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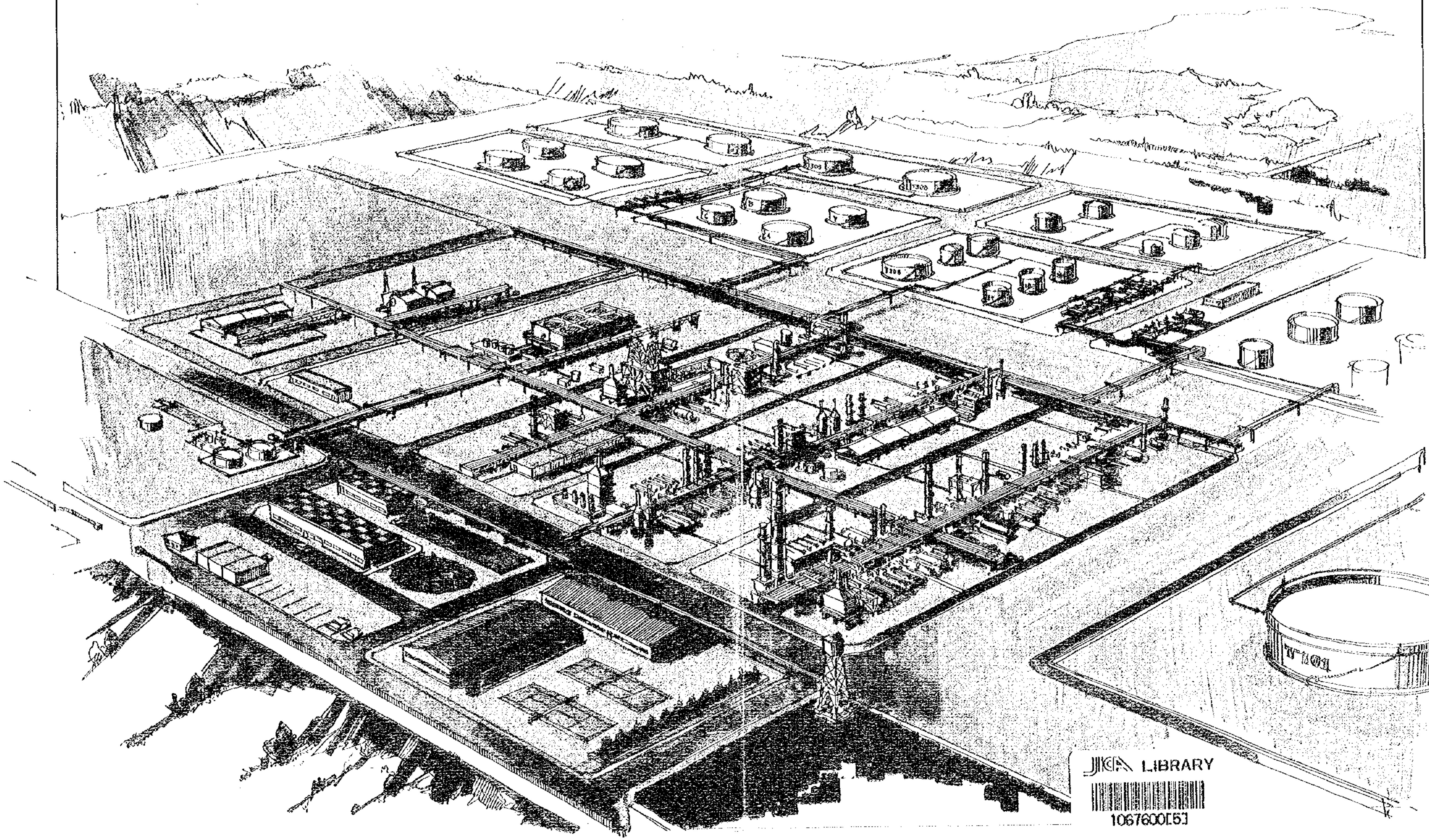
THE SOCIALIST REPUBLIC OF THE UNION OF BURMA

FEASIBILITY STUDY ON OIL REFINERY CONSTRUCTION PLAN

SEPTEMBER, 1976

JAPAN INTERNATIONAL COOPERATION AGENCY

CONCEPTIONAL VIEW OF THE MANN REFINERY



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PREFACE

The Government of Japan, at the request of the Government of the Socialist Republic of the Union of Burma, commissioned Japan International Cooperation Agency (JICA) to study feasibility of the plan to construct an oil refinery in Mann area, on the west bank of Irrawaddy River, Central Burma.

Subsequently, JICA organized a survey team consisting of eleven experts headed by Dr. Shigeo Ueki of Japan Consulting Institute and dispatched the team to Burma from February 14 to March 9, 1976.

The survey team held discussions with the Burmese government officials concerned on the plan, conducted a field survey of the proposed construction site, through which necessary data for the feasibility study were collected. In order to get reference data, the team also made visits to existing oil refineries and other plants in operation along the west bank of Irrawaddy River, with the cooperation of the Burmese government. Since its return to Japan, the survey team has carried on compiling the feasibility report.

In this report, the project of constructing a 25,000 BPSD oil refinery in Mann area, on the west bank of Irrawaddy River, Central Burma has been concluded feasible.

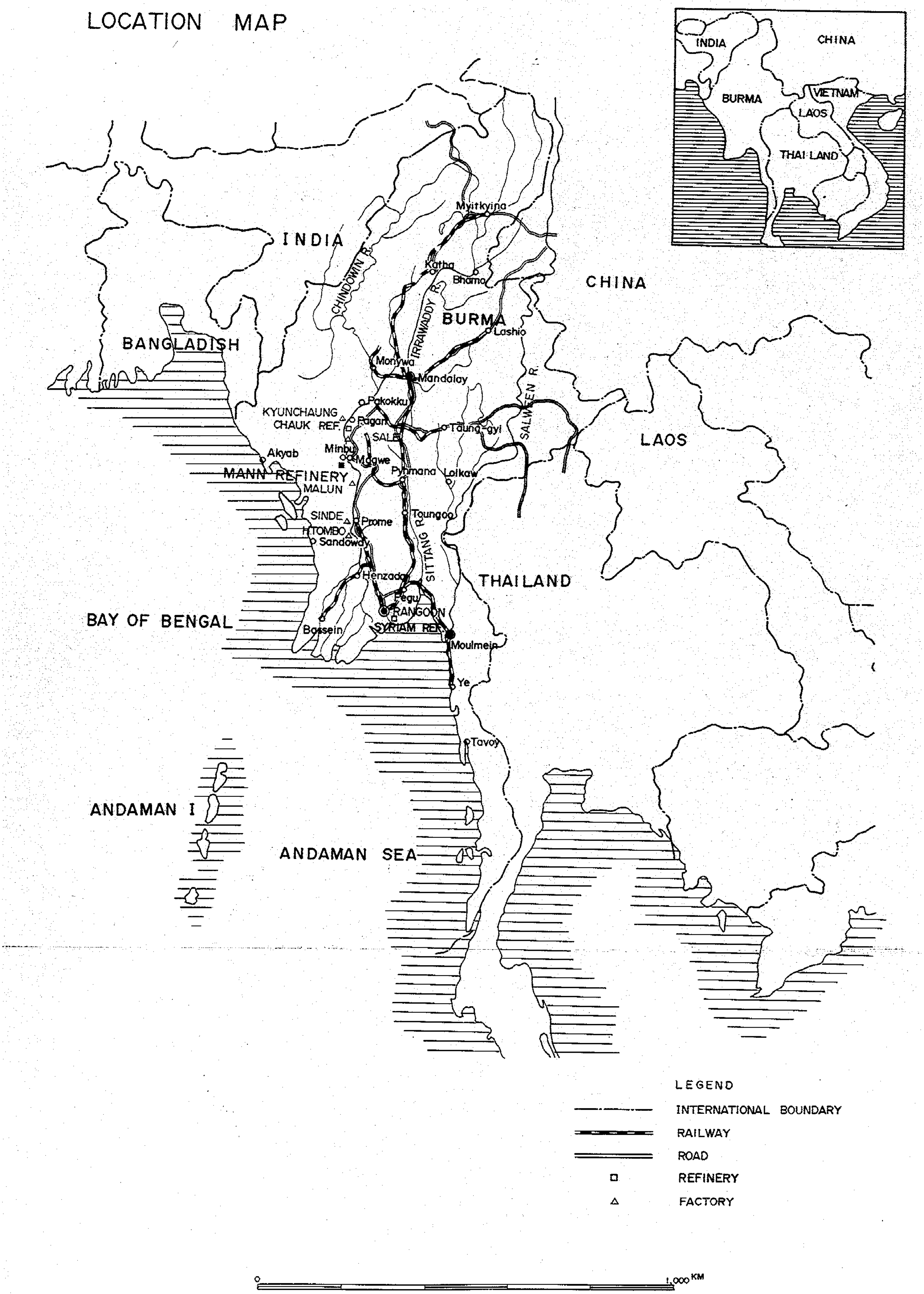
Nothing would be more gratifying to us, should this report prove helpful for the social and economic development of Burma and contribute to the promotion of friendship between Burma and Japan.

We avail ourselves of this opportunity to express our deepest gratitude to the Government of the Socialist Republic of the Union of Burma and to other authorities concerned, for their kind cooperation and assistance extended to the survey team, without which the survey work could not have been carried out so successfully.

September, 1976

Shinsaku Hogen
President
Japan International Cooperation Agency
Japan

LOCATION MAP



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INTRODUCTION

1.1 Background of Survey

1) Industrial Development and Increasing Demand for Petroleum Products in Burma

In Burma, two refineries are in operation - the Syriam Refinery and Chauk Refinery with crude oil processing capacities of 20,000 BPSD and 7,000 BPSD, respectively. While these plants are of relatively small scales, they are currently being operated at a considerably high operation rate.

However, for Burma which has a population of roughly 30 million, the operation of these two refineries alone will be insufficient for meeting the steadily increasing domestic demand for petroleum products. While plans have been drawn up in the past for construction of a new refinery, unfortunately none of these plans had been implemented.

But with the gradual development of her industries, mechanization of agriculture, improvement of the people's livelihood and larger population, the demand for petroleum products has grown to such an extent that the situation now requires constructing a new refinery as soon as possible.

While industrialization has not necessarily come about at a fast pace in Burma, the government is currently advancing ambitious plans for the nation's industrialization, and in the "1976 Law on Economic Plan Targets in Production and Services" that was promulgated in March, 1976, the targets for net growth rates of the country's two leading industries - manufacturing and agriculture, were placed at 10.6% and 5.1%, respectively, for the 1976/1977 period.

Right now, the governments is directing its efforts at developing the regions along the banks of Irrawaddy River. The main industrial plants lying on the east and west banks of the river are as follows:

West bank

Automobile assembly plant	Htonbo
Battery manufacturing plant	Sinde
Foundry	Sinde
Agricultural machinery manufacturing plant	Sinde
Tractor assembling plant	Malun
Urea fertilizer plant	Kyunchang
Cement plant	Kyangin
Cement plant	Tayetmyo

East bank

Oil refinery	Chauk
Urea fertilizer plant	Sale

Meanwhile, in the Rangoon district, there are a truck assembly plant, a shipyard, an oil refinery and others, and a sugar mill, thermal power generation plants and other plants are in other areas. Substantial development is being expected also in the development of mining.

Owing to the development of Burma's manufacturing, mining and agricultural industries in the manner described above, the demand for diesel oil has increased rapidly, as with the demand for kerosene for civilian purposes.

Crude oil production in Burma had long been continued along the banks of Irrawaddy River, but the output fell to nearly nil for a while with the outbreak of World War II. Production gained momentum with termination of the War, and after the nation gained independance, the output has been increasing at the hands of the Burmese people themselves.

What is notable about domestic crude oils in Burma is the fact that crudes contain only a small amount of sulfur and a large proportion of aromatic components in its light fraction. And stimulated by the increasing output of crude oil and the growing demands for petroleum products, it appears only natural that a plan of constructing a new oil refinery is contemplated as urgent matter.

2) Plan to Construct New Refinery

The Industrial Planning Corporation (current Technical Service Corporation) of Burma had conducted a field survey to sound out the feasibility of constructing a new oil refinery in Burma, and in January, 1975, compiled a report of "Feasibility Studies on the First Phase of Petrochemical Industry Complex Project."

This survey report actually involved two phases of feasibility studies - one in connection with the plan to construct a 25,000 BPSD oil refinery in the Mann area that is to use crude oil produced in the Mann Oil Field as raw material, and the other in connection with the plan to manufacture dimethyl terephthalate by utilizing naphtha produced by the new oil refinery.

3) Survey of Oil Refinery Construction Project by Japan International Cooperation Agency

Japan International Cooperation Agency dispatched a survey team to Burma during the period from February 14 to March 9, 1976, to conduct a feasibility study of the planned oil refinery construction program. After conducting various field surveys in Burma, the survey team returned to Japan, studied accumulated data and advanced other related work, then compiled this report.

1.2 Objective of The Survey

The objective of the survey was to investigate the feasibility of the project to construct a new refinery in Burma, and major items included in this study are as follows;

1) Study on the supply of crude oil.
   - Studies on reserve and production of crude oil.
   - Preparation of an oil production plan.
2) Demand forecast for petroleum products.
3) Study on the scale and plant configuration of the refinery.
4) Study on the facilities plan of the refinery.
5) Study on the plan for transportation of machinery, equipment and materials for construction of the refinery.
6) Study on the possibility of local fabrication of machinery and equipment.
7) Study on the subject of transportation of crude oil and products.
8) Study on the recruiting of technicians and workers.
9) Study on related infrastructures.
10) Preparation of refinery construction plan.
11) Estimation of required capital investment.
12) Financial evaluation of the project.
13) Economic evaluation of the project.

1.3 Members of The Survey Team

The survey team was comprised of the following members;

		Post at Time of Survey
Leader	Dr. Shigeo Ueki	Manager, Technical Department, Japan Consulting Institute (JCI)
Adviser	Dr. Akira Matsuzawa	Director, Japan Petroleum Development Corporation

Member	Akira Nagumo	Consultant, JCI
"	Etsuo Nakamura	Consultant, JCI
"	Sumiyuki Yoshii	Technical Advisor, Survey and Development Department, Overseas Economic Cooperation Fund
"	Yasuo Kobayashi	Production Section Chief, Technical Department, Japan Petroleum Development Corporation
"	Shunji Akaiwa	Consultant, JCI
"	Takanori Ogino	Consultant, JCI
"	Jun Okuyama	No. 1 Business Section Chief, No. 2 Business Department, Overseas Economic Cooperation Fund
"	Masakazu Yamada	Consultant, JCI
"	Toshio Hida	Industrial Survey Section member, Mining & Manufacturing Planning & Survey Department, Japan International Cooperation Agency

.4 Field Survey

The Survey team members exerted their utmost efforts to accumulate data necessary for the feasibility study through close discussion with the Burmese side during their stay in Burma.

