4 giant field discoveries over the next 8 years. Only one giant field has been discovered in Argentina; Tupengata in 1934.

It is believed that production is likely to increase at a slower rate, an average annual rate of 2.0 percent to 185 million barrels by 1985, or 507 thousand BD. The reserve finding rate requirements would average 230 million barrels per year.

Brazil

- Petrobras (Petroleo Brasileiro S.A.), the State controlled company, dominates exploration and development, although private companies have been invited to do exploration work under service contracts.
- Statistics (See Table II-10):
 - One-half of the prospective area (PA) of the LA-LDC located in Brazil, 1.8 million square miles;
 - Contains less than 10 percent of total wells in LA-LDC, one well per 387 SMPA;
 - Has less than 10 percent of total producing oil wells in LA-LDC;
 - Yield of 1,010 barrels per SMPA less than one-fourth the LA-LDC average; and
 - Approximately 30 to 33 fields with producing capabilities less than 1,000 BD, 14 to 16 fields less than 10 thousand BD, and four fields with daily production of 17 to 26 thousand BD. Also nearly 20 fields awaiting development.
- Discussion of Sedimentary Basins:
 - Reconcavo Basin (No. 7, Figure IV-1). Drilling began before World War II. Nearly forty fields discovered, no giants. However, 6 fields produce 95 percent of the oil from this Basin. Most of the fields in this Basin are depleting; they have produced nearly 85 percent of Brazil's total cumulative production through 1977, and they continue to supply over half of Brazil's production.
 - The Sergipe-Alagoas Basin (No. 8, Figure IV-1) had the first discovery after Reconcavo. It is the second most important Basin with only 11 producing fields; only one produces over 5 million barrels per year, 13.7 thousand BD. Production from the remaining fields does not equal 5 million barrels a year.

- Campos Basin (No. 9, Figure IV-1) is the most promising of the basins. Geophysical activity off the coast of Brazil began in 1950 and the only significant finds offshore to date have been in this Basin. Some 6 fields have been discovered with some wells capable of producing several thousand barrels per day.
- Discoveries have been made in the Portiquar (No. 10, Figure IV-1), Espirito Santo (No. 11), and the Barreirinhos (No. 12) Basins.
- Significant supplies of new oil are not likely to be found in the large onshore basins such as the Upper and Middle Amazons (Nos. 13 and 14), or the Parana and Maranhao Basins (Nos. 15 and 16). Small discoveries have been made in the coastal basins of Marajo and Portiquar (No. 12-A); the Santos Basin (No. 17) has had only dry tests. The principal reason for the lack of prospectiveness of the large interior basins is due to the pervasive nature of igneous intrusions and relatively thin sedimentary sections.

- Summary:

Excellent discoveries have been made offshore, which, however, will sustain only modest growth in production by 1985. Considering the apparent poor terms under which foreign explorationists operate, and the relatively poor oil finding results, the drilling of an average of 225 exploratory and development wells per year during the last three years seems remarkable; the dry hole percentage is high. Brazil will find it essential to accelerate drilling merely to displace losses of production as the fields of the Reconcavo Basin are depleted. Over the last eleven years 1,034 exploratory wells were drilled in Brazil; an average of 8 exploratory wells a month. During this period Brazil's production increased at an average annual rate of 3.3 percent; however, production has been declining for the last three and possibly four years. Demand on the other hand has increased at a rate of 9.8 percent (1966-1976). Thus, imports have been increasing at a rate of nearly 12 percent per year.

The forecasts of Brazil's 1985 production, shown in Table III-1, ranging from 500 to 750 thousand BD, would require production from 1977 to 1985 to increase at annual average growth rates of 15 to 21 percent. In addition, the reserves necessary to support such production would have to be found at a rate equivalent to one giant oil field per year, 0.5 billion barrels; assuming a R/P of 20 to 1 compared to the current 31 to 1. With the exception of a recent possible giant oil field discovery (Namorado) offshore, no giant fields have been discovered in Brazil.

The most prospective sources of new production in Brazil will come from the deep water sites. Given the lag times associated with bringing sizeable supplies on stream from such environments a more conservative view is projected. An average growth rate of 4 percent would raise production in 1985 to 83 million barrels, or 228 thousand BD. The reserve finding rate necessary to support such production is about 169 million barrels annually, assuming an R/P of 20 to 1.

Colombia

- Colombia has been drilled extensively and it is believed that most potential areas have been identified.
- Exploration activity in 1977 was at a high level; 27 exploratory wells were drilled which resulted in 2 oil producers, 5 gas wells, 12 dry holes, and 8 wells awaiting tests.
- There are now 20 separate companies retaining land holdings under concessions or in association with Ecopetrol (the state company).
- Statistics (See Table II-10):
 - Colombia has only 326 thousand SMPA;
 - Its yield of 9,210 thousand barrels per SMPA is over twice the average of the LA-LDC:
 - It has the fewest dry holes per producing well, almost 2 dry for each producer;
 - The average well production rate of 66 barrels per day is below the LA-LDC average;
 - There are six basins with oil discoveries and two with gas discoveries; and
- Discussion of Sedimentary Basins:
 - Middle Magdalena Basin (No. 18, Figure IV-1) also shown in Figure IV-2, is the site of the only giant field in Colombia, Infantas-LaCira field which has produced nearly one-third of the cumulative production; although it now has less than 10 percent of Colombia's total proved reserves. Even though the giant field continues to produce nearly 7 million barrels per year and accounts for less than one-eighth of total production, its production has declined over one million barrels within

Figure IV-2

Source: American Association of
Petroroleum Geologists
Bulletin, Vol. 62/10, Oct. 1978.

the past two years. This Basin has half of the total number of fields in Colombia including four of the five fields which produce over 10 thousand BD.

- Maracaibo Basin (No.19, Figure IV-1 and IV-2). The Colombia portion of this predominantly Venezuelan Basin is relatively small. The largest field produces 16 thousand BD, most of the other 7 fields produce less than 1,000 BD. The prospects of significant new discoveries appear nil.
- The Lower and Upper Magdalena Basins (Nos. 20 and 21, Figure IV-1), Meta (No. 22), and Putumayo (no. 23), have a total of 20 fields which produce less than 1,000 BD and 7 fields which produce less than 10 thousand BD. The Lower Magdalena Basin has the largest number of gas fields in Colombia.
- The Guajira (No. 24), and the Sinu-Atlantico (No. 25) Basins have no oil discoveries but several gas fields have been discovered.