After their inspection of port and harbor facilities, shipyard, and to numerous industrial plants along the banks of Irrawaddy River, they studies how to take industrial water from Irrawaddy River and install the appropriate facilities for unloading plant machinery and equipment and for shipping the petroleum products over the river.

Furthermore, they also studied the possibility of utilizing existing local plant facilities for the local manufacture and maintenance of machinery and equipment of the planned oil refinery.

The details of the itinerary of the survey team are as follows:

Survey Schedule

Date	Day	Description
2.14	Sat	Departed from Tokyo, arrived at Bangkok.
2.15	Sun	Departed from Bangkok, arrived at Rangoon.
2.16	Mon	Held deliberations at Japanese Embassy in Rangoon, also held deliberations with the Ministry of No. 2 Industry and Technical Services Corporation at TSC office.
2.17	Tue	Dr. Matsuzawa and Mr. Kobayashi: Called on Myanma Oil Corporation (MOC) for deliberations. Others: Had discussion at TSC.
2.18	Wed	Courtesy call to Minister for No. 2 Industry and Minister for Mines. Dr. Matsuzawa and Mr. Kobayashi: Held deliberations at MOC. Others: Had discussion at TSC.
2.19	Thu	Dr. Matsuzawa and Mr. Kobayashi: Held deliberations at MOC. Messrs. Akaiwa, Nagumo and Nakamura: Surveyed Rangoon port facilities. Others: Had discussion at TSC.
2.20	Fri	Dr. Matsuzawa and Mr. Kobayashi: Held deliberations at MOC. Messrs. Akaiwa, Nagumo and Nakamura: Surveyed Rangoon port facilities. Others: Had discussion at TSC.
2.21	Sat	Dr. Matsuzawa and Mr. Kobayashi: Held deliberations at MOC.

		Messrs. Akaiwa, Nagumo, Nakamura and Hida: Left Rangoon and arrived at Htonbo, surveyed automobile assembly plant.
		Others: Had discussion at TSC.
2.22	Sun	Messrs. Akaiwa, Nagumo, Nakamura and Hida: Went to Sinde to survey wattmeter plant.
		Others: Had discussion among member.
2.23	Mon	Dr. Matsuzawa and Mr. Kobayashi: Held discussion at MOC.
		Messrs. Akaiwa, Nagumo, Nakamura and Hida: Surveyed transportation facilities of Taungdwingyi Station, surveyed crude oil pipeline terminal at Malun.
		Others: Had discussion at TSC.
2.24	Tue	Messrs. Akaiwa, Nagumo, Nakamura and Hida: Surveyed tractor plant.
		Others: Discussed on reserves and supply situation of crude oil among the members.
		Dr. Matsuzawa and Mr. Kobayashi: Held deliberations at MOC (afternoon).
		Others: Had discussion at TSC (afternoon).
2.25	Wed	Messers. Akaiwa, Nagumo, Nakamura and Hida: Departed from Malun, arrived at Mann.
		Others: Departed from Rangoon, arrived at Mann.
		All members: Surveyed Mann oil field and candidate plant site, surveyed candidate sites for water intake and jetty.
2.26	Thu	Dr. Matsuzawa and Mr. Kobayashi: Departed from Mann after surveying Mann oil field, arrived at Rangoon.
		Others: Surveyed aforementioned tractor plant at Malun. Departed from Malun, arrived at Chauk.

2.27	Fri	Dr. Matsuzawa and Mr. Kobayashi: Held deliberations at Japanese Embassy. Others: Surveyed Chauk Refinery, surveyed fertilizer plant at Kyunchang, arrived at Pagan.
2.28	Sat	Dr. Matsuzawa and Kobayashi: Held deliberations at MOC. Others: Departed from Pagan, arrived at Rangoon.
3.1	Mon	Dr. Matsuzawa and Mr. Kobayashi: Departed from Rangoon. Others: Conducted survey of Syriam Refinery, surveyed Danidaw Depot.
3.2	Tue	Worked on preparation of interim report.
3.3	Wed	Held meeting at Japanese Embassy, had discussion at TSC, and worked on preparation of interim report.
3.4	Thu	Had discussion at TSC and worked on preparation of interim report.
3.5	Fri	Worked on preparation of interim report and held meeting at TSC.
3.6	Sat	Reported the results of survey to the Minister for No. 2 Industry and Minister for Mines, then submitted interim report.
3.7	Sun	Had discussion on work to be done after returning to Japan.
3.8	Mon	Departed from Rangoon, arrived at Bangkok.
3.9	Tue	Departed from Bangkok, arrived at Tokyo.

1.5 Acknowledgements

We avail ourselves of this opportunity to express our sincere gratitude for the tremendous cooperation, convenience and most helpful suggestions offered to the survey team during their stay in Burma, particularly to His Excellency Colonel Maung Cho, the Minister of the Ministry of No. 2 Industry. His Excellency U Maung Maung Kha, the Minister of the Ministry of Mines, His Excellency U Myo Myint, the Deputy Minister of the Ministry of Planning & Finance, Ministry of Foreign Affairs and also the following governmental organs:

Technical Services Corporation
Myanma Oil Corporation
Petrochemical Industries Corporation
Petroleum Products Supply Corporation
Heavy Industries Corporation
Electric Power Corporation

We should also like to make special mention for the efforts of Technical Service Corporation, which compiled the report "Feasibility Studies on the First Phase of Petrochemical Industry Complex Project," as described earlier, and which had advanced detailed studies on this project in the process of preparation of the report, without which the surveys conducted by the survey team, extending over a wide scope of area and items, could not have been accomplished so efficiently and smoothly.

Chapter 1.

SUMMARY AND CONCLUSION

Chapter 1

SUMMARY AND CONCLUSION

The conclusion of the report endorses the feasibility of the plan to construct an oil refinery having crude processing capacity of 25,000 BPSD in Mann area on the west bank of Irrawaddy River, Central Burma.

The summary of the survey is as follows:

1) The crude oil to be processed by the planned refinery will primarily consist of domestic crude oil supplied from oil fields nearby, mainly the Mann oil field, the reserve of which accounts for roughly 70% of total reserve of the country and that will be ample enough for sustaining the planned refinery's operation.
2) After various case studies of development of whole oil fields in the country, it is recommended to increase the oil drilling capacity by installing three new rigs by 1978 for producing necessary volume for the refineries.
3) The larger proportion of demand for petroleum products lies in Central and Upper Burma, with the remaining demand sustained by Lower Burma. Progress of development of Central Burma by the Government would lead to rapid increase of demand for petroleum products in the area in the future.

   The rate of increase of the demand for petroleum products in Burma is considered to be 3.5% annually.

4) Taking both oil production center and petroleum products consuming areas into consideration, the Mann area is recommendable for constructing the planned refinery. There exists the place considered to be suitable for the construction site about 8 km south from the town of Minbu.

5) A processing capacity of 25,000 BPSD appears most suitable for the refinery when observed comprehensively from the aspects such as limitation of crude oil supply, market demand and availability of capital.

6) Based on studies of diverse factors including the properties of stock oil, the decided capacity of each process unit is as follows:

Unit	Capacity (BPSD)
Topping Unit	25,000
Stabilizer	5,400
Splitter	5,200
Naphtha HDS Unit	5,000
Reforming Unit	2,800
SPI Unit	3,000
Coking Unit	5,000
LPG Recovery Unit	900
Naphtha Merox	700

7) The determined capacities of utility facilities are as follows in conformity with the process units described above:

Facility	Capacity
Water intake and treating facility	12,500 m^3/D
Cooling water facility	7,000 t/H
Boiler	60 t/H x 2
Power receiving and distribution facility	14,000 KVA
N_2 generation facility	300 Nm^3/H
Compressed Air system	1,500 Nm^3/H x 2
Home fuel system	144 x 10^6 Kcal/H

8) The followings are included as the off-site facilities: waste water disposal system, flare system, tankage, filling facilities, product shipping facilities, jettys, fire fighting facilities, telecommunications facilities, pipeline system and others.

9) The followings are included as auxiliary facilities: internal transportation facilities, laboratory equipment, maintenance equipment and tools, protective appliances, first-aid appliances and others.

10) A construction period of about 42 months will be required after conclusion of the contract between the Burmese Authority and the plant supplier, (hereinafter called "the contract") For example, should the contract be concluded in July, 1977, commencement of plant operation would be in January, 1981.

11) The total capital requirement estimated is as follows:

	Foreign Currency (¥1,000)	Local Currency (K1,000)
Total construction cost	29,460,500	157,854
Commissioning cost	266,500	8,369
Pre-operation cost		2,200
Training cost	194,000	
Operation guidance cost	29,000	
Sub-total	29,950,000	168,423
Working capital		26,400
Total capital	29,950,000	194,823

Note: Interest incurred during period of construction not included in the table.

12) When calculated on the basis of both crude oil price (k 0.83/I.G. = U.S. $4.4/Bbl) and the domestic selling price of petroleum products as of March 1976, the planned refinery shows financial loss. However, where Petrochemical Industry Corporation is concerned which operates three oil refineries, the internal rate of return of the Mann refinery project will be 2.2%.

13) In order to maintain the internal rate of return of 5% and 10%, it is calculated that the domestic selling price of petroleum products shall be raised roughly 20% and 65% respectively.

14) From an economic standpoint (evaluation of the value of goods manufactured against the value of natural resources consumed), the internal rate of return of the project, unlike that of the financial evaluation, is

sufficiently high with the result that the project is expected to provide great benefits to Burma.

15) To secure smooth implementation of construction works and start-up of the refinery, it is necessary for the Burmese side to carry out the following ancillary jobs:

a) Securing exclusive vessels for transporting construction materials over the Irrawaddy River.

b) Completion of the greater part of site surveys before conclusion of "the contract."

c) Completion of an access road before commencement of civil engineering works.

d) Completion of power transmission works by March, 1980 for the start-up operations.

e) Advancement of studies on provision of land transportation facilities for the products.

Chapter 2.

CRUDE OIL PRODUCTION AND RESERVES

Chapter 2

CRUDE OIL PRODUCTION AND RESERVES

2.1 Summary

The Burmese Tertiary geosyncline covers an area of approximately 83,000 square miles and the results of past exploration projects indicate that these strata should be considered as areas of high potential when contemplating future exploration.
However, it is foreseen that most of the oil fields yet to be discovered in this area would contain in the order of tens of millions of barrels; whereas previously discovered fields, for example, Yenaungyaung, Chauk and Mann, have proved to contain recoverable reserves in excess of one hundred million barrels.

At the end of 1975 it was estimated that the balance of proved onshore recoverable reserves in Burma totaled 217 million barrels in six fields. However, if approximately 135 exploratory wells were to be drilled in the 10 years from 1976 to 1985 then we consider that there is a strong possibility of the discovery of another 200 million barrels in recoverable reserves. Assuming this to be so, we consider that optimum development of the fields would result in a maximum attainable production capacity in the region of 60,000 b/d.

After due consideration of the size and economic background of the Myanma Oil Corporation, however, a more realistic figure for production capacity would be 40,000 b/d in 1985, estimated as shown in Fig. 2.7 and Table 2.12.
In order to achieve the above production estimate it would be necessary to improve the present exploration and development

facilities, by improving the quality and increasing the number of exploratory seismic surveys and by the introduction of modern drilling units.

To this end, we propose the introduction of 3 units in 1978, 2 units in 1988 and 2 units in 1995.

2.2 Geographical distribution of oil and gas and oil producing areas in Burma.

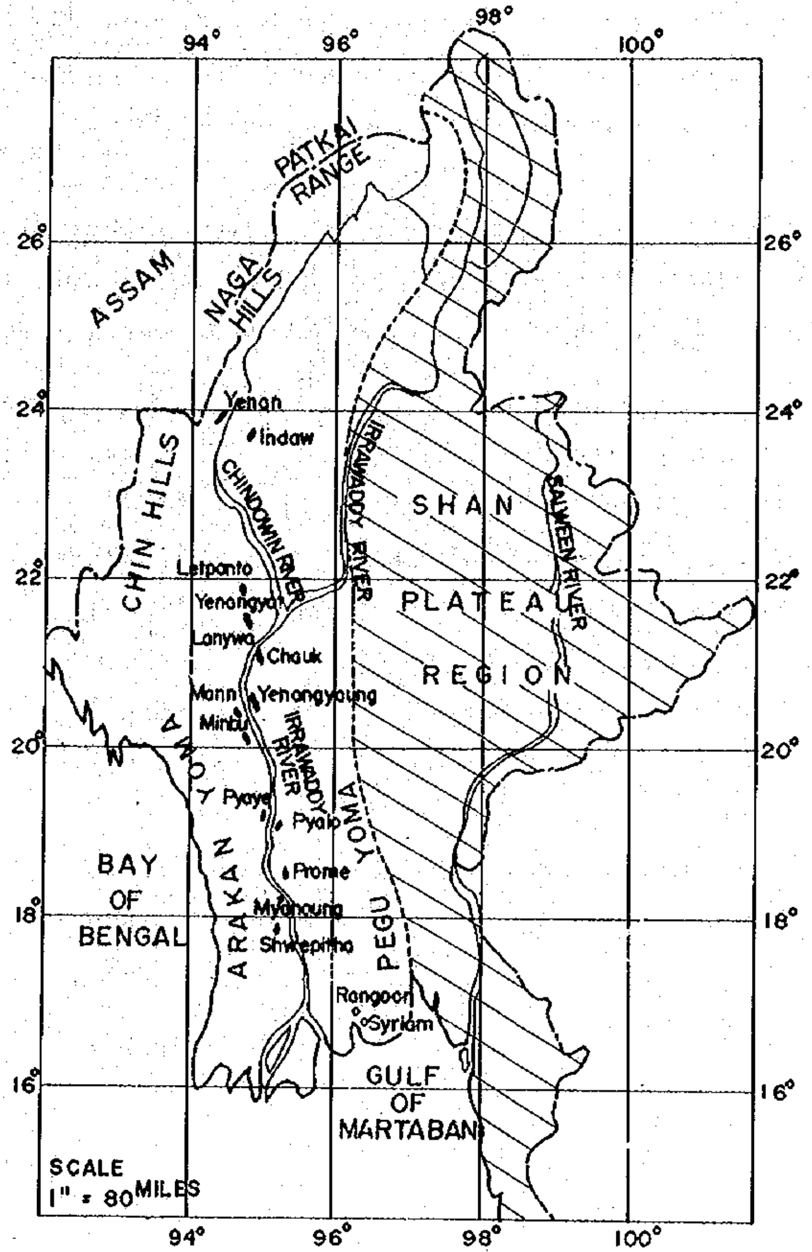
2.2.1 Tertiary sedimentary basin (Fig. 2-1).

Most of the onshore Burmese oil producing areas lie in the long and narrow Tertiary sedimentary basin, which extends from north to south in central Burma and comprises an area of about 80,000 square miles.

The eastern side of this basin is, bounded by the Shan Shelf, and the area known as the "Shan Plateau Region" extends to the east of the basin from the Sittang river in the south and the Irrawaddy river north of Mandalay. The Tertiary sedimentary basin was developed to the west of the "Shan Plateau Region".

The Arakan mountains lie to the west of tertiary sedimentary basin. It is believed that these mountains started to develop at the onset of the Tertiary period and continued their upheaval during this period under the influence of the Himalayan orogenic movement, as the zones separated from Assam run crookedly southward.

FIG. 2-1 TERTIARY SEDIMENTARY BASIN SHOWING DISTRIBUTION OF OIL FIELDS IN BURMA



All the known oil fields in Burma lie in the Tertiary geosyncline, which is bounded on the east and west by the Shan Plateau and the Arakan mountains respectively; although remarkable oil showings exist to the west of the Arakan mountains mainly on Ramree Island, but also in other places near the coast of the Bay of Bengal. However, since the geological beds west of the Arakans are folded in a complicated manner, no large scale oil fields have been found so far. Some small scale oil fields have been exploited in this area, the oil being obtained from hand dug wells.

2.2.2 Division of the sedimentary basin and distribution of oil and gas fields. The tertiary geosyncline in Burma is divisible into the following 11 parts by geological structure as shown in Fig. 2-2, A-K.

A.	Hukawng basin	5,345 sq. miles
B.	Upper Chindwin basin	17,715
C.	Monywa Shwebo alluvial area	9,525
D.	Central basin	11,264
E.	Thayetmyo syntaxis	2,150
F.	Lower Irrawaddy basin	15,636
G.	Northern Pegu Yoma	5,632
H.	Southern Pegu Yoma	6,800
I.	Pegu alluvial area	2,285
J.	Sittang depression	3,890
K.	Arakan coastal area	4,915
	Total	85,157

FIG. 2-2 DIVISION OF TERTIARY SEDIMENTARY BASINS IN BURMA

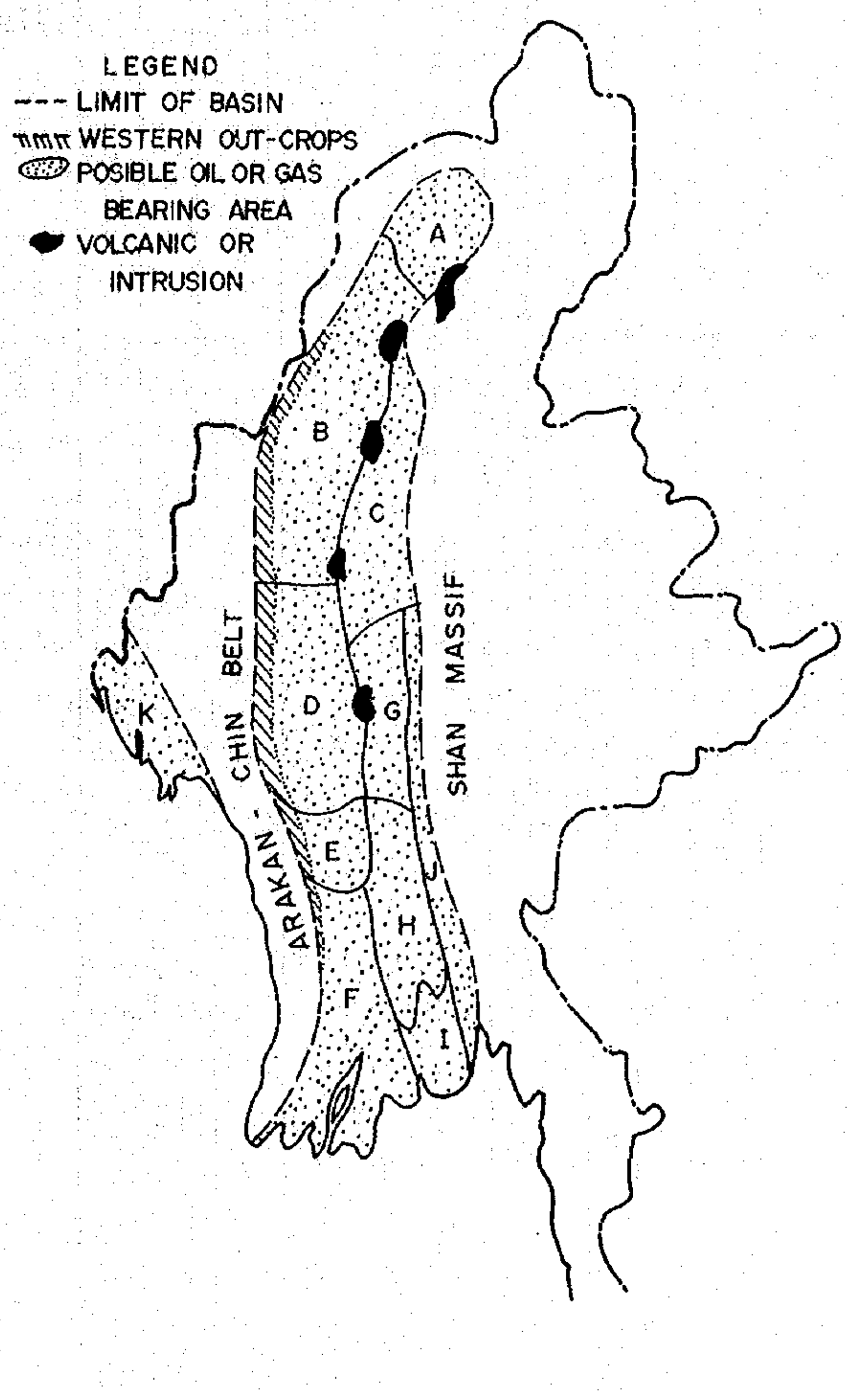


TABLE 2.1 TERTIARY STRATIGRAPHY IN BURMA

GIOI'GIC AGE		Stratigraphical subdivision	CENTRAL BURMA BASIN			UPPER CHINDWIN - HUKAWANG		
			Formation	Thickness	Lithology	Formation	Thickness	Lithology
		Calabian						
TERTIARY	PLIOCENE	Astian	Irrawaddy	9000' ~ 10000'	l.m - c gritty sst peb or band of fossils	Mingin	5000'	coarse gravity sst w clay band (fresh water)
		Platisancian						
		Pontian						
	MIOCENE	Sarmatian	Obogon	3500'	alt.bl.g. clay/m-f sst brackish Continental	Shwethamin	8400'	arenaceous lt color med-coarse sst w quartz peb Same as Shauknan sst of Shwebo Hill
		Vindobonian						
		Burdigalian	Kyaukkok	4100'	ye. bw - g f - m sst/gth clay			
		Aquitanian	Pyawbwe	4380'	bl. g. clay sst	Natma	4250'	argillaceous altemation
	OLIGOCENE	Chattian	Okhmintaung	6460'	sand Lepidocyclina	Letket	8000'	sdy formation lt color grained
		Rupelian	Padaung	4000'	bk. bl. g marine. sh.			
		Lattorfian	Shwezetau	3500'	g. hd. f sst wg. bw sdy sh Nummulites			
	EOCENE	Ludian	Yaw	3000'	many variations cge bed. bw. bl. g. sh lignite fi grained sst	Yaw	4000'	bw-bl.g.sh thinner in the north; Quartz cgl
		Bartonian	Pondaung	7500' ~ 9000'	lt. bw. hd mass m - f sst	Pondaung	6900'	upper part non marine lt.bw.hd. mass m-f sst peb - cgl band thick in the north
		Auversian						
		Lutetian	Tabyin	10600'	mudstone Shale to the north cgl Ngapet	Tabyin Tilin Laungshe	13000' ~ 15000'	dk.g.sh f. grained sst grits cgl sdy development abundant fossils clay
		Ypresian	Tilin	9800'				
	PALAEOCENE	Sparnacian	Laungshe / Paunggy	10000' ~ 15000'				
		Montian						
		Meastrichtian		thin	Shale subordinate sand stone band			Shale

2.2.2.1 Hukawng-Upper Chindwin (A, B)

The Hukawng basin is located in the northern most part of the tertiary sedimentary basin, but in this area the Tertiary formation is unknown, since only a general reconnaissance has been made, and this area is not regarded as an important area for exploration in the near future owing to communication and transport difficulties. The Chindwin sedimentary basin has received more attention than other areas and stratigraphic subdivision is possible as far north as latitude 25 degrees north. In this area Oligocene formations are almost non-existent and oil showings lie in formations ranging from upper Eocene to upper Miocene. In the northern part of this basin oil showings lie in the lower formations and are known only in the Eocene north of latitude 23 degrees north.

In this area the following three areas are considered to have exploration potential.

1) Eastern zone: The areas be considered in this zone are the Mahadaung, Himyaung, Paiuswa and Shwebo Hill structures which are thrust faulted in the eastern wing of the anticline. The Eocene is considered to hold the greatest exploration potential in this zone.
2) Central zone: The Indaw and Uyu anticline structures lie within this zone. In the Indaw anticline oil and gas showings are present in the Indaw sandstone. In the Uyu anticline a sedimentary formation with a thickness of more than 25,000 ft exists but an accurate assessment of the age of these formations cannot be made due to the absence of fossil evidence.
3) Western zone: This area contains the Yetho-Yenan - Poyataung and Puttha anticlines. The oil-bearing sands in this zone lie in the middle and lower Eocene formations. In this area the Yenan anticline is considered to hold the greatest potential.

2.2.2.2 Central basin (D)

This sedimentary basin is considered to have the highest oil and gas potential in Burma and contains many large known oil fields. It is also the most thoroughly geologically and geophsically surveyed area in Burma. The basin contains a very thick sedimentary formation ranging from Eocene to Pliocene.

1) The Eocene formation consists of very thick mudstone interspersed with several thousands of feet of sandstones. There are many oil showings in this sandstone, particularly in the upper Eocene (Pondaung formation). Unfortunately, commercially exploitable oil reservoirs are not formed, because of the low permeability and porosity of the reservoir rock in this formation.

   However, should future exploration reveal reservoir rock of higher quality, it is possible that oil fields may be found formed in stratigraphic and fault traps.

2) The main oil producing formations of the Yenangyat, Chauk, Yenangyaung, Minbu, Mann etc. oil fields are in the Oligocene and Miocene formations. The Shwezetaw formation in the lowest part of the Oligocene is continental sediment which is potential reservoir rock over the whole area.

   In the Padaung formation mudstone is generally dominant, but the ratio of sandstone to mudstone increases to the north and east where, characteristic reservoir and source rock types exist.

   In the Okmintaung, Pyawbwe, and Kyaukkok formations, the Tertiary formation is clearly exposed along western outcrops where in general the oil reservoir potential is greater in the south than in the north. However, the potential of both of these areas would be increased if appropriate stratigraphic and structural traps were to be found. Notably, in Yenanma there is a high possibility of oil field formation in stratigraphic traps.

2.2.2.3 Thayetmyo (E)

Many oil and gas showings can be found in formations ranging from Miocene to Oligocene and there are several small oil fields such as Yenanma, Padaukpin, Sakhangyi, Pyaye etc. This area has a complicated structural form containing many faults and, in consequence, is not conducive to oil accumulation, however, the deeper parts may have some potential. The source rock here was formed in the Tabyin, Tiyo and Pyawbwe formations in the Eocene and Miocene periods and there are also some Eocene and Miocene cap rock formations. However, apart from this case few good reservoir rocks were formed in the Eocene period, but Miocene sandstone formations are good as reservoir rock. There are many structures in this area and those having exploration potential are Natmi, Lime Hill, Padankpin, Myeyataung, Yinaing, Pyaye, Pyalo, Sawgetaung, Peukaung etc.

2.2.2.4 Lower Irrawaddy Basin (F)

Two oil fields, Myanaung and Prome, and a gas field, Shwepitha were discovered in a geological unit known as the "Prome Embayment" at the northern end of this area. In the western line of the sedimentary basin the Myangnaung-Kogwe - Leymyethna-Daunggy-Myangmya anticline has many possibilities for stratigraphic and fault traps. Many wildcat wells were drilled in the southern delta area and gas was discovered in Payagon, but not in commercial quantities. There is still room for exploration in Taikkyi, Tantabin, Hlegu, Twante and Naisingon on the eastern edge of the sedimentary basin.

2.2.2.5 Other areas (C, G, H, I, J and K)

Other areas are considered as having less potential, compared with the above areas, but gas showings are known in Yebgonat (Latitude 22° 28' North, Longitude 95° 91' East) in the Shwebo - Monywa area.

The Pegu Yoma area has generally complicated structures in the north, but showings of oil and gas are known in the wildcat wells of Kyatti, Kabat and Lebya etc. In these areas there are defects and the source rocks are not good, but since the proportion of marine sediments increases with depth, there is a possibility of source rock in the deeper strata.

Oil recovery has been undertaken by the natives for a long time in Ramree Island and Bolonga Island in the Arakan area, facing the Bay of Bengal. The oil producing formations here are mainly the lower Miocene and oil fields which have been exploited using hand dug wells are Yenandaung, Leikkamaw, Maragyan, Ondaw, Kyaukprank and Sinbok. In this area the structures are so complicated that there is little chance of finding oil fields with commercial volume in the future.

2.2.3 The scale and character of oil fields

In Burma 14 oil fields, each containing more than one million barrels and three gas fields have already been discovered. This makes a total of 17 oil and gas fields in all and data from these are shown in Table 2-2. Of these, four oil fields and one gas field have more than 100 million barrels of recoverable reserves and these lie in the central basin (D).

TABLE 2.2 OIL AND GAS FIELDS IN BURMA

Basin	Name of field	Year of discovery	Oil or gas field	Company*	Present status	Size *
B	Indaw	1918	Oil	IBP	Suspended	S
	Yenan	1938	Oil	BOC	Suspended	S
B	Yenangyaung	1800	Oil	Twinzayos	Under production	L
	Yenangyat/Sabe	1890	Oil	BOC	Upper production	M
	Lanywa	1893	Oil	BOC	Under production	L
	Chauk	1902	Oil	BOC	Under production	
	Minbu	1910	Oil	BBP	Suspended	S
	Mann	1969	Oil	MOC	Under development	L
	Chauk-Subthrust	1960	Gas	BOC(1954)	Under production	L
	Yenangyat-Subthrust	1962	Gas	BOC(1954)	Under production	M
	Letpanto	1973	Oil	MOC	Under development	L
E	Yenanma	1920	Oil	BOC	Suspended	S
	Pyaye	1924	Gas	IBP	Suspended	S
	Pyalo	1975	Oil	MOC	Under exploration	?
F	Myanaung	1964	Oil	POI	Under production	M
	Prome	1965	Oil	POI	Under production	M
	Kogwe	1967	Gas	POI	Not developed	M

* BOC = Burmah Oil Co. IBP = Indo-Burma Petroleum Co.
BBP = British-Burma Petroleum Co. POI = People's Oil Industry
MOC = Myanma Oil Corporation

* Size L = Above 100×10^6 BL (Gas fields are rated as volume equivalent)
M = Above 10×10^6 BL
S = Above 1×10^6 BL

The characteristic points of five representative Burmese oil fields, Yenangyaung, Chauk, Myanaung, Prome and Mann are shown in Table 2-3. These figures will become the basic data for later estimates of future oil production.