- Summary:

The Basins of Colombia have been well explored. With the exception of 4 fields which produce more than 10 thousand BD, most fields yield less than 1,000 BD. There are nearly as many natural gas fields as there are oil fields. Development and exploration activity have not been successful in slowing the production decline; in the last seven years production declined about 5 million barrels per year. The possibility of an upturn in the production trend is remote. At present, 85 percent of the oil wells are on pump.

Colombia's production declined to 49.8 million barrels in 1977, 136.4 thousand BD; it has been declining at a rate of 7 percent annually from a peak in 1970. The 1977 R/P ratio was 19.3 to 1. Demand, however, has been increasing at a rate of 2.7 percent from 1972 to 1976, and as a result, Colombia may become a net importer.

The prospect of Colombia's 1985 production reaching the high of the forecasts shown in Table III-1 is not likely, and Colombia will be fortunate to maintain current production levels. A one percent average annual growth rate would increase production to 148 thousand BD by 1985, which would require a yearly average finding rate of 62 million barrels per year over the next 8 years. Even this low rate does not seem possible. Demand through 1985 may increase at an average annual rate of 2 percent per year, to 63 million barrels, leaving Colombia as an importer of as much as 10 million barrels by 1985.

Peru

- Many of the geological structures of eastern Peru are dry; however, deeper formations may be productive.
- Statistics (See Table II-10):
 - Peru contains over 10 percent of prospective area among the LA-LDC, 400 thousand square miles;
 - Over 10 thousand wells have been drilled in Peru resulting in the highest density among the LA-LDC, one well per 40 square miles;
 - Oil yield of 4,340 barrels per SMPA is equivalent to the average for the LA-LDC; and
 - Average well production rate of 36 BD is approximately one-half LA-LDC average.
- Discussion of Sedimentary Basins
 - Piura Basin (No. 26, Figures IV-1 and IV-3). Although this Basin comprises only 3.5 thousand square miles, it has the greatest number of fields of any basin in Peru. It represents the largest productive area in Peru with total discovered oil amounting to 1.3 billion barrels, about three-fourths of the total discovered oil in Peru. The giant LaBrea-Parinas field discovered in 1869 is located in this Basin.
 - Maronon Basin (No. 27). Some 16 fields are located in this Basin which is the second largest producing area in Peru. Only three of the fields are producing.
 - Upper Amazon Basin (No. 21), which includes the Ucayali subbasin. The two producing fields in this Basin yield approximately 1,500 BD. Also natural gas has been discovered in this Basin.
 - Titicaca Basin (No. 28), is the site of the Perin field which has been depleted after producing 287 million barrels of oil.

Figure IV-3.

Peru Geological Map

- Summary:

Peru is one of the more extensively explored and developed countries among the LDC of the world. The one giant field was discovered in 1869. Peru's production history over the last 10 years has been relatively stable, increasing from 23 to 33 million barrels per year. An average of 3 exploratory wells per month have been drilled in Peru during this period.

Expectations that production will increase from 90 thousand BD to 190 or 220 thousand barrels per day as shown in Table III-1, would require an average annual production growth rate of about 9 percent compared with the historical rate of 3.3 percent (1966 to 1977). Consumption during this historic period increased at an average rate of 3.5 percent. Peru has been a net importer of approximately 10 million barrels of crude products per year.

In order to accomplish the projected production rates and to maintain a reserve to production ratio of 20 to 1 by 1985, new reserves would have to be found at an average yearly rate of 133 million barrels. During the last three years Peru's reserves have declined.

If a 3.0 percent growth in production is assumed, production by 1985 would be 42.3 million barrels, 116 thousand barrels per day. A reserve finding rate of 62 million barrels yearly would have to be maintained; which may be difficult. A 2 percent annual average increase in demand would result in a 1985 demand of 51.6 million barrels. On the basis of these assumptions, Peru could be a net importer of 9.5 million barrels by 1985.

Bolivia

- Bolivia has many untested structures although its ultimate production potential may not be large.
- In 1977, nine of the 13 private companies terminated activities when the period of their exploration agreements with YPFB, the state oil company were completed.
- The earliest discovery of a field still producing was in 1924, however, fields discovered over 25 years ago yield only 5 percent of the total production.
- The largest single producing region with the first discovery in 1962, produces less than 15 thousand BD; 40 percent of Bolivia's total production.
- Statistics (See Table II-10):
 - With the exception of Brazil, Bolivia has the least densely drilled prospective area among the LA-LDC, one well per 292 square miles;
 - The average production per well of 124 BD is the highest among the LA-LDC; and
 - Its yield, 2,220 barrels per SMPA, is half the average for the LA-LDC.
- Discussion of Basins:
 - The SubAndean Zone (No. 5, Figure IV-1) also called Tarija, is the sole producing area of Bolivia. Only one field out of approximately 15 produces more than 10 thousand BD and 12 fields produce less than one thousand BD. Production has declined steadily since 1973.
 - Chaco Basin (No. 29) has a gas field and an oil discovery well. The oil prospects are minimal.

- Summary:

Despite the drilling of 138 exploratory wells, an average of over one a month during the past 11 years, and subsequent development of discoveries, Bolivia's decline in oil production during the last four years has not been reversed. Production in 1977 was 12.7 million barrels compared to 17.3 million in 1973; an average annual decline rate of 6.4 percent. During this same period, Bolivia's consumption of petroleum increased at an annual rate exceeding 7.5 percent. As a result, Bolivia's yearly export capability has declined to less than 8 million barrels, 22 thousand BD.

Expectations of future production (as shown in Table III-1) of 100 to 115 thousand barrels per day, an average annual increase of 12 to 14 percent, seem improbable.