Three of these fields, Yanangyaung, Chauk and Mann lie in the central basin and have exploited an area of good initial oil showings. As can be seen from the figures for the thickness of the reservoir and barrels/acre-foot in Table 2-3, the central basin has a much better geological environment for oil field formation than the Lower Irrawaddy Basin.

The Yenangyaung oil field with its shallow reservoir is one of the oldest fields in the world. Since more than 4,000 production wells have been drilled in this field up to the present time, the average ultimate production quantity per well is expected to be only 55,000 barrels.

TABLE 2-3 DATA FROM EXISTING OIL FIELDS

Name of Field	Yenangyaung	Chauk/Lanywa	Myanaung	Prome	Mann
Year of Discovery	1887	1902	1964	1965	1970
Extent of Field	2,600	2,560	1,500	1,300	3,000
Reservoir Thickness	960	650	250	180	655
Producing Strata (Formation)	KK-PY-OK-PA	OK-PA	OB-KK-PY	PY-OK	KK-PY-OK-PA
Depth of reservoir (Ft)	0–3,500	1,200–4,500	2,200–4,500	1,800–5,500	2,000–8,000
Original Deposit (MMBL)	544	369	64	40	390
Oil-rock Ratio of Original Deposit (Volume) (BL/Acre-Ft)	218	221	170	171	198
Recoverable Percentage (%)	42	38	47	43	49*
Recoverable Quantity (MMBL)	228	140	30	17	190
Oil-rock Ratio of Recoverable Deposit (Volume) (BL/Acre-Ft)	91	84	80	77	97
Number of Producing Wells (well)	4,100	1,200	150	50	388
Average Total Production/Well (BL/Well)	55,610	116,667	200,000	340,000	488,866
Average Well Spacing (Ft)	50–100	100–150	200–300	300–400	400–500

Latterly, since production facilities and technology have advanced tremendously with the passing of time, average production per well is reckoned to be 120,000 barrels in Chauk and 200,000 barrels in Myanaung, in addition to this it has been possible to increase well spacing. In the Mann field, well spacing of 400-500 ft is scheduled for future development, giving a planned yield of 490,000 barrels per well inclusive of secondary recovery. Oil fields in production at present are shown in Table 2-4 and their balance of recoverable reserves is estimated at 217 million barrels.

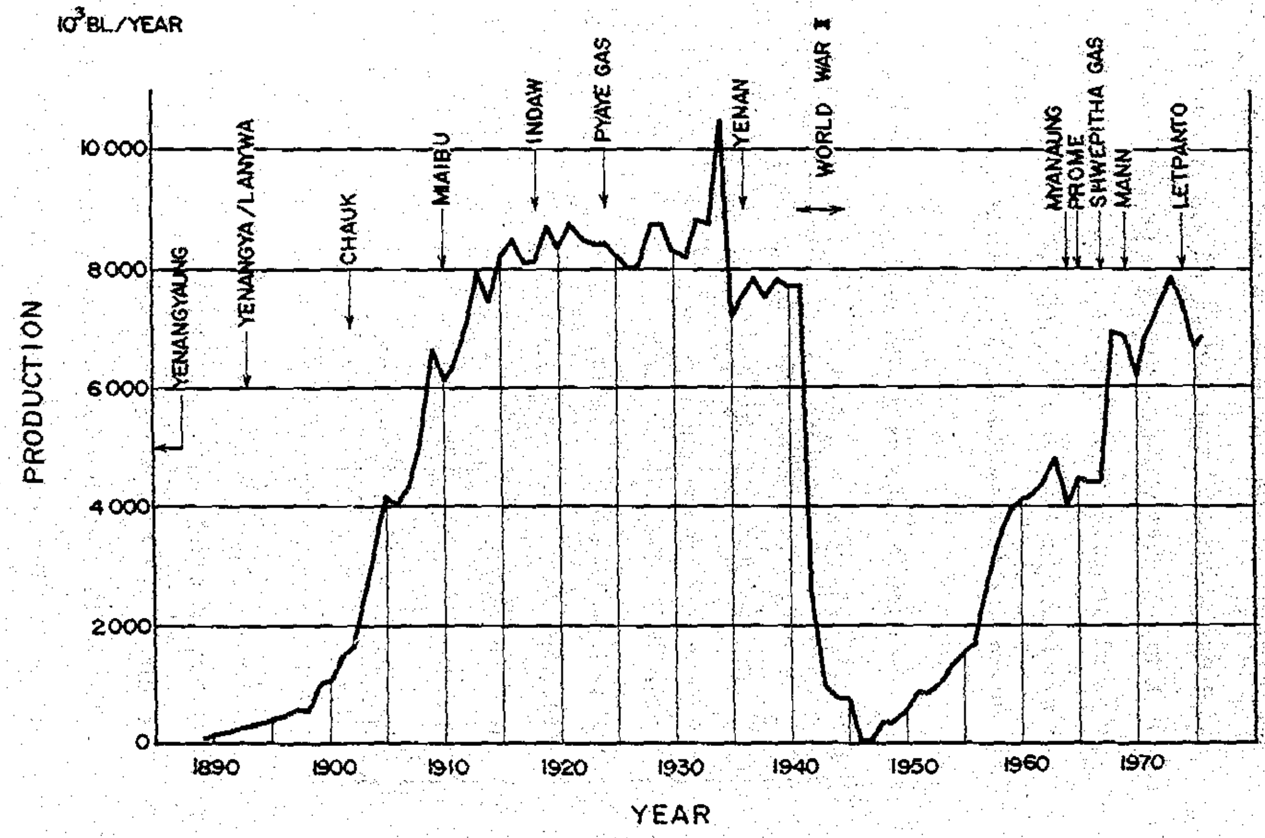
TABLE 2-4 PRODUCING OIL FIELDS

Name of field	Recoverable reserves MMBL	Cumulative production MMBL	Balance of recoverable reserves MMBL
YENANGYAUNG	227	199	28
CHAUK/LANYWA	140	134	6
YENANGYAT	9	8	1
MYANAUNG	30	17	13
PROME	17	5	12
MANN	190	15	175
TOTAL	613	378	235

2.2.4 History of crude oil production

The origin of crude oil production in Burma is not clear, but it is known that at the end of 18th century small scale oil production was performed in Yenangyaung oil field. However, the statistics of production were not recorded before Burma was colonized by the United Kingdom after the Burmese defeat in the Anglo-Burmese War in 1885, and North Burma which contains the Yenangyaung field was taken over by the British in 1886.

FIG. 2-3 HISTORY OF CRUDE OIL PRODUCTION IN BURMA



In this year the first oil company, Burmah Oil Co. (BOC) was established by British capital. In 1888 the first oil well was successfully drilled and production began in the Yenangyaung field. After that BOC discovered the Yenangyat and Lanywa oil fields in 1893 and the Singu oil field (presently Chauk) in 1902, in a period of rapid oil development.

In the course of the rapid development of Burmese oil fields, many oil companies were established and participated in oil operations but most of them were unable to compete with the capital power of the large oil companies and disappeared.

During that time, in 1909, the Indo-Burmah Petroleum Co. (IBP) was established and constructed a refinery in Syriam. In 1918 IBP discovered the Indaw oil field and embarked on its development and in 1924 discovered the Pyaye gas field. In 1937 crude oil production Burma rose to about 8 million barrels per year and 6 million barrels out of this 8 million (75%) was exported to foreign countries. However, in 1939 World War II broke out and in 1942 the British Army entirely destroyed 4,000 oil wells, the facilities attached to the fields, refinery installations, electric power generators, pipelines and pumping stations, when they withdrew from Burma before the Japanese invasion.

During the period from the entry of the Japanese army from 1942 to 1944 a little restoration of the above facilities was undertaken and a little oil production was performed under the control of the Japanese army until the end of World War II in 1945. In 1946 oil production showed the lowest figure of 15,000 barrels in Burma's oil history, but in 1947 the British oil companies came back to Burma and started to restore the oil fields.

However, because of the insurrection accompanying the illegalization of communists which occurred after the independence of Burma in 1948, restoration of oil fields undertaken by oil companies advanced slowly. Therefore, annual oil production amounted to only one million barrels in 1953 and Burma had to import oil to supplement its domestic supply. In 1954 the Burma Oil Co., Ltd. was resurrected and the Burmese government participated in Burma Oil by acquiring one third of its shares, based on a contract concluded between the Government and BOC, BBP (British-Burma Petroleum Co.) & IBP. BOC (1954) gave priority to the restoration of Chauk field and in 1959 an annual oil production of 3.9 million barrels was obtained from Chauk field and the restoration of Yenanyaung oil field was begun in 1960. In 1961 the Government increased its share of BOC (1954) and raised its equity from 33.3% to 51%.

In 1962 the Government proclaimed "The Burma Petroleum Concession Rules" and in 1963 succeeded in the nationalization of oil fields by acquiring all the shares of BOC (1954).
By that time the British monopoly of the oil industry came to an end. And in 1964, BOC (1954) changed its name to People's Oil Industry (POI). After this, oil exploration continued actively, aided by technological cooperation from Japan and many oil fields were found, such as, Myanaung (1964), Prome (1965) and Kogwe Gas Field (1967). Later on Mann and Letpanto Oil Fields were discovered by the national oil industry in 1969 and 1974 respectively.
As a result, annual oil production in 1974 rose to 7.6 million barrels which was the peak during the post war period.

The total amount of annual oil production in 1975 was down by 22% from 1974 (from 7.6 million barrels in 1974 to 6.7 million barrels in 1976). The biggest production drop occurred in the Mann field with a fall of 32%, from 12,114 b/d in December 1974 to 8,200 b/d in December 1975. The field operated below capacity because of difficulties in transporting the crude oil to refineries at Chauk and

Syriam. In 1976 25 miles of pipeline was already completed between Mann and Minlha, and annual oil production in 1976 is estimated to exceed that of 1974. It is estimated that the total amount of Burmese oil production would have reached 24,000 b/d as of March 1976, if there had been no crude oil transport problems.

TABLE 2-5 CRUDE OIL PRODUCTION

As of Dec., 1975

Name of field	Number of flowing wells	Number of pumping wells	Total number of production wells	Daily production (B/D)
CHAUK	5	143	148	988
YENANGYAUNG	5	168	173	3,465
MYANAUNG	13	36	49	2,148
PROME	22	12	34	1,798
MANN	58	2	60	8,200
TOTAL	103	361	464	16,599
(Dec., 1974)	(102)	(406)	(508)	(21,116)

TABLE 2-6 GAS PRODUCTION

As of Dec., 1975

Name of gas field	Number of gas production wells	Daily production (MMCFD)	Annual production (MMCF)
CHAUK	7	7.7	2,800
KYUNCHAUNG YENANGYAT AYADAW	8	7.7	2,800
TOTAL	15	15.4	5,600
(Dec., 1974)	(17)	(12.6)	4,705

2.3 Proved reserves and estimated probable reserves

2.3.1 Proved reserves

6 oil fields are now in production and 100% of the balance of recoverable reserves is considered as the proved reserves in those oil fields where more than 50% of total recoverable reserves have already been extracted and in which the balance of recoverable reserves is less than 50%. With respect to the oil fields where the cumulative production is under 50% of the total recoverable reserves, 90-95% of the balance of the recoverable reserves is regarded as proved recoverable reserves.

The total proved recoverable reserves in these 6 oil fields is 217 million barrels and this figure is regarded as the balance of proved recoverable reserves in Burma as of January 1, 1976 as shown in Table 2-7, group A.

2.3.2 Probable reserves

It is believed that the estimate of reserves will be proved accurate in respect of the extension of the existing oil fields (the northern parts of Mann and Myanaung oil fields) and the structures Letpanto, Shwepitha, and Pyalo, under exploration as a result of successful wildcats, but as these reserves are not yet confirmed, 50-70% of the reserves are considered to be probable recoverable reserves. There are 5 structures of this kind with a total of 103 million barrels as shown in Table 2-7, group B.

TABLE 2-7 ESTIMATED RESERVES

Group	Name of oil field or structure	Basin	Extent of field	Thickness of reservoir	Oil rock ratio of recoverable deposit (volume)	Recoverable reserves	Cumulative production	Balance of recoverable reserves	Probability	Remaining reserves (Proved, Probable, Possible)
			(Acre)	(Ft)	BL/Acre-Ft	MMBL	MMBL	MMBL	%	MMBL
A	Yenagyaung	D	2,600	960	91	227	199	28	100	28
	Chauk/Lanywa	D	2,560	650	84	140	134	6	100	6
	Yenagyat	D	600	450	70	9	8	1	100	1
	Mann	D	3,000	655	97	190	15	175	90	158
	Myanaung	F	1,500	250	80	30	17	13	100	13
	Prome	F	1,300	180	72	17	5	12	95	11
	Group sub-total		11,560	-	-	613	375	235	590	217
B	Letpanto	D	3,000	450	70	95	-	-	70	67
	Mann North	D	1,000	400	70	28	-	-	70	20
	Shnepitha	F	1,300	250	(gas) 16	5	-	-	70	4
	Myanaung North	F	600	250	80	12	-	-	50	6
	Pyalo	E	1,500	300	70	32	-	-	50	16
	Group sub-total		7,400	-	-	172	-	-	310	103
C	Yenan	B	3,000	250	70	52	-	-	40	21
	Indaw	B	2,500	250	70	44	-	-	40	18
	Minbu	D	2,000	200	70	28	-	-	40	11
	Yenangyat North	D	1,000	450	70	32	-	-	40	10
	Mahudaung South	B	2,000	250	70	35	-	-	20	7
	Yenangyaung subthrust	D	600	960	70	40	-	-	20	8
	Yenangyat	D	600	450	70	19	-	-	20	4
	Yenanma	E	1,500	250	75	28	-	-	20	6
	Peukaung	E	700	300	70	15	-	-	20	3
	Group sub-total		12,900	-	-	286	-	-	250	88
D	Palusawa	B	1,000	250	70	18	-	-	10	2
	Aingy	D	600	600	70	48	-	-	10	5
	Myaing	D	1,000	300	70	21	-	-	10	2
	Sawgetaung	E	1,000	300	70	21	-	-	10	2
	Uyu	B	1,000	250	70	18	-	-	5	1
	Himyaung	B	1,000	250	70	18	-	-	5	1
	Shwebo	C	1,000	250	70	18	-	-	5	1
	Pyaye Deep	E	500	300	70	11	-	-	5	1
	Natmi	E	1,000	300	70	21	-	-	5	1
	Tondaung	F	1,000	300	70	21	-	-	5	1
	Group sub-total		8,100	-	-	215	-	-	70	17
E	10 other structures	A–K	1,000x10	300	70	210	-	-	2x10	4
	Overall total		38,400	-	-	1,496	-	-	1,240	429

2, 3, 3 Possible reserves

The possible recoverable reserves have been calculated as shown in Table 2-7, groups, C, D, & E based on the assumption that, from the geological viewpoint, assured reservoir rocks exist located near the known existing oil fields in the case of group C, and that there is a 20-40% chance of discovering oil reservoirs in 9 structures where wildcats have not yet been drilled.

The possible recoverable reserves in group C are calculated as 88 million barrels. In group D structures exist, but the true extent of the reservoirs is not certain, so that a 5-10% chance of discovering oil reservoirs is taken into consideration when calculating possible recoverable reserves. Oil discoveries by future exploration are anticipated in 10 structures with total possible recoverable reserves estimated at 17 million barrels.

In group E, 10 structures are taken into consideration, in which oil discoveries may be made with the help of additional geophysical exploration, and the total possible recoverable reserves have been calculated at 4 million barrels on the assumption of a 2% chance of oil reservoir discovery in these structures.

The above figures are summarized in the following Table 2-8.

TABLE 2-8 RESERVOIR CALCULATION

Ranking	Discoverable amount(MMBL)	Number of structures	Number of possible discoverable oil fields
A(Proved reserves)	*217	6	*6
B(Probable reserves)	103	5	3, 1
C+D+E(Possible reserves)	109	29	3, 4
Total	429	40	12, 5

* Discovered

(The above reserves show the total of the existing 217 million barrels and the 212 million barrels discoverable in the next 10 years, and the number of oil fields shows the total of the existing 6 fields and the 6.5 fields discoverable in the next 10 years.)

2.4 Estimated optimum exploration and production programme.

2.4.1 Number of exploratory wells and drilling units

Since the nationalization of the entire Burmese oil industry in 1963, about 130 exploratory wells have been drilled during the last 12 years. The total amount of recoverable reserves of 210 million barrels was discovered during this period and a breakdown of these reserves is shown in the following table.

Myanaung	30	million	barrels
Prome	17	"	"
Shwepitha	5	"	"
Mann	158	"	"
Total	210		

If the same ratio of discovery is assumed for the next 10 years, 135 exploratory wells will be needed in order to discover oil reserves of 212 million in the period from 1976 to 1985.
These 135 exploratory wells are to be drilled in the total area of 38,400 acres as shown in Table 2-7, but on the assumption that in the A group area exploration wells have already been drilled, the total area of 38,400 acres minus the group A area of 11,560 acres leaves 26,840 acres to be covered by 135 exploratory wells.
That is one exploratory well is to be drilled for each 200 acres.
Supposing that the distribution of the 135 exploratory wells is estimated as shown in Table 2-9, A & B and that the drilling

efficiency at each depth can be assumed from results experienced in the past, as shown in Table 2-9, D, 8 drilling units would be needed to complete these 135 wells in 10 years, each of them drilling 1.687 wells per year on average, so that a total depth of 1,059,750 feet would be drilled in 10 years.

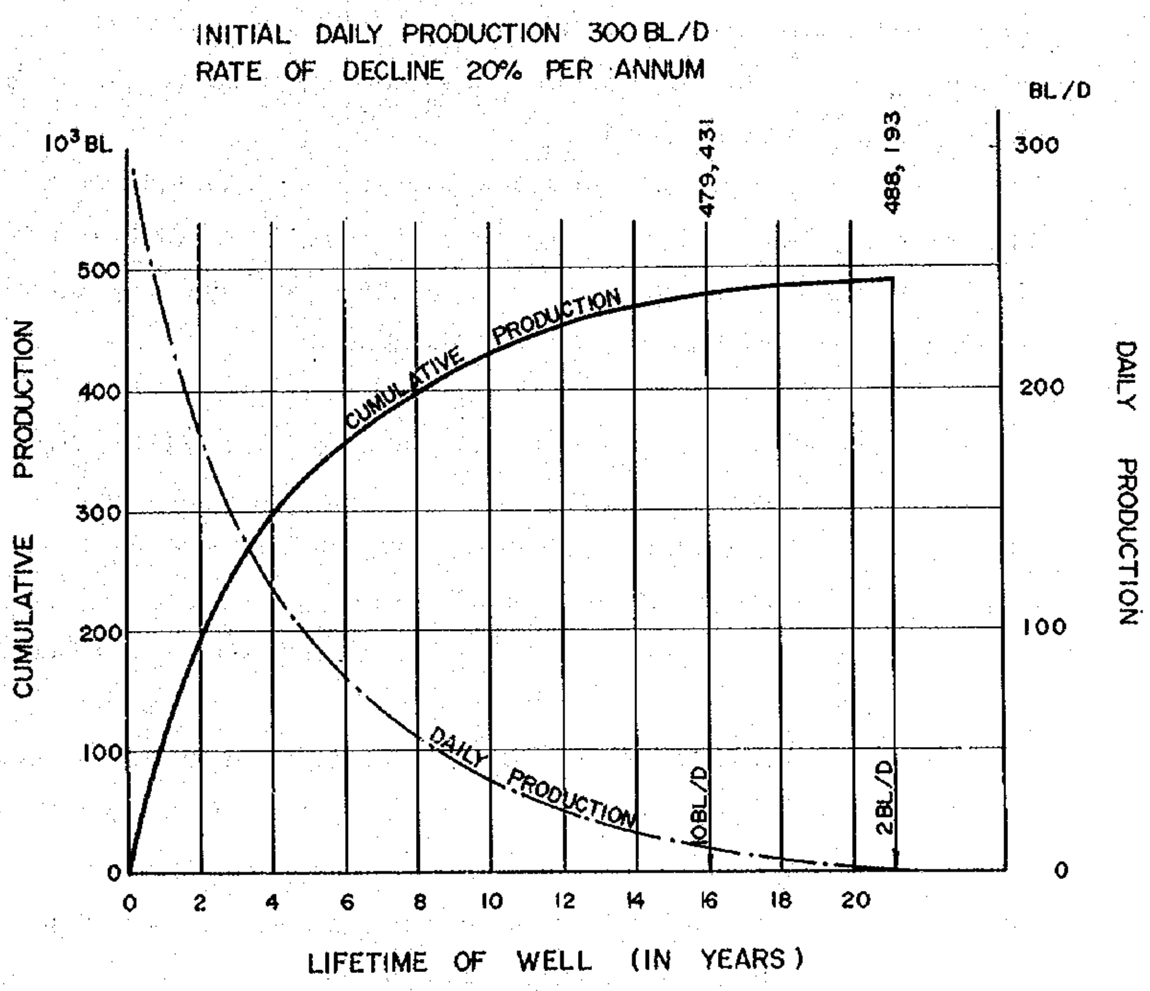
TABLE 2-9 ESTIMATED DATA FOR EXPLORATORY WELLS

A	B	C	D	E	F	G	H
Depth Ft	Well allocation %	Total No. of wells well	Wells per rig per year well/year	Completion time using 1 rig(years) c/d	No. of rigs for 10 year program E/10	Total drilled depth Ft A x C	Average depth/well Ft
5,000	5	6.75	2.6	2.60	0.260	33,750	7,850
6,000	15	20.25	2.2	9.20	0.920	121,500	
7,000	25	33.75	1.9	17.76	1.776	236,250	
8,000	25	33.75	1.7	19.85	1.985	270,000	
9,000	15	20.25	1.5	13.50	1.350	182,250	
10,000	10	13.50	1.3	10.38	1.038	135,000	
12,000	5	6.75	1.0	6.75	0.675	81,000	
	100	135	1.687	80.04	8.004	1,059,750	

2.4.2 Number of exploitation wells and drilling units

Assuming that the initial daily production per well will be 300 barrels with a 20% average rate of decline per annum for Burmese oil fields and that production will continue until the daily production falls to 2 b/d, then the life of one exploitation well will be 21 years with a total lifetime production of 488,000 barrels as shown in Fig. 2-4.

FIG. 2-4 PROJECTED PRODUCTION



The number of exploitation wells necessary to produce the reserves of 429 million barrels shown in Table 2-8 is calculated as follows.

In group A (Table 2-7) all the oil fields, except for Mann have been fully developed so there is no need for more exploitation wells in these areas. In Mann oil field 15 million barrels of oil had been produced by the end of 1975 from 60 exploitation wells. The total number of exploitation wells required for the development of Mann oil field is calculated as follows. The sum of 15 million barrels of cumulative production and 158 million barrels of proved recoverable reserves is 173 million barrels, which is the estimated ultimate cumulative production. This figure divided by the 490,000 barrels of estimated ultimate production per well gives a result of 353, which represents the total number of exploitation wells required for the development of Mann oil field.

However, since 60 successful wells have already been drilled in the Mann oil field the remaining 293 wells must be drilled after 1976. Assuming a success rate of 80% it will be necessary to drill further 366 exploitation wells in the Mann field.

In the structures of group B, C, D and E of Table 2-7, 212 million barrels of reserves are yet to be discovered in an estimated 6.5 fields. Assuming a total production of 490,000 barrels per well will require a total of 433 exploitation wells, if the above 80% success rate is also applied to this case, it will be seen that 541 wells must be drilled.

Therefore, it will be necessary to drill 366 wells in the Mann field and 541 wells in the structures of group B, C, D and E giving a total of 907 wells for oil. To this total must be added the 63 wells which must be drilled for the exploitation of gas. Thus, a total of 970 wells should be drilled over the next 20 years.

Assuming that the drilling efficiency for these 970 wells and their depths will be as shown in Table 2-10, B and D, then 14.42 drilling units will be required to complete the program in 20 years and a total of 5,596,900 ft will be drilled.

TABLE 2-10 ESTIMATED DATE FOR EXPLOITATION WELLS

A	B	C	D	E	F	G	H
Depth Ft	Well allocation %	Total No. of wells well	Wells per rig per year well/year	Completion time using 1 rig(years) C/D	No. of rigs for 20 year program E/20	Total drilled depth Ft A x C	Average depth/well Ft
4,000	13	126.1	5.0	25.2	1.26	504,400	5,770
5,000	30	291.0	4.0	72.8	3.64	1,455,000	
6,000	30	291.0	3.5	83.1	4.16	1,746,000	
7,000	12	116.4	3.0	38.8	1.94	814,800	
8,000	8	77.6	2.5	31.0	1.55	620,800	
9,000	5	48.5	2.0	24.3	1.42	436,500	
10,000	2	19.4	1.5	12.9	0.65	19,400	
	100	970	3.366	288.1	14.42	5,596,900	

The number of completed wells and drilling rigs working annually are shown in Table 2-11. These figures are based on the assumptions that one drilling rig is capable of drilling an average of 3.366 wells per year and that a success rate of 80% will be maintained. If the production of Burmese oil fields decays at an annual rate of 20% as shown in Fig. 2-5, 5 drilling rigs will be required to drill exploration wells in order to maintain the existing production of 21,000 b/d. Furthermore, in order to increase the production to more than 21,000 b/d, it will be necessary to introduce proportionate number of drilling rigs to the production quantity as shown in Fig. 2-5 and therefore 10 drilling rigs will be needed for 40,000 b/d and 13 drilling rigs will be needed for 50,000 b/d.

FIG. 2-5 ESTIMATED DAILY PRODUCTION BY NUMBER OF RIGS

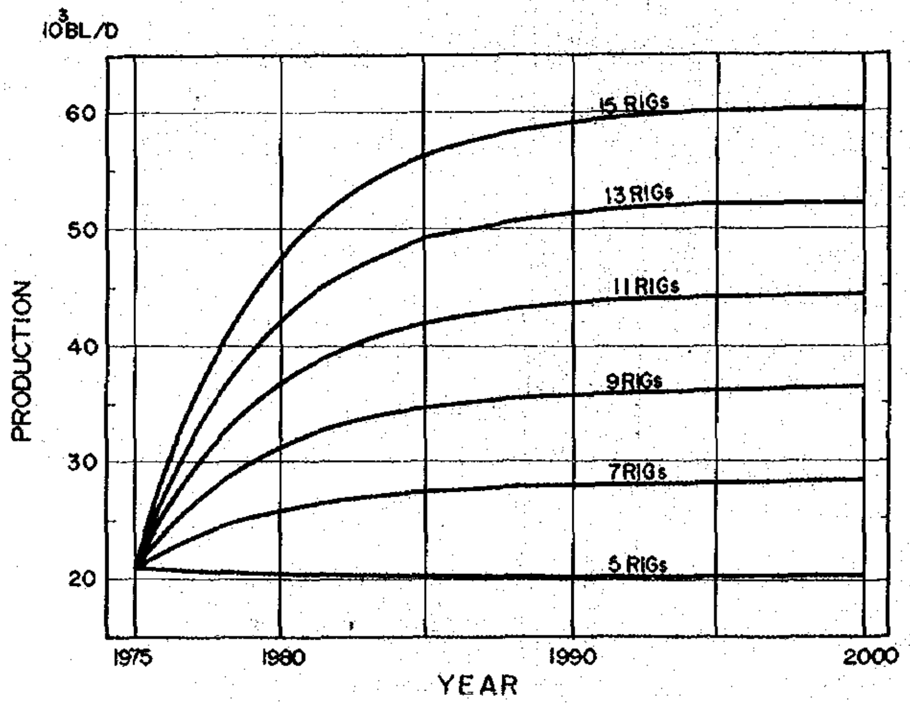
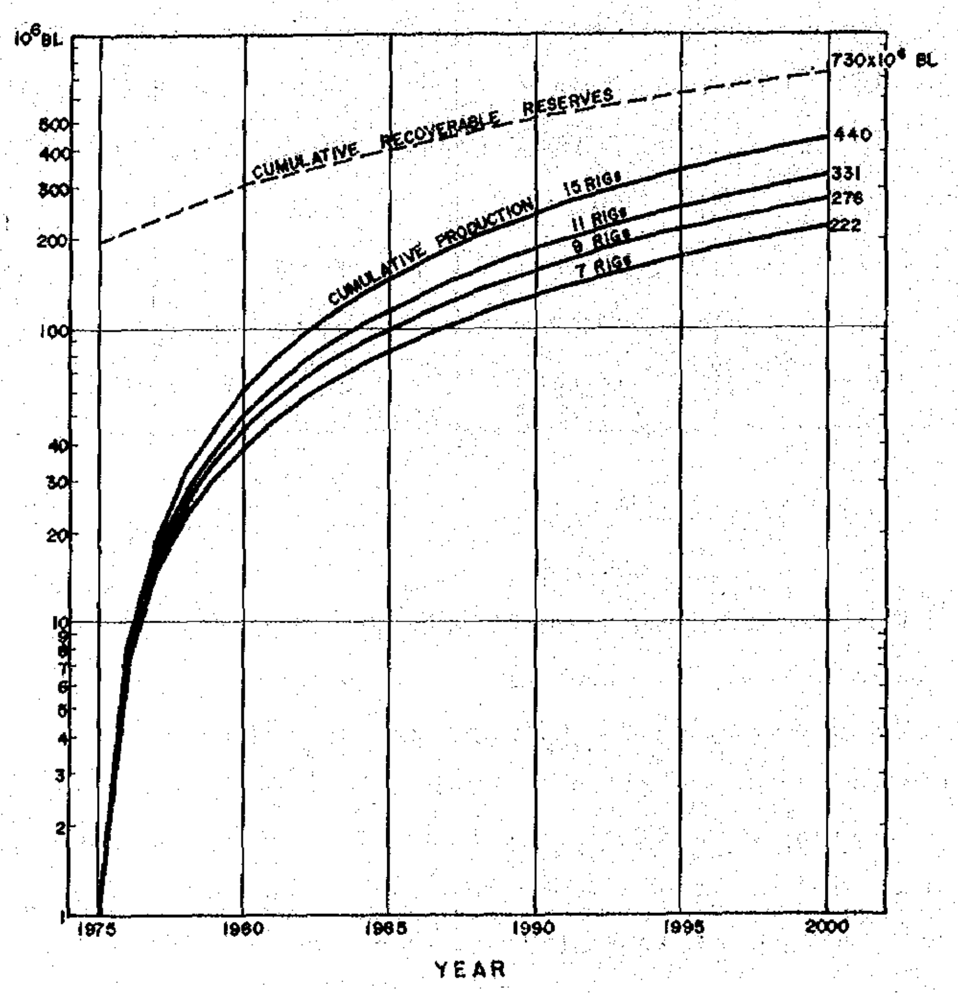


TABLE 2-11 NUMBER OF WORKING RIGS AND NUMBER OF WELLS DRILLED/YEAR

Number of working rigs/year	Number of wells drilled/year	Number of successful wells/year	Additional production(B/D)/Year
7	23.56	18.85	5,655
8	26.93	21.54	6,462
9	30.29	24.23	7,269
10	33.66	26.93	8,079
11	37.03	29.62	8,886
12	40.39	32.31	9,693
13	43.76	36.01	10,503
14	47.12	37.70	11,310
15	50.49	40.39	12,117

In Fig. 2-6 the curves of the cumulative production and the cumulative recoverable reserves are shown during the period of operation of the given numbers of drilling rigs. It is considered that, as this Figure shows, a difference of about 290 million barrels exists between the cumulative recoverable reserves and the cumlative production in the year 2000 there would be no shortage of reserves, even if 15 drilling units were working at their maximum rate.