It has been reported that a production target of 70 thousand barrels per day has been set (no date for such production is stated). If that production rate is achieved by 1985, this would require a production growth rate of 9 percent per year and new reserves would have to be found at a rate of 55 million barrels per year, one-sixth of current reserves. This rate is very speculative. An alternative and more realistic production forecast is 55 thousand barrels per day, 20.4 million per year, a 6 percent growth rate. This would require a finding rate of 37 million barrels of new reserves each year; about 10 percent of current reserves. If demand continues to increase at a 7 percent rate, to 13 million barrels in 1985, the export potential would be about 7 million barrels, 19.2 thousand BD.

Chile

- Control of exploration and development as well as the granting of rights to concessions rests with the Empresa Nacional del Petroleo (ENAP).
- ENAP also controls downstream operations, including pipelines and refineries.
- A risk service contract was granted to two private companies, involving 22 million acres of the Pacific Ocean continental shelf, out to water depths of 900 feet. Under the agreement, the initial exploratory well need not be drilled for four years, although a decision to do so must be made within the first two years. The full term of the agreement is 35 years, a 5-year exploration phase and a 30-year exploitation phase. A commitment was made to spend \$11 million during the exploration phase.
- Statistics (See Table II-10):
 - Chile has been densely drilled, one well per 34 SMPA;
 - Its yield is two and a half times greater, nearly 10,650 barrels per SMPA, than the LA-LDC average;
 - Its well production average is 51 BD, which is 50 percent lower than the LA-LDC average;
 - There are approximately 26 oil fields and 24 gas fields in Chile. The largest field discovered in 1961 produces over 2 thousand BD.
- Discussion of Basins:
 - Magallanes Basin (No. 6, Figure IV-1), partially offshore, is the largest and only producing Basin. It has produced approximately 231 million barrels of oil. All of the 30 exploratory wells drilled in Chile during the last two years were drilled in this basin, resulting in 4 oil and 2 gas discoveries.

-- The Valdiva Basin (No. 30) is a narrow, Andean Basin on the Continental Shelf of the Pacific. To date, only gas has been discovered. The risk contract agreement referred to earlier includes a large part of this basin, as shown in Figure IV-4. The offshore Valdiva Basin has tested natural gas, and for the most part, the Andean basins are not prolific sources of oil. However, further drilling is essential, and should help to determine this basin's long-term future as an oil prospect.

- Summary:

Generally, the poor quality of the fields discovered does not support optimism with respect to Chile's future production capabilities. Historically, production from Chile has been declining since 1971, at an average annual rate over 10 percent per year. This decline has occurred while 228 exploratory wells were drilled in eleven years, nearly two a month. Chile's demand for oil also has been declining at a rate of 2.4 percent during the last ten years; imports were reduced to 24 million barrels in 1976.

Table III-1 displays the broad range of expectations for Chile's production in 1985; from 39 to 100 thousand BD. In order to achieve those levels, a significant turnaround of the downward production trend must occur, supported by the finding of new reserves. Reportedly reserve additions have been sizeable from the close of 1976 to 1977, when proved reserves increased from 182 million barrels to 440 million barrels; a difference of 258 million barrels. If the additional reserves represent new discoveries (such as the newly discovered Spiteful field), then Chile's production capability is likely to increase. However, if the reserve additions are revised estimates, the production capabilities are not significantly affected.

Figure IV-4

Source: American Association of
Petroleum Geologists
Bulletin, Vol. 62/10, Oct. 1978.

Based on the assumption that new reserves are available from the Spiteful field and other discoveries, Chile's production in 1985 may increase to approximately 14.6 million barrels, 40 thousand BD, an 8.3 percent average annual increase.

The R/P in 1977 is over 60 to 1, thus apparently sufficient proved reserves exist to support a significant production increase. The major constraint, however, may be the lack of adequate development and production infrastructure to make a two-fold increase in production in eight years possible. Chile's demand pattern for oil levelled-off at 40 million barrels in 1972 and 1973 and subsequently declined to 23.1 million in 1976, an average annual decline rate of 5.7 percent. As production increases, demand should increase. If a demand of 40 million barrels by 1985 is assumed, an average annual rate of increase of 2.5 percent, Chile may reduce imports to 70 thousand BD by 1985.

Trinidad-Tobago and Barbados

- Trinidad's production has been increasing steadily since 1971, from 47 million barrels to nearly 84 million in 1977, an annual average growth rate of 10 percent. While domestic demand during the same period increased only 4.3 percent, thus net exports have been increasing.
- In 1977, a total of 200 development wells and 17 exploratory wells were drilled. Also a total of 230 exploratory wells, an average of slightly less than two exploratory wells a month have been drilled over the last 11 years.
- Trinidad has approximately 52 producing oil fields located in five distinct geological environments. Over half of the fields produce less than 1,000 BD; however, 4 fields produce within a range of 35 thousand to 53 thousand BD. In addition, as a result of 1977 exploratory drilling some 6 wells were confirmed discoveries and are awaiting development. In addition, 3 gas fields are located in Trinidad.
- Barbados has 4 oil fields and 4 gas wells (no reported gas production). All the fields produce less than 1,000 BD.
- Barbados has had only two development wells drilled in 1977, as exploration opportunities are limited. The daily average production in early 1978 increased to 1,000 BD from 314 BD in 1977. However, consumption outstripped production in 1976 by 4 million barrels.
- Statistics (See Table II-10):
 - Both countries have extraordinary well drilling densities, one well per 1.4 and 10 SMPA, respectively.
 - Similarly, both countries have high yields per SMPA, 182 thousand and 70 thousand barrels, respectively.
 - The nearly 3,100 wells producing in Trinidad are second in number, only to Argentina with 5,700 wells, among the LA-LDC.

- Summary:

The limited but prolific characteristic of the prospective areas of these countries and the generally favorable attitude towards foreign investments have resulted in exceptional oil yields. The expected production by 1985 shown in Table III-1, ranges from 180 thousand BD to 300 thousand BD for Trinidad-Tobago.

It is expected that Trinidad's production may continue to increase, given the fact that three of its four largest fields are of recent vintage, early 70's discoveries. An annual 1.5 percent growth in production, well below the historical 10 percent, is likely.