FIG. 2 - 6 ESTIMATED CUMULATIVE PRODUCTION



2.4.3 The optimum production rate

It is foreseen that the Burmese oil supply in 1976 will lie between a minimum of 26,000 b/d and a maximum of 30,000 b/d.

The future estimate of the oil supply would be as shown in Fig. 2-7 provided that the annual rate of increase is 3.5%. It is considered that the production plan shown in Table 2-12 might be the most likely to approximate to the production estimate curve in Fig. 2-7.

FIG. 2-7 DAILY PRODUTION

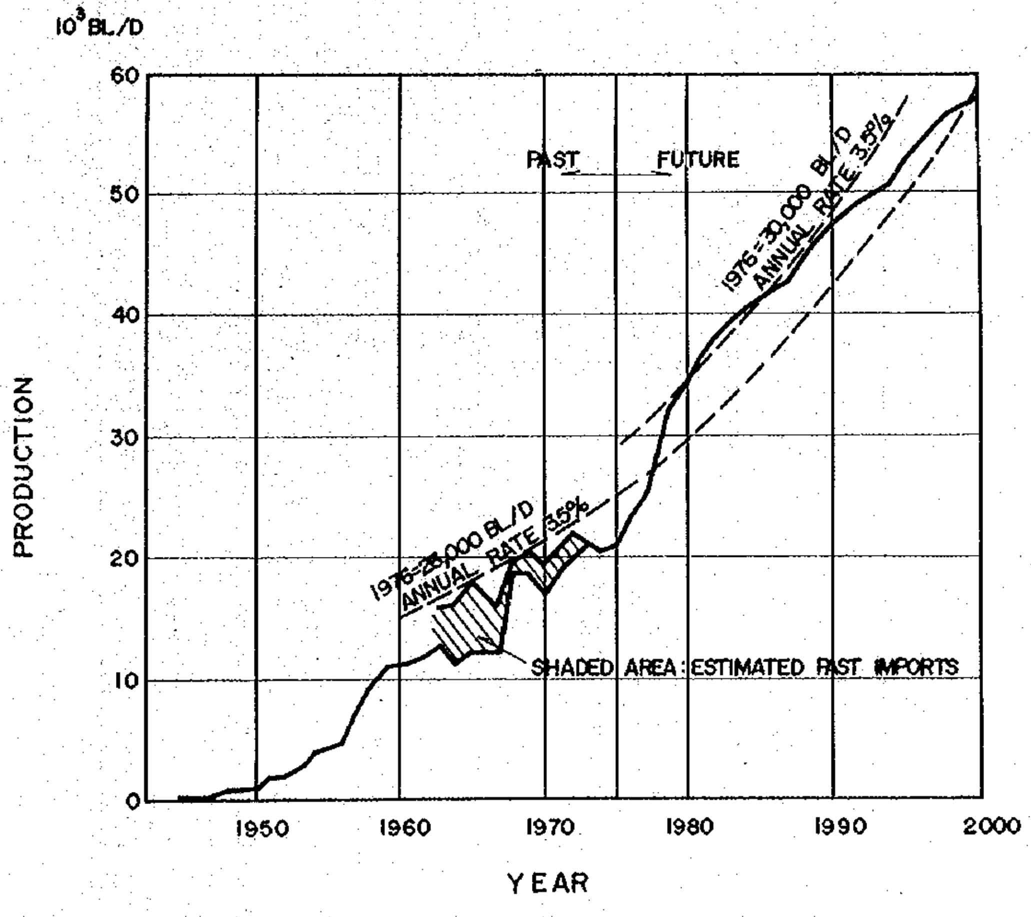


TABLE 2-12 OPTIMUM ESTIMATED PRODUCTION

Year	Number of rigs	Production from new exploration BL/D	Daily production BL	Annual production 10^3 BL	Cumulative production 10^3 BL	Recoverable production MMBL	Discovered reserves MMBL	R/P	Number of exploratory wells	Number of exploitation wells: Annual	Number of exploitation wells: Total	Number of exploitation wells: Successful Total
1975	8	6,462	21,000			203		24.1				
76			23,262	8,078	8,078				11.8	26.93	26.93	
77			25,072	8,821	16,899				23.6		53.86	
78	11	8,886	28,943	9,858	26,757		103.5		37.1	27.03	90.89	
79			32,041	11,130	37,887				50.6		127.92	
1980			34,518	12,147	50,034	257		21.4	64.1		164.95	131.96
81			36,501	12,961	62,995				77.6		201.98	
82			38,087	13,612	76,607				91.1		239.01	
83			39,355	14,133	90,740		109.0		104.6		276.04	
84			40,370	14,550	105,290				118.1		313.07	
1985			41,182	14,883	120,173	295		20.0	131.6		350.10	280.08
86			41,832	15,150	135,323				145.1		389.13	
87			42,351	15,363	150,686				158.6		424.16	
88	13	10,500	44,381	15,829	166,515		98.1		172.1	43.76	467.92	
89			46,005	16,495	183,010				185.6		511.68	
1990			47,304	17,029	200,039	314		18.5	199.0		555.44	444.35
91			48,343	17,456	217,495				212.5		599.20	
92			49,175	17,797	235,292				226.0		642.96	
93			49,840	18,070	253,362		88.3		239.5		686.72	
94			50,372	18,289	271,651				253.0		730.48	
1995	15	12,118	52,416	18,759	290,410	312		16.6	266.5	50.49	780.97	624.78
96			54,040	19,428	309,838				280.0		831.46	
97			55,358	19,965	329,803				293.5		881.95	
98			56,405	20,397	350,200		79.5		307.0		932.45	
99			57,242	20,741	370,941				320.5		982.93	
2000			57,911	21,015	391,956	289		15.8	334.0		1,033.42	826.74

For this purpose the arrangement of drilling rigs as shown in Fig. 2-8 will be necessary and the following new drilling rigs should be introduced: 3 rigs in 1978, 2 rigs in 1988 and 2 rigs in 1995.
A production quantity of more than 31,000 b/d can not be attained without increasing the number of drilling rigs and this production figure lies between the 7 rig and 9 rig curves shown in Fig. 2-5.

FIG. 2-8 NUMBER OF RIGS FOR OPTIMUM PRODUCTION

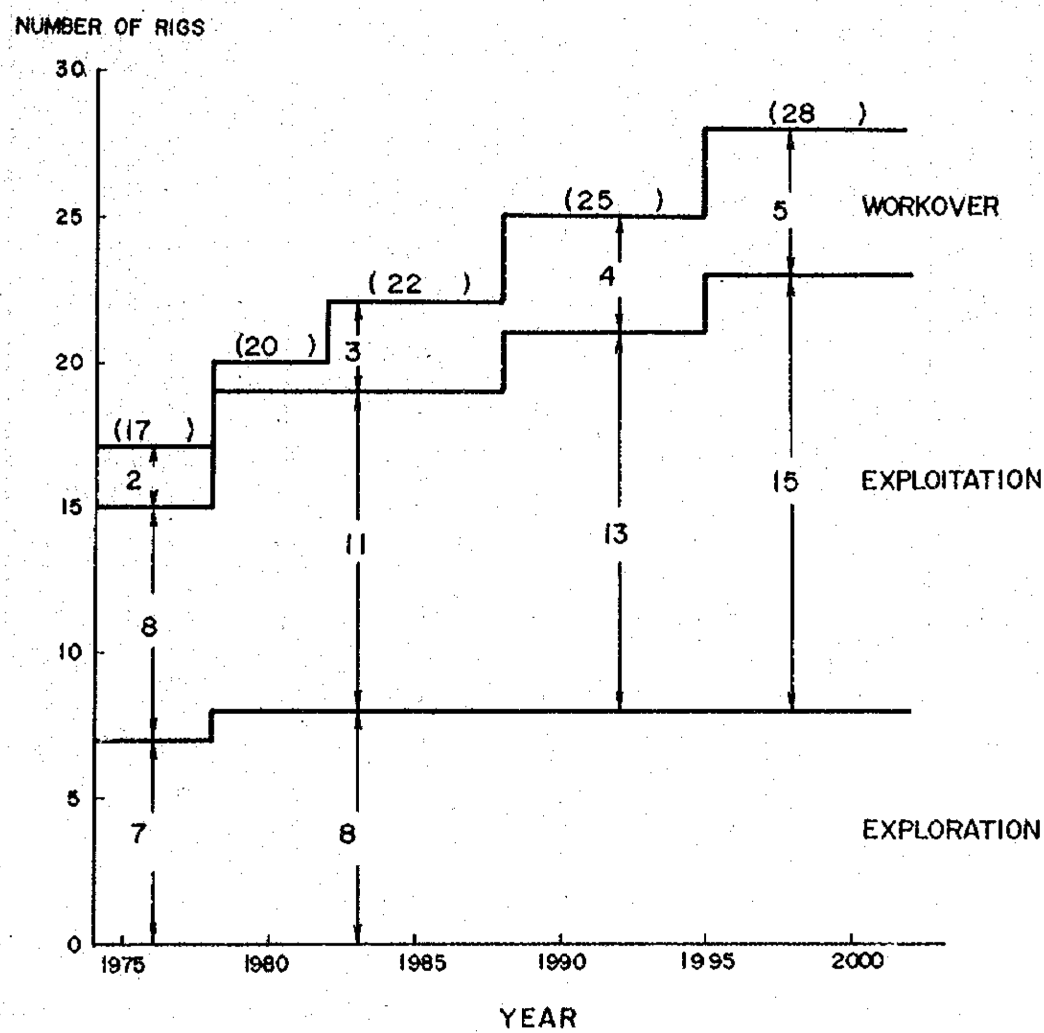


TABLE 2-13 EXISTING RIGS

As of March, 1976

No.	RIG	Year of purchase	Depth to date
1	National 80 GN	1961	12,000'
2	" 80 PAX	1962	12,000'
3	National 50	1961	8,000'
4	" 50	1961	8,000'
5	National 55	1968	9,000'
6	" 55	1968	9,000'
7	" 55	1968	9,000'
8	" 55	1972	9,000'
9	" 55	1972	9,000'
10	" 55	1972	9,000'
11	" 55	1974	9,000'
12	" 55	1974	9,000'
13	4LD - 150	1963	12,000'
14	T45	1961	7,500'
15	T45	1961	7,500'
16	L350	1961	4,500'
17	WegnerMoorehouse	1965	Workover

TABLE 2-14 WORKING STATUS OF RIGS

As of March, 1970

Position	Exploration	Exploitation	Workover	Total
MANN	0	6	1	7
LETPANTO	2	0	0	2
MYANAUNG	0	(GAS) 1	1	2
YENANGYAT	1	(GAS) 1	0	2
PYALO	1	0	0	1
PERI (MINBU)	1	0	0	1
YENANMA	1	0	0	1
CHINBYIT	1	0	0	1
Total	7	8	2	17

2.5 A discussion of each oil field

2.5.1 Yenangyaung oil field

This oil field is very interesting since it is one of the oldest producing oil fields in the world and has a production history of several centuries. In the two areas of Twingon and Beme, the Burmese people had already dug wells by hand by the end of the 18th century and oil mining rights in this area were granted by the King of Burma as an hereditary right to 24 families called "the Twinzayos". No member was able to sell this exclusive mining right without the consent of the other members of the Twinzayos. Burma was defeated by the British in the 3rd Anglo-Burmese. War in 1885 and North Burma was colonized by the British in 1886. At this time the Twinzayo's mining right was extended by the British Government

and the Twingon area of 295 acres and the Beme area of 155 acres were classified as "Native Reserves".
Most of the "Native Reserves" are divided into circular areas each 60 feet in diameter, which were allocated to each family of the Twinzayos with a limit of 12 areas to one family.
However, 137 (164 in another report) irregularly shaped areas owned by King Mindon of Burma himself at the time of defeat of the War were taken over by the British Government, and were leased to the incipient Burmah Oil Company (BOC). Oil mining rights were first established by legislation and the British government imposed a royalty on the crude oil produced from those areas and granted the free transfer and sale of the mining rights.