Trinidad-Tobago's R/P ratio has declined to less than 8 to 1 in 1977. Therefore if production is increased to 94 million barrels in 1985, or 258 thousand BD and the R/P ratio improved to 10 to 1, new reserves must be found at an average annual rate of 125 million barrels, or nearly 20 percent of current reserves; it is feasible depending on rates of development. Also, the forecast production rate may be influenced not by resource constraints, but by capital absorption capabilities. Net exports could be as great as 70 million barrels. The historic consumption rate of 7.8 percent may decline to 4.0 thus increasing the capability of Trinidad to export.

Barbados' production has minimal prospects of increasing to any significant levels by 1985; consumption growth rates will outstrip production growth over the next 8 years.

See figure IV-1 for the relative location of the sedimentary basin.

Egypt

- Egypt has the potential to expand production capacity; however, the rate of development of the giant fields is the critical factor in the forecast.
- Four of the five sedimentary basins, entirely or partly located in Egypt, are appraised as having limited potential as sources of new oil discoveries.
- During the last decade an average of 2 exploratory wells have been drilled each month and extensive geophysical activity has taken place.
- As of the end of 1977, 213 thousand square miles of Egypt was under production sharing contracts, exploration licenses, participation agreements and development leases involving 28 companies. This is equivalent to two-thirds of the total prospective area.
- Statistics (See Table II-10):
 - Egypt has over one-third of the SMPA of the African LDC (A-LDC): 325 thousand SMPA;
 - It has over 40 percent of the total wells drilled and over half of the producing wells in the A-LDC;
 - It is more densely drilled than the average of the A-LDC;
 - Its yield of 1,194 barrels per SMPA is slightly better than the average for the A-LDC; and
 - The production per well is below average at 112 BD.
- Discussion of Basins:
 - Gulf of Suez Basin (No. 31, Figures IV-5, IV-6 and IV-7) contains all five giant fields of Egypt-- El Morgan, Ramadan, July, Belayem, and Belayem, Marine--which produce approximately 85 percent of Egypt's total production. Of the remaining 22 fields in this Basin, 7 produce

Figure IV-5: Africa
Sedimentary Basins

Source: US Geological Survey,
Map of Prospective
Hydrocarbon Provinces
of the World.

Source: American Association of
Petroleum Geologists
Bulletin, Vol. 62/10, Oct. 1978

Figure IV-6

- 1977 WILDCATS

- 1 - GS 9 - 1
- 2 - GS 24 - 1
- 3 - GS 160 - 1
- 4 - GS 195 - 1
- 5 - EPK - 1X
- 6 - KK 85 - 1
- 7 - E. AL WADI
- 8 - AL KHALIGUE
- 9 - SHUKHEIR MARINE
- 10 - GS 392 - 1
- 11 - ASHRAFI W - 1
- 12 - ASHRAFI E - 1
- 13 - ABU SHIBAN - 1
- 14 - RSO - T - 95 - 1
- 15 - RSO - Z - 95 - 1
- 16 - OUSEIR A - 1 X
- 17 - OUSEIR B - 1 X

Source: American Association of
Petroleum Geologists
Bulletin, Vol. 62/10, Oct. 1978

Figure IV-7

less than 1,000 BD and 8 produce less than 10 thousand BD and there are 2 gas fields. The areal limits of the basin is 9,000 thousand square miles. The basin is a graben, a fault subsidence valley, with a thick stratigraphic section.

- Nile Delta (No. 32, Figure IV-6), an area of 14 thousand square miles, has had three gas discoveries. The stratigraphic section is relatively thick, and is undergoing geophysical exploration. The Delta is expected to be an important gas supply area and despite the lack of success up to now in finding oil, there is some optimism. The valley to the south is less prospective; two unsuccessful tests were drilled in 1978. This area has not attracted a large play, because the other basins of Egypt are more prospective.
- Red Sea Basin (No. 33, Figure IV-7). Only one-sixth of this basin lies in Egypt, the balance is in Saudi Arabia. No discoveries have been made in the 15 thousand square miles of the basin located in Egypt. However, a giant gas-condensate field, Barga, was discovered in the Saudi Arabian sector. There is no Red Sea production. Five wells were drilled to depths ranging from 6 thousand to 16 thousand feet in 1977, without success.
- The Western Desert (No. 34, Figure IV-5) is the largest petroleum province, 150 thousand square miles. This is the only other producing basin in Egypt. The El Alamein field discovered in 1966 is an exceptional field in this area. It has produced over 53 million barrels of oil, but its daily average has declined to 7.5 thousand BD. After drilling over 200 exploratory wells in the Western Desert, there are only small shut-in fields which produce one million barrels in total. The only other producer is the Abu Ghoradig field discovered in 1972; it recently doubled its production to 11 thousand BD.

-- Sinai and Eastern Desert (No. 35 Figure IV-5).
A few oil shows, but tests have been disappointing. There has been considerable drilling in these two areas, including offshore in the Mediterranean.

- Summary:

Egypt's consumption of oil has been increasing at an average annual rate of 4.2 percent, from 1966 to 1976. Production, however, has been increasing at an average rate of nearly 12 percent over the comparative period. The high growth rate is principally due to the discovery and development of the five giant fields in the Suez Basin. Three of the largest giants were discovered after 1965.

Expectations that production will increase in 1985, as shown in Table III-1, a range of 476 to 1,233 barrels per day, 174 million to 450 million barrels per year, illustrates the uncertainty regarding Egypt as an important source of oil. Egypt's 1977 production was 415 thousand BD. The high of the range of 1.2 million BD may be feasible, and would require a production average annual growth rate of slightly more than 14 percent; the proved reserve finding rate would have to average over 0.7 billion barrels per year to sustain the high production forecast for 1985. It is believed that a lower growth rate, about 8 percent, may be manageable and would result in the production of 767 thousand BD. The necessary rate of finding new reserves to support such production, assuming a 16 to 1 R/P ratio, would be slightly less 0.5 billion barrels per year for the next 8 years. Given an annual increase of six percent in domestic consumption, to 330 thousand BD, Egypt's export potential may be nearly 440 thousand BD in 1985. The political and economic policies will be the key factor determining Egypt's 1985 production.