FIG. 2-9 YENANGYAUNG OIL FIELD
3700' SANDS

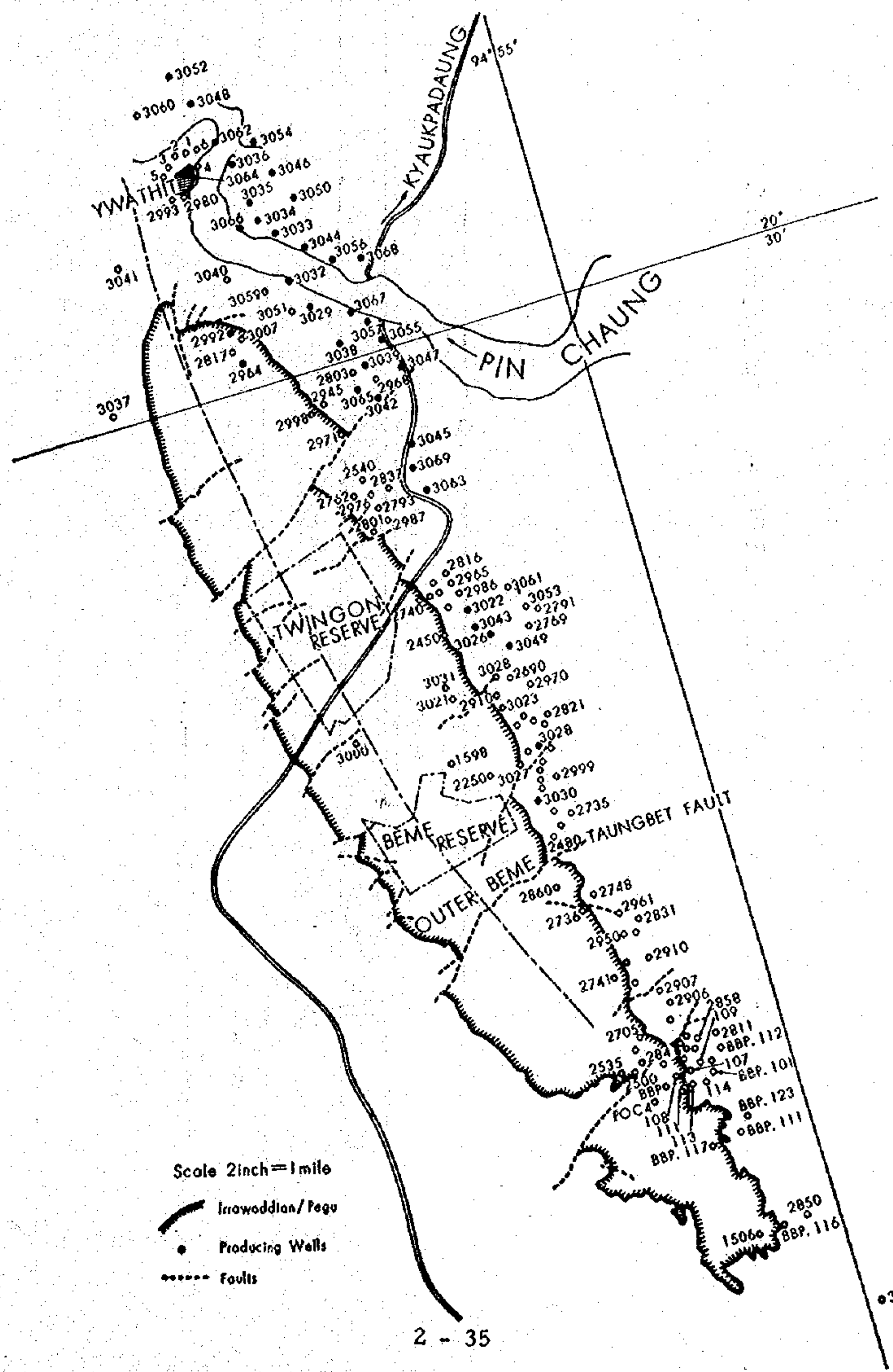
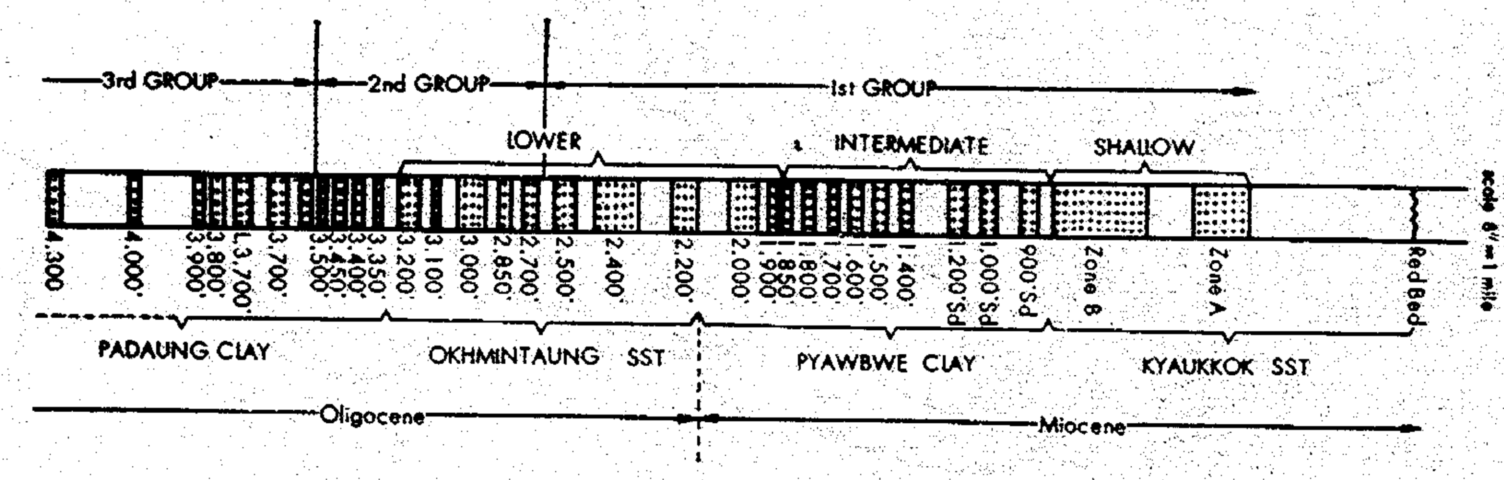


FIG. 2-10 VERTICAL SECTION YENANGYAUNG



Oil mining before 1889 was conducted by bailing the oil percolating from the outcropped oil-bearing sandstone out of several ditches made by cutting into the exposed oil reservoirs, or out of wells ranging in depth from several feet to several tens of feet drilled by cable tool rigs.
Oil production from cable tool rigs reached 600 b/d in 1900 due to the gradual increase of the number and depth of wells.

In 1887 BOC first introduced drilling rigs to this oil field and the first well using this method was started at Khodaung on the south bank of the Aungban river and was completed in 1889. This well had a depth of only 727 feet and other wells drilled in the early days were of a similar depth.
According to the records one of those wells, BOC No. 8, produced oil from a reservoir at a depth of 350 feet for over 50 years.
Up to 1906 only BOC and the Twinzayos were operating as the mining right holders in the Yenangyaung oil field, and in 1907 Rangoon Oil Co. (a different company from the R. O. C. which was founded in 1870 and merged with BOC) started to operate in the concession area leased from the Twinzayos. In 1908, 4 companies were operating in this oil field and they were joined later by many other companies. As a result many derricks stood close together with intervals of only 60 feet in both the Twingon and Beme areas. In other areas, the acreage was divided into larger concessions and wells were drilled at wider intervals.

Production from this field gradually rose up to the end of 1800s and increased remarkably after 1900, particularly in 1908. In 1916 the production reached a peak of 16,000 b/d. In this period the production was mostly from reservoirs shallower than 3,500 feet, although some of the reservoirs were deeper than 4,000 feet. These deep wells were developed from the top of the anticline to

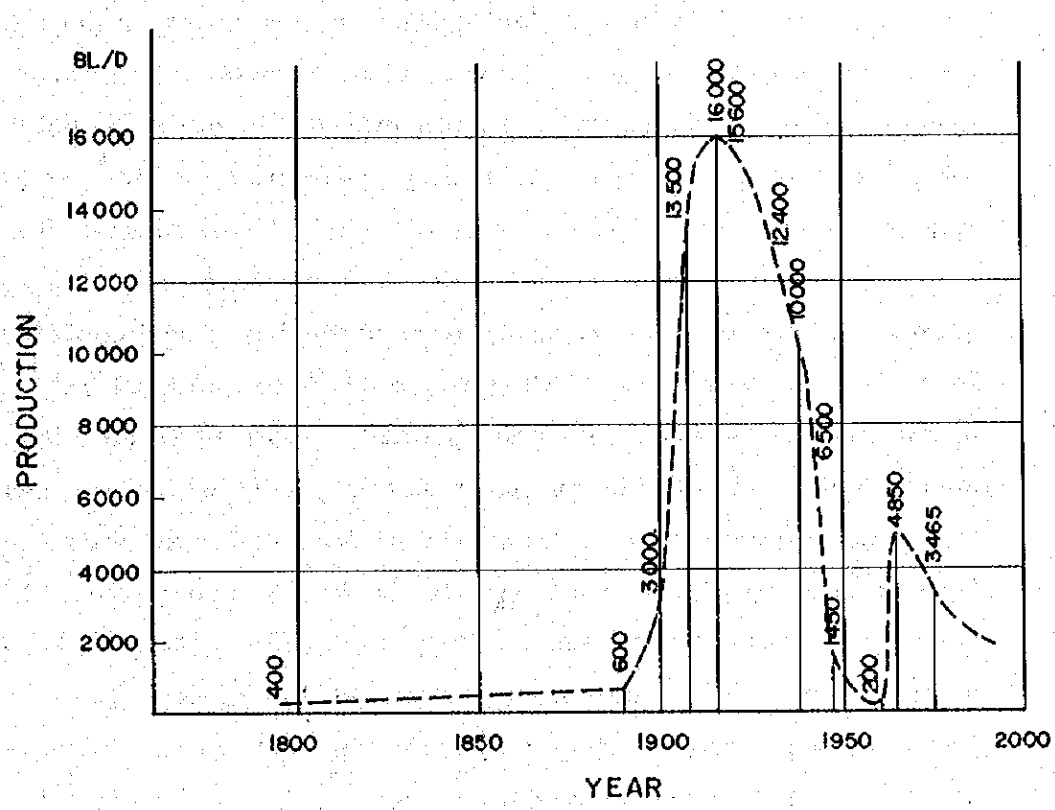
the east wing.
Later oil production gradually decreased and by 1938 it had declined to about 10,000 b/d and within the year first place in Burmese oil production was taken over from Yenangyaung by Chauk. By 1942 the production had decreased to 6,500 b/d. In 1942 the oil field installations were destroyed by the British Army, but about 1,500 b/d were produced under the control of the Japanese army between 1942 and 1944 after the entry of the Japanese army into Burma.

In 1947 British oil companies returned to Burmese oil fields and started to engage in the restoration of the destroyed facilities. BOC gave priority to the restoration of Chauk oil field and transferred all the facilities of the Yenangyaung oil field to Chauk after suspending operations in Yenangyaung, so production from Yenangyaung until 1959 was solely from the shallow wells of Twingon and Beme area except for NOC's 6 wells in the Ywethit area by the Pin Chaung river. These are operated by Oil Industry Corporation Society (OICS) which produced 200 b/d from 200 wells in the Native Reserves in Twingon and Beme and from some of BOC's wells by acquiring temporary oil mining rights renewed on a yearly basis.

Number of wells drilled in Yenangyaung

1800	500 wells	(by cable tool rig)
1931	2,750 "	(185 wells by cable tool rig)
1934	3,017 "	
1942	4,000 "	
1954	3,662 "	(206 producing wells)
1975	?	(173 producing wells, 5 flowing wells 168 pumping wells)

FIG. 2-11 PRODUCTION HISTORY (YENANGYAUNG)



When BOC had almost completed the restoration of Chauk oil field they started to restore Yenangyaung oil field in 1960. By this time almost all the reservoirs shallower than 3,000 ft had been developed, so BOC concentrated on the development of new reservoirs around 3,700 feet, while restoring reservoirs from 3,000 feet to 3,500 feet.

Thus, in 1960 in addition to the restoration of No. 3028 well, BOC started new drilling with No. 3029 to a depth of 5,287 feet and found oil flowing at a rate of 240 b/d from 3,700 feet reservoirs. Furthermore, in 1961 7 production wells were drilled and the production of this field was increased to 1,480 b/d and its production capacity rapidly restored to 4,000 b/d in 1963 as the development of the 3,700 feet reservoirs continued. During this time the nationalization of the oil producing industry was progressing, leaving only local operations in very shallow reservoirs independent; then in February 1964 the state-owned "People's Oil Industry (POI)" gained a total monopoly of the continuing operations in this field.

This state-owned company changed its name from the People's Oil Industry to the Myanma Oil Corporation in 1968 and drilled 7-10 production wells every year. Its production has declined from a peak of 4,850 b/d in 1965 and decreased to 3,450 b/d in December 1975, and at present the oil is produced from 5 flowing wells and 168 pumping wells, 173 wells in all. In the pre-war period, the cumulative production of the Yenangyaung oil field was about 150 million barrels and in the post-war period this oil field has produced about 50 million barrels, so about 200 million barrels of oil have been produced to date.

Growth of recoverable reserves of Yanangyaung oil field

	Proved reserves (MBBL)	Probable reserves (MBBL)	Possible reserves (MBBL)	Cumulative production (MBBL)
Jan. 1, 1964	10,350	4,150	3,500	
Oct. 1, 1973	25,000	5,000	0	197,000
Apr. 1, 1975	28,000	0	0	199,000

Geological outline of Yenangyaung oil field

The Yanangyaung oil field lies in the long and narrow anticlinal structure from which Kyaukkok sandstones (Miocene) shown as outcropping on the central part. The boundary between the Kyaukkok sandstones and the upper Irrawaddy system is clearly marked by thin, but continuous "Red Bed" and "White Bed".

The fold shows asymmetry, the west wing showing a maximum of 50 degrees dip, the east wing showing a maximum of 40 degrees dip. These are cut by many cross faults stepping down towards the north and a fall of 50-400 feet. In some areas the boundary between oil and water is significantly influenced by these faults.

There is an interesting formation of mud-veins in the southern part of the field. The mud-veins are well developed especially in the western half of the anticline structure and also in the west side in Irrawaddy sandstones and they continue eastwards through the Beme reserves and are sometimes recognizable in the eastern part of the Irrawaddy sandstones.

The lithology of the chocolate coloured mud-veins is slate produced from shale and they intrude the surrounding structures sharply, unlike other stratified clay. Structures formed by the flow of materials in the formation almost are sometimes seen and generally they are formed in parallel with the formation but here the most of the mud-veins intrude the formation at right angles.

Some parallel sheet mud-veins can be partly seen on the upper and lower sides of the stratified clays.

The clay formations are somewhat curved where the mud-veins have passed, and the mud-veins often contain impure calcareous materials and selenium deposits and sometimes consist crystalline. In some areas the intruding mud-veins remain as walls after the erosion of the surrounding soft formations. In other areas, where the mud has intruded a sandstone formation the mud-vein has been more easily eroded and two smooth vertical sandstone walls can be seen. The mud-veins lie at a right angle or an acute angle to the anticlinal axis with a horizontal direction of about N60° E - S60° W. This mud comes from the Pegu clay and may have originated in a mud volcano formed at the top of the anticline in past times and the intrusions are undoubtedly created by the local tension associated with the folding movement. Oil is seldom contained in the mud-veins, but the fact that a large amount of gas is contained there shows the existence of an old mud volcano.