Angola-Cabinda

- The Malongo field, with its north and west extensions, is a supergiant field, Figure IV-8, which provides nearly three-fourths of Angola's production.
- Excluding Cabinda, there are, as shown in Figure IV-9, 10 separate concession arrangements which include most all of the onshore and offshore prospective areas.
- Statistics (See Table II-10):
 - Angola is the most densely drilled area among the A-LDC; one well per 70 SMPA;
 - It has the highest yield among the A-LDC: 36 BD per SMPA; and
 - It has less than 5 percent of the A-LDC prospective area, but nearly 20 percent of the total wells drilled among the A-LDC.
- Discussion of Sedimentary Basins:
 - Cabinda Coastal Basin, also called the lower Congo Basin, (No. 36, Figure IV-5), is the locale of the giant Malongo field. In addition, there are some 10 other discoveries, 5 of which are completed as fields. Three of the five fields produce at an average rate in excess of 10 thousand BD. Offshore production in total yields about 85 percent of Angola production.
 - Cuanza Basin (No. 37, Figure IV-5) is essentially the area shown in Figures IV-9 and IV-10. There are approximately 14 oil fields and 4 gas fields in this Basin. Ten of the fields produce less than 1,000 BD.
- Summary:
 - Operations in this country are controlled by Petrangol, the state company. In 1977, there was no development drilling, and of the exploratory wells drilled, 4 out of 6 were completed as discoveries.

- 60 -

Figure IV-10

Source: American Association of
petroleum Geologists
Bulletin, Vol. 62/10, Oct. 1978

An average of slightly less than 2 exploratory wells per month have been drilled in Angola over the last decade.

Angola's production increased nearly 60 percent in 1977 over 1976. Except for the one-half million BD estimate, the expected 1985 production shown in Table III-1 assumes a 4 percent growth in the production rate. Angola could exceed this rate as new discoveries and the offshore potential provide the required reserves. The production of 234 thousand BD, in 1985, would require an average annual reserve finding rate of at least 100 million barrels per year over the next 8 years, assuming an R/P of 18 to 1.

Angola's consumption in 1976 was nearly 4 million barrels per year. It is expected that demand will increase at an average annual rate of 9.6 percent to 20 thousand BD in 1985. Thus the export potential in 1985, could exceed 200 thousand BD.

Tunisia

- Tunisia's future producing prospects are good based on recent discoveries and the view that additional discoveries are likely.
- The El Borma Field which is in the giant classification and the Ashtart Field, a potential giant, are the source for over 90 percent of Tunisia's production of 32 million barrels of oil.
- Nearly two-thirds of the prospective area is under concessionary agreements. There are 16 separate concessionary arrangements, as shown in Figure IV-II.
- Statistics. (See Table II-10):
 - Tunisia is one of the least drilled areas among the A-LDC; one well per 269 square miles of prospective area; and
 - It shares with Angola the highest yield among the A-LDC.

Discussion of Sedimentary Basins:

- North Sahara Basin (No. 38, Figure IV-5). The basin lies mostly in Algeria, but it includes southern Tunisia (also referred to as the Illizi Basin). Except for the giant El Borma near the Algerian border, this basin has not been comparatively productive elsewhere in Tunisia, despite a number of successes in Algeria; it has not been productive in Libya either. There are 3 other fields in the basin; 2 produce less than 1,000 BD, the other less than 10 thousand BD.
- Gulf of Gabes (No. 39, Figure IV-5), also called Pellogin, is the locale of the other giant field of Tunisia, Ashtart, which is located offshore. Two other smaller fields are awaiting development. There are two gas fields located in this Basin. Additional large discoveries are expected from this area which yields production from a limestone reservoir.

Figure IV-11

Source: American Association of Petroleum Geologists Bulletin, Vol. 62/10, Oct. 1978

- The Gulf Hammamet or Sousse Basin (No. 40 Figure IV-5) has been the site of several discoveries awaiting development. No production as yet. Cape Bon is included within this Basin.
- Atlas Mountain Folded Belt (No. 41 Figure IV-5) consists of the northern rim of the Sahara Desert - no production prospects as yet.
- Summary:

Tunisia's production has increased at an average annual rate of 20 percent over the last decade. Most of the growth has occurred in recent years. Demand during the same period has increased at a rate of less than 9 percent. The range of expected production by 1985, as shown in Table III-1 is 100 to 151 thousand BD; an average annual growth rate range of 1.6 percent to 6.1 percent. It is expected that several additional important discoveries may be made in Tunisia and therefore an expected production rate as high as 175 thousand BD, a growth rate of 9 percent, is possible. This would require a reserve finding rate of 48 million barrels per year over the next 8 years while maintaining an R/P of 40 to 1 compared to the present 83 to 1. Domestic demand may increase to 28 million barrels, 76.7 thousand BD, by 1985. Thus the potential for exports in 1985 may approach 100 thousand BD.

Congo

- Six exploration permits cover the coastal and offshore prospective area of the Congo, as shown in Figure IV-12.
- One concessionaire plans to drill an offshore test well that will be the deepest water operation in the world; 4,400 feet of water.
- Statistics (See Table II-10):
 - The Congo has only 30,500 SMPA; all of the lands along the coast and offshore are under concessions;
 - Its yield per SMPA is 1,436 barrels, about 50 percent greater than the average for the A-LDC;
 - Ninety-four of the 97 total wells producing are on pump; and
 - An average of only two test wells a year has been drilled over the last decade.
- Discussion of Sedimentary Basins:
 - The production of the Congo is from the Gabon coastal Basin (No. 42, Figure IV-5). Virtually all of the production of the Congo, 32.9 thousand BD out of a total output of 33.2 thousand BD, comes from the offshore giant field, Emeraude Marine, discovered in 1969. Another field, the Loango Marine discovered in 1972, is regarded by some as a potential giant.
- Summary:

A total of 12.6 million barrels of oil was produced in the Congo in 1977; 34.4 thousand BD. It is not expected that the Congo production by 1985 will be much larger than 25 million barrels; therefore, the 70 thousand barrels per day production estimate shown in Table III-1 is reasonable. This would represent an average annual growth rate of 9.3 percent, and in order to maintain a R/P ratio of at least 20 to 1, compared to the present 29 to 1 R/P, the reserve

Figure IV-12

Source: American Association of
Petroleum Geologists
Bulletin, Vol. 62/10, Oct. 1978

finding rate must be 38 thousand barrels per year over the next 8 years; a reasonable possibility. The Congo wells are on pump and the reservoirs of the giant field are expected to have a low recovery factor, approximately 10 percent, which precludes a more optimistic forecast.

The deep water offshore test will be an important factor in the status of the Congo's future production, but even with success no production is likely to occur from this source by 1985.

Zaire

- Except for the offshore areas, exploration in Zaire has been extremely disappointing.
- Additional drilling activity by U.S. and foreign companies is continuing along the coast as well as onshore.
- Production began in 1975.
- Statistics (See Table II-10):
 - Zaire is the least dense drilled area among the A-LDC; an average of one well for each 7,950 SMPA;
 - Its yield of 620 barrels per SMPA is the lowest among all LDC; and
 - Its 12 producing wells have the highest average production, 2,000 BD, among the LDC.
- Discussion of Sedimentary Basins:
 - Cabinda Coastal Basin (No. 36, Figure IV-5) is the major geological feature in which two offshore fields produced 22.6 thousand BD in 1977. In addition, the Basin has two suspended gas fields. All of the offshore areas shown in Figure IV-8 are being tested.
 - Congo Basin (No. 43, Figure IV-5). Not a great deal of information is available, except that the geology is not sufficiently attractive at this time to compensate for the logistical problems associated with operation in this Basin.
- Summary:

The 1977 production can be more than tripled to 69.5 thousand BD by 1985. The estimates shown in Table III-1 are all possible. The 370 thousand BD estimate, however, would require a significant acceleration in the rate of development. The forecast of 69.5 thousand BD would require an average annual growth rate of 15 percent and an average of 55 million barrels of reserve must be found annually to maintain an 18 to 1 R/P ratio. Zaire may be a nominal exporter by 1985, 4 thousand B/D.

Cameroon

- The first discovery in Cameroon occurred in 1972 and it has been one of the most actively drilled areas in Africa. A total of 32 exploratory wells were drilled in 1977, compared with 41 such wells drilled in the last 10 years.
- Nearly 19 oil discoveries were completed in 1977, which is over twice the number of producing wells.
- Statistics (See Table II-10):
 - Cameroon has the fewest SMPA, less than the average for the A-LDC--it could easily have the largest yield by 1985; and
 - It ranks among the most densely drilled areas among the A-LDC.
- Discussion of Sedimentary Basin:
 - The Cameroon Coastal Basin (No.44, Figures IV-5, and IV-13, and IV-14) is the sole producing area and it is undergoing development; 9 development wells were drilled in 1977. Virtually all of the prospective area is under concession.
- Summary:

Cameroon is an excellent prospect for a short term increase in production. The estimates of 27 to 100 thousand BD by 1985, as shown in Table III-1, probably captures the production likely by 1985. A more realistic expectation of production is likely to fall within the range of 27 to 50 thousand BD. Oil available for export could range from 15 to 40 thousand BD.

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Figure IV-14

Source: American Association of
Petroleum Geologists
Bulletin, Vol. 62/10, Oct. 1978

Morocco

- Prospects of additional oil supplies from Morocco are likely, but the quantities may be limited as the geological factors are not favorable to finding large fields.
- One-fourth of the PA is retained under concessions; over half is retained by BRPM, the Berriau de Rescherches et de Participations Minieres (See Figure IV-15).
- Statistics (See Table II-10):
 - Although relatively densely drilled, one well per 219 SMPA, greater than the average for the A-LDC and greater than many of the LDC, Morocco has one of the lowest yields per SMPA, 110 barrels .
- Discussion of Sedimentary Basins:
 - Rharb Basin (No. 45, Figure IV-5) provides the only production in Morocco, the Haricha field. Increasing attention is being paid to the offshore part of this basin.
 - Essaoura Basin (No. 46, Figure IV-5) off the mid and southern coast of Morocco is receiving additional attention in the offshore area. To date a number of dry holes have been drilled.
- Summary:

Over the last 11 years some 80 exploratory wells were drilled; 13 during the last two years. None proved commercial quantities of oil. The fields of Morocco have or will shortly be depleted, as production in 1977 amounted to 166 thousand barrels of oil, 455 BD. Morocco was an importer of over 25 million barrels of oil. Prospects for 1985 production is nil.

Figure IV-15

Source: American Association of
Petroleum Geologists
Bulletin, Vol. 62/10. Oct. 1978

Senegal

- Interest in permits in offshore Senegal are waning.
- However, the Senegal Basin is a large area which warrants additional drilling.
- Statistics (See Table II-10):
 - Senegal has one of the lowest drilling densities among the LDC; and
 - It had no production in 1977.
- Discussion of Sedimentary Basin:
 - Senegal Basin (No. 47, Figure IV-5). There have been several oil shows and reserves of 30 thousand barrels have been reported. Some 27 exploration wells have been drilled over the last decade with no commercial success. Outstanding concessions are shown in Figure IV-16.
- Summary:

There is no expectation that Senegal will be a significant producer of oil by 1985. Longer term prospects are marginal.

Figure IV-16

Source: American Association of
Petroleum Geologists
Bulletin, Vol. 62/10. Oct. 1978

Brunei-Malaysia

- Drilling began in 1866. See Orientation Map IV-17.
- A total of three or four giant fields may exist in this area. The earliest discovered giant was in 1928; the nearly depleted Seria field. Active exploration and development continues.
- Petronas, the state oil company of Malaysia has concluded a production sharing agreement with Exxon. This followed a period of suspended activity after the passage of the Petroleum Development Act of 1974. Drilling in this area accelerated as a result of the agreement. East Malaysia has had over 150 development and 25 exploratory wells drilled in the last three years. Brunei also has had over 150 development wells and 28 exploratory wells drilled over the same period.
- Statistics (See Table II-10):
 - Brunei-Malaysia has the largest SMPA, 167 thousand square miles, among the Far East (FE) LDC;
 - It has one of the highest yields, 36,920 barrels SMPA, and the largest proved reserves 4.1 million barrels among all the LDC; and
 - It is the highest average production per well among the FE-LDC, 613 BD.
- Discussion of Sedimentary Basin:
 - Brunei Coastal Zone within the NW Borneo Basin also known as the Sarawak Basin (No. 48, Figure IV-18), has two giants, Ampa and Seria, both largely depleted. A total of five fields produced all of Brunei 78 million barrels in 1977. Three exploratory wells were drilled in 1977, two were completed as gas condensate wells and 154 development wells were drilled. Figure IV-19 shows the development.

Figure IV-17

Source: American Association of
Petroleum Geologists
Bulletin, Vol. 62/10, Oct. 1978

Figure IV-18: Far East (incl. Asia)
Sedimentary Basins

Source: US Geological Survey, Map of Prospective
Hydrocarbon Provinces in the World.

Figure IV-19

Source: American Association of
Petroleum Geologists
Bulletin, Vol. 62/10, Oct. 1978

- The fields of Sarawak in East Malaysia, shown of Figure IV-20, are not as large as the Brunei fields, although one, Baronia discovered in 1967 produces about 19 million barrels a year. The Miri field discovered in 1911 is shut-in after producing nearly 80 million barrels. In total, the fields of Sarawak and Sabah, Figure IV-21 (the largest field in Sabah is Samarang, which produced over 54 million barrels) produced 67 thousand BD in 1977.
- The dry holes drilled off the coast of the Malaysian Peninsula are shown in Figure IV-22. This area of East Malaysia lies in the Penyu Basin (No. 49, Figure IV-17). As yet there is no production from this Basin, although two discoveries have been made. Of the 14 exploratory wells drilled in 1977, only one discovered oil.
- Summary:

Production from Brunei-Malaysia has increased at an average annual rate of nearly 25 percent over the last decade; the greatest growth has occurred in East Malaysia. The aggregate production in 1977 was 145 million barrels, 397 thousand BD. The production estimates for 1985, shown on Table III-1, range from 521 to 625 thousand BD. This would require that production increase at an average annual rate ranging from 3.4 percent to 5.8 percent, respectively. The prospect of Brunei-Malaysia's 1985 production being within that range is possible. A 600 BD forecast by 1985, represents a 5.3 percent growth rate, and would require a new reserves finding average of 223 million barrels per year during the next 8 years; assuming an R/P of 20 to 1 compared to the current 28 to 1. Based on a demand of nearly 160 thousand BD in 1985, Brunei-Malaysia's export potential may exceed 400 thousand BD.

Figure IV-20

Source: American Association of
 Petroleum Geologists
 Bulletin, Vol. 62/10, Oct. 1978

Source: American Association of
Petroleum Geologists
Bulletin, Vol. 62/10, Oct. 1978

Figure IV-21

Source: American Association of
 Petroleum Geologists
 Bulletin, Vol. 62/10, Oct. 1978

Figure IV-22

India

- State companies dominate petroleum activity; the Oil and Natural Gas Commission (ONGS) and Oil India. Only one foreign contractor was active in offshore drilling in 1977.

In recent years, many new gas and oil discoveries have been made as a result of the policy to accelerate exploration and development. The Bombay fields commenced production and India's petroleum fortunes are on the ascendency.

- Statistics (See Table II-10):
 - Except for Brazil and Argentina, India has the largest prospective area, 469 thousand square miles, among the LDC;
 - It is the least densely drilled among the FE-LDC, one well per 245 square miles; and
 - It has over 60 percent of the total producing wells, 1,600 wells, among the FE-LDC, but its average well production is nearly one-half as great as the FE-LDC average.
- Discussion of Sedimentary Basins:
 - Cambay Gulf Basin (No. 50, Figures IV-18 and IV-23) located in the west is the principal producing area in India. The first discovery in this basin was made in the early 1950's. One report indicates that through 1970, 175 exploratory wells were drilled on some 30 geological structures; half of these tested oil but only eight resulted in commercial fields. The giant fields in India, the Bombay High and the South Bassein, (2 probable giants) are located offshore. The two fields have a targeted production of 240 thousand BD by 1981. There are at least 16 to 18 fields in this basin, over half of which produce less than 1,000 BD.
 - Assam Valley (No. 51, Figure IV-18) in the north-eastern part of India is the oldest producing area; the first discovery was in 1890. There are 6 producing fields; the best field produces about 20 thousand BD.

Figure IV-23

Source: American Association of
Petroleum Geologists
Bulletin, Vol. 62/10, Oct. 1978

- Cutch Basin (No. 52, Figure IV-18) has no production; however, it has potential. It will not be as significant a source as the Cambay Gulf Basin since its potential pay zone is relatively thin.
- The Bay of Bengal (No. 53, Figure IV-18) is the principal source of natural gas; two giant gas fields have been discovered in the Basin. Two non-commercial oil discoveries represent the only signs of oil. Although this Basin requires additional drilling, principally in the deep water environment, only natural gas is expected.
- The Indus Basin (No. 54 Figure IV-18) extends into northwestern India. Oil has been discovered in that part of the Basin which extends into Afghanistan and Pakistan, but none has been found in India.
- Krishna-Godavari Basin's (No. 55 Figure IV-18) thickest sedimentary section is located in the valley of the Godavari River. The sedimentary deposits of this basin are relatively thin and not productive.
- Cauvery Basin (No. 56 Figure IV-18) includes parts of the Palk Straights which separates India from Sri Lanka. A well was drilled in the basin by a private company. The 12,396-foot well was plugged and abandoned. This basin may have potential.
- The Ganges Basin (No. 57 Figure IV-18) is a narrow basin along the Himalayas. It consists of a set of sedimentary deposits with a full range of thicknesses; from a thin section of sedimentary fill to sediments as thick as 30,000 feet and deeper.
- Kerala Basin (No. 58 Figure IV-18) is a comparatively small offshore basin with limited prospects.

- Summary

There is a lack of detailed drilling data available for India; virtually all drilling is accomplished by the state companies. It is expected that India's production will increase. After a modest growth in production in the later part of the sixties, production stabilized at about 52 to 58 million barrels. However, production has accelerated from 1974 to 1977 at an average annual growth rate of 14.6 percent. Consumption during this same three year period has increased at an average rate of nearly 4 percent. The range of expected production in 1985, as shown in Table III-1, of 427 to 575 thousand BD represents growth rates of 8 to 12 percent, respectively. Either end of the range is possible. A 10 percent average annual growth would increase production to 493 thousand BD by 1985. The rate of finding new reserves to support such production, assuming a R/P of 25 to 1 compared with nearly 36 to 1 at present, must average 320 million barrels per year over the next eight years. If it is assumed that demand will continue at a 4 percent rate, India would still be a net importer of nearly 90 million barrels in 1985. Thus, any significant change in the availability of oil as a result of India's development would require a more significant increase of production; a growth rate of approximately 16 percent over the next 8 years would achieve a balance between production and consumption. This prospect is possible if exploration and development programs are sustained at the accelerated rate.

Burma

- Burma is an old producing area dating back to the beginning of the century.
- Myanmar Oil Corporation (MOC) is the state oil company which conducts all operations in Burma.
- At the end of 1977 all private interest relinquished their holdings to offshore areas. A reentry by the foreign interests is possible. (See Figure IV-24). Current data regarding drilling onshore is not available.
- Statistics (See Table II-10):
 - Burma is the most densely drilled area, one well per 29 square miles, among all the LDC, with the exception of the two island nations of Trinidad-Tobago and Barbados;
 - Burma has one of the lowest yields among the LDC, 3,840 barrels per SMPA, which is nearly one-third the FE-LDC average; and
 - Burma also has one of the poorest individual well production averages, 57 BD, among the LDC, less than one-fourth the average of the FE-LDC.
- Discussion of Sedimentary Basin:
 - Burma's Irrawaddy Basin (No. 59 Figure IV-18) also called the Irrawaddy-Gulf of Martaban Basin is a long narrow depression conforming with the Irrawaddy River Valley in central Burma. Of the five producing fields, only one provides more than 15 thousand BD and one produces less than 700 BD, the other three produce 1.5 to 3 thousand BD. It is reported that 4 to 6 rigs are active in exploratory drilling and one discovery was made in 1977; no detail is available.

- Summary:

The anticipated production for Burma in 1985, as shown in Table III-1, ranges from 41 to 70 thousand BD. This would require an average annual growth rate of 7.3 percent per year, respectively. Burma's production has increased at an average annual rate of 6.7 percent over the last ten years.

Based on current interest and activity, a production growth rate of 0.5 percent, or 28.8 thousand BD by 1985 is feasible. Demand during the last 10 years has been erratic, providing no basis for a projection. If it is assumed that consumption in 1985 may be as great as 27.3 thousand BD, Burma's export capacity would be nil in 1985. An equivalent of approximately 20 percent of Burma's proved reserves would be necessary to replicate each year over the next 8 years to support the very modest growth in production. The R/P of 6 to 1 is the lowest among the LDC.

Pakistan

- Exploration interest by foreign contractors is increasing. New concessions are being granted to U.S. firms. A total of 10 exploratory wells and 14 development wells have been drilled in the last three years. (See Figure IV-25).
- The number and quality of gas discoveries and fields (11) exceed the oil fields (7) found in Pakistan.
- Statistics (See Table II-10):
 - Pakistan has one of the highest per well production averages; 588 BD among the FE-LDC:
 - It has the lowest yield per SMPA, 2,410 barrels, among all LDC; and
 - The density of one well per 249 SMPA ranks as the lowest among the FE-LDC.
- Discussion of Sedimentary Basins:
 - Potwar Basin (No. 60, Figure A-18) is the most actively drilled area in Pakistan, also it has all the oil producing fields. The production of the five oil fields range from 490 to 4,500 BD; the total average is slightly less than 2,000 BD.
 - Indus Basin (No. 54) is principally a gas producing area; 10 gas fields have been discovered. The only well drilled offshore tested dry.

Summary:

Pakistan production of 3.8 million barrels, 10.1 thousand BD in 1977 is a recovery from a downward trend which reached a low of 2.2 million barrels in 1975. The estimated production by 1985 as shown in Table III-1, ranges from 41 to 50 thousand BD; an average annual growth rate of 19 to 22 percent, respectively. A lesser rate of increase through 1985 is more likely. A 15 percent average annual growth rate would result in 1985 production being 31 thousand BD. This would require a new reserve finding rate of only 8 million barrels per year over 8 years and a drawdown of the R/P from nearly 76 to 1 in 1977 to 25 to 1 in 1985. Pakistan demand will continue to exceed production by a substantial margin.

Figure IV-25

Source: American Association of
Petroleum Geologists
Bulletin, Vol. 62/10, Oct. 1978

Thailand

- Thailand's petroleum production at the end of 1977 was zero; it declined from a 1956 production rate of 57 thousand barrels, or 156 BD.
- There is interest in Thailand's prospects as shown by the number of offshore concessions in Figure IV-26.
- Statistics (See Table II-10):
 - Thailand's SMPA is one of the least densely drilled among the LDC; one well per 1,760 square miles.
 - It also has the lowest yield among all the LDC.
- Discussion of Sedimentary Basins:
 - The Mae Fany Basin (No. 61, Figure IV-18) is located in the north. This is the only Basin producing oil in Thailand. Two field discoveries were made in 1953 and 1963. The production from these fields peaked in 1971 at 95 thousand barrels, 250 BD, and have since declined to zero. There is no apparent interest in this Basin.
 - Gulf of Thailand (No. 62, Figure IV-18). As shown in Figure IV-26, this Basin has attracted interest and explorationists have been rewarded with six gas field discoveries. A feasibility study has been made regarding the transportation of natural gas to Bangkok.
 - Andaman Basin (No. 63, Figure IV-18). This Basin has had eleven dry tests.
- Summary:

Over 30 exploratory wells have been drilled in Thailand over the last three years, although only 3 were drilled in 1977. It is likely that Thailand will not be an important oil producer.

Figure IV-26

Source: American Association of
Petroleum Geologists
Bulletin, Vol. 62/10, Oct. 1978

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