In Yenangyaung oil field there are about 40 sheets of oil reservoirs from Miocene to Oligocene as shown in Fig. 2-10 (Vertical Section). Of these the reservoirs shallower than 2,500 feet were developed from 1887 to 1930, the production area being limited to the top of the structure, and characteristically they do not have clear gas caps. These oil reservoirs produced about 9.2 million imperial barrels by the end of 1923.

The oil reservoirs between 2,700 feet and 3,500 feet (Fig. 2-10, 2nd Group) were developed in the pre-war period after 1930, and the main development of the upper reservoirs above 3,000 feet was performed at the beginning of 1930s.
The oil producing area in this upper reservoir lies in the top of the anticlinal structure as do the reservoirs in the 1st Group.
The oil in the reservoirs of the 1st Group and the upper reservoirs of the 2nd Group, was completely exploited in the pre-war period. However, as for the lower part of the 2nd Group the oil producing area lies in the east wing of the anticlinal structures and the development of its northern and southern extension was conducted in the post-war days.

The Yenangyaung oil field has an area of about 2,600 acres where about 4,000 wells were drilled in 35 sheets of oil reservoirs up to 3,500 feet in the pre-war period and 153 million barrels of oil have been produced.
Therefore, in the shallow sands and intermediate sands, the oil has been almost completely extracted and no room exists for further exploitation there. The development of oil reservoirs from 2,500 feet to 3,500 feet was started in the pre-war period and was continued until completely exhausted. The oil reservoirs (Fig. 2-10 3rd Group) from 3,500 feet to 4,300 feet were developed in the post-war period, and the 3,500 feet and 3,700 feet reservoirs were mainly developed between 1963 and 1973, and became the main producing reservoirs of Yenangyaung oil field.

The production situation in reservoirs deeper than 3,800 feet is explained in the following table. As the 3,900 feet reservoir has a slightly higher pressure than hydrostatic pressure and the lower part of the 3,900 feet reservoir has a considerably higher pressure, there is a large difference in pressures of different blocks.
In reservoirs deeper than 4,300 feet the sand formation is very thin and the structures are complicated, so that there are no good oil reservoirs.
Therefore, it is considered that oil may be found in the reservoirs from 3,700 feet to 4,300 feet. The deepest well in Yenangyaung oil field was No. 3031 well drilled in 1961. No. 3021 well drilled prior to No. 3031 well for the purpose of deep exploration after the War encounted a high pressure water-bearing zone on the way and was abandoned at 5,540 feet.

TABLE 2-15 Yanangyaung production data of 3,800 ft. and deeper sands

Well	sq.	Final Depth ft.	Horizons Tested	Production Data
583	D 25	3,953	3,800' sand	Water-bearing, sand range 3,940'~3,952'
1506	F 35	5,390	4,300' sand	17 b.o.p.d. & 62 b.w.p.d., probably from the sand of 4,941'~4,955'; oil coming from 11 3/4" & 8 5/8" casing annulus. Water coming through the hole in 8 5/8" casing at about 4,312' at the rate of 25 b.w.p.d. Plugged back with cement to 5,022' and turned to production. Flowed for sometime of 3 b.o.p.d. and 9 b.w.p.d. Water production later increased to 80 b.w.p.d. Flowing stopped in 2/1,935'. Abandoned in 4/1,936'.
1730	F 15	4,340	3,900' sand	Gas sand at 4,055 ft. 4 1/4 MMcu. ft/day.
2450	G 14	7,265	3,900' sand 4,300' sand	Not tested. High Pressure water sand of 6,379'~6,341' B.H.P. & 6,150 psi.
2757	G 18	4,715	3,900' sand	Gas show between 4,662~4,664 ft. upper part of 3,900' sand with 250 ft. of water inflow. At 4,696 ft. of water inflow. At 4,696 ft. water inflow increased to 3,750 ft.
2784	G 26	4,350	3,800'/3,900' sand	No fluids of only kind.
2791	I 15	6,254	3,900' sand	Tested at 5,975 ft. 65~70 b.w.p.d. with oil show. High Pressure gas sand met at 6,248 ft. S.I. pressure, 1,700 psi with 105 Lb/cu. ft. mud in hole
2821	H 18	9,705	& 3,900' sand & 4,100' sand	Only water and some gas. (D.S.T) Sand to at & 5,445 ft. Water sand at 5,683~5,686 ft. At 5,701 well made 9 bl of fluid with 98 lb/cu.ft. mud. S.I. pressure 1,650 psi with 102 lb/ cu. ft. mud.
			4,300' sand	Sound top at 5,956 ft. Trace of oil near the bottom of the sand. High pressure water sand at 8,275'~8,281' where mud weight dropped from 120 lbs to 109 lbs/cu. ft. Well kept under control with 130 lbs/cu. ft. mud and 700/900 lbs surface pressure (B.H.P. & 8,300 psi).
2837	G 10	4,590	3,800' sand 3,900' sand	Water with some Gas (D.S.T.) A good deal of Gas with no signs of oil or water (D.S.T.)
2844	H 29	5,038	3,800'/3,900' sand	D.S.T. failed due to mechanical reasons. Shut down in 12/1936.
2850	G 35	5,728	4,000' sand U 4,300'	High Pressure Gas sand. Water. Lower part of the sand cut off by faulting.
2970	G 17	7,250	3,900' sand	Started to gas considerably between 4,887 ft and 4,892 ft. Water inflow was about 18~30 bls/hour. B.H.P. about 3,200 psi.
			& 4,000' sand	Water sand at 5,019~5,020 ft. made fluid at about 45 bls/1/2 hour while the mud weight dropped from 100 to 92 lbs/cu. ft. Kept under control by surface pressure of 1,350 lbs (B.H.P. & 4,560).

Well	sq.	Final Depth ft.	Horizons Tested	Production Data
			6,965/7,020' sand	Flowed 1,008 bls of water at a back pressure of 1,200 psi. Drilled to 7,250 ft. and S.I. Pressure about 1,000 psi on 18.2.41. Pressure built up to 1,500 psi. on 24.2.41.
3031	F 16	11,187	8,700' sand	Flowed 1,000 bls of formation water with small quantities of solution gas at on approximate rate of 40 bls/hour through 1/8" bean (Solinity 2,850 ppm Chloride). Other sand not tested.
3033	I 1	5,500	3,900' sand	Flowed through 16/64" bean. Trace of oil with 34 bls of water per day (10/1961).
3040	G 1	4,700	3,900' sand	Gas production through 32/64" bean 3.47 MMCFD (Tested 3 days).
3041	D 102	4,550	3,900' sand	No inflow although swobbed down to 3,500 ft.
3042	I 7	5,280	3,900' sand	Intermittent flowing production through 16/64" bean (4 days average)–22 b.o.p.d. (12/1962).
3045	I 9	5,480	3,900' sand	2 day's average production through 20/64" bean–Trace of oil and 21 b.w.p.d. (2, 1963).
3048	I 105	5,900	3,900' sand	3 days average production through 16/64" bean–28 b.o.p.d. and 2 b.w.p.d. (3/1963).
3051	H 3	5,240	3,900' sand	Flowing through 16/64" bean–41 b.o.p.d. and 1 b.w.p.d. (5/1963).
			3,800' sand	Gas production through 48/64" bean on 23.3. 1964–3,610 MMCFD.
3059	G 2	5,150	3,900' sand	Gas only
3065	H 6	5,040	3,800' sand	Flowing through 16/64" bean–123 b.o.p.d. with G.O.R., 1,220 (2/1964)
3066	H 101	5,020	3,900' sand	Gas production through 12/64" bean on 10.4, 1964–0.78 MMCFD. Corrected Static BHP., 2,397 psia.
3068	J 3	6,700	3,900' sand	Flowing through 16/64" bean–69 b.o.p.d, and 1 b.w.p.d. (7/1964).

No. 3031 well was drilled at a point 300 feet north of No. 3021 well. The drilling of No. 3031 well was started on June 9, 1961 and reached an ultimate depth of 11,187 feet on October 10, 1961. A high pressure water-bearing zone containing a small amount of gas exists in the upper part of the Padaungs. The stratigraphy drilled by this well is as follows.
As this well often confirmed clear gas showing in the Swezetaw formation, $5^1/2$" casing was set at 8,957 feet and the 8,700 feet formation is to be considered the most promising. As a result of gun perforation between 8,705 feet and 8,720 feet, there was a flow of water containing a very small amount of methane gas. The first production of water showed about 1,000 bwpd by 8/64" bean and tubing pressures dropped rapidly indicating low permeability. As a result of electric logging, the repetition by fault was recognized in the lower part of the Padaung formation.

TABLE 2-16 NO. 3031 WELL DATA

Well Depth ft.	Formation	Indications of hydro-carbons
0~ 1,213	Kyaukkok	Common fluorescence and gas reading in nearly all sands
1,213~ 2,475	Pyawbwe	
2,475~ 3,696	Okhmiutaung	
3,696~ 8,285	Padaung	Rare fluoresence except in the upper part of the Padaungs, but below 7,700 ft, fairly common gas readings and some trip gas.
8,285~ 9,350	Shwezefaw	
9,350~10,620	& Yaw	
10,620~11,187	& Pandaung	

The oil producing area in the reservoirs deeper than 3,000 feet is only in the east wing of the structures and no oil pool has ever been discovered in the west wing. In 1961 No. 3037 well was

drilled more than 3,700 feet in the west wing of the north block of the oil field and the sample taken between 3,350 feet and 3,700 feet showed strong fluorescence, but the tests at 3,400 feet, 3,450 feet, 3,500 feet and 3,700 feet indicated high pressures of water, although the formations were in a higher position than those of the east wing. It is considered that the corresponding formations of the west wing show high pressure water-bearing zones caused by the outcrop of Padaung formation in a high position on the western side, although in the east wing gas, oil and water pressures are similar to the hydrostatic pressure.
It is assumed on the other hand that the pressure in the east wing is the hydrostatic pressure caused by the outcrop in Gwegyo and under the Irrawaddy formation unconformity in the south. There are some other wells such as No. 3000 well and No. 3041 well in the west wing, and any of them confirmed only high pressure water-bearing zones from 3,500 feet to 3,700 feet.
From the above results it was concluded that the main oil producing reservoirs of Yenangyaung were limited to the reservoirs between 3,500 feet and 3,700 feet in the east wing of the structure, and in 1970s the development was concentrated on this formation.
Consequently the oil producing area from 3,500 feet to 3,700 feet was extended to the north and south increasing the recoverable reserves, and this field is still producing more than 3,000 b/d, while Chauk oil field has declined.

The future trend of oil production of this oil field may go on decreasing and is estimated to decline to about 2,500 b/d around 1980 and about 1,800 b/d around 1990.
However, potential for the discovery of a new oil pool by seismic surveys remains in the southern area of the structures, and if they are successful the field may possibly maintain a production of about 3,000 b/d by around 1990.

2.5.2 Chauk-Lanywa oil field

The Yenangyat oil field was discovered by BOC in 1893 and then the Lanywa oil field was discovered on the southern extension, and further in 1902 Chauk oil field was found and rapidly developed on the other side of the Irrawaddy river. In 1924 reclamation work on the Irrawaddy river was completed in 1927 in order to enlarge the Lanywa oil producing area.

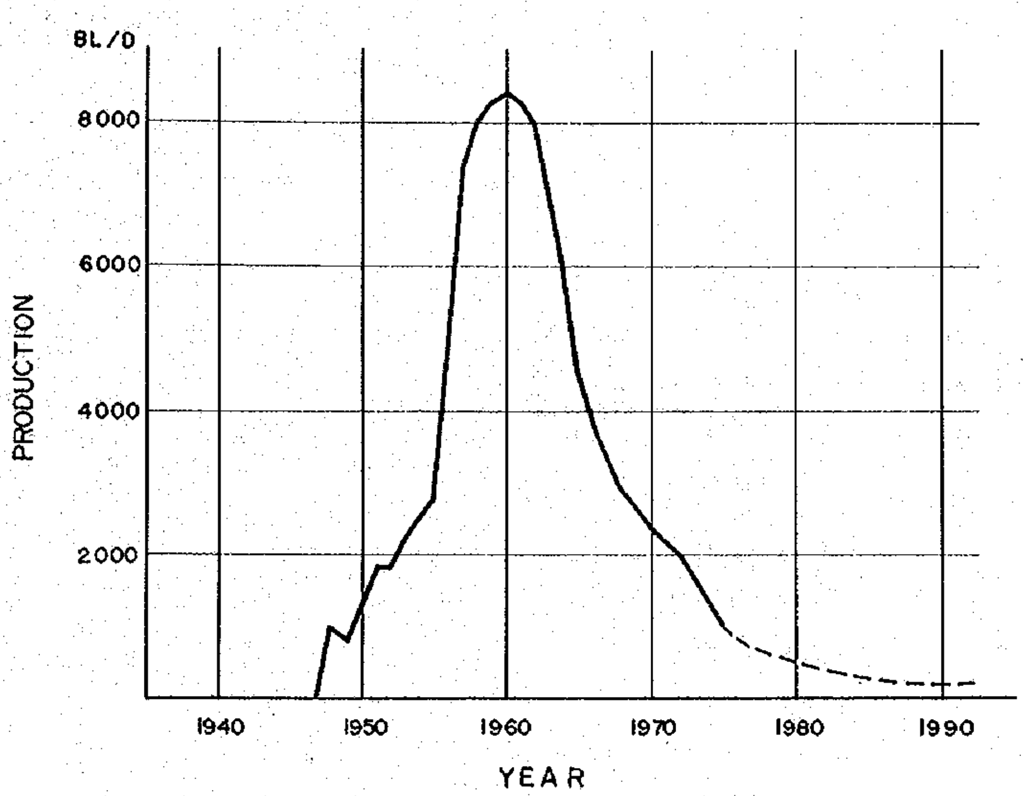
Chauk oil field increased the annual production and in 1938 became the biggest producing oil field in Burma, exceeding the Yenangyaung oil field and reached a production of more than 10,000 b/d, but was destroyed by the British army in 1942 prior to the entry of the Japanese army into Burma.

In 1945 the War ended and in 1947 British companies returned to Burmese oil fields and started to restore the destroyed oil fields. BOC gave priority to the restoration of the Chauk oil field and transferred all the facilities of Yenangyaung oil field to Chauk oil field and restarted oil production.

The restoration and development of Chauk oil field were continued and almost completed by 1960 and a production of 8,400 b/d was attained. By 1961 164 production wells had been drilled and 242 wells had been repaired. Later the main exploitation was transferred from Chauk field to Yenangyaung field.

In this field some additions to production wells and repairs to them have been made, but there was already no room for production and the field went on decreasing and declined to about 1,000 b/d as of the end of 1975. This oil field will probably go on decreasing in the future and is estimated to produce about 500 b/d in 1980 and 200 b/d in 1990.

FIG. 2-12 PRODUCTION HISTORY (CHAUK)



Geology of Chauk-Lanywa oil field

These oil fields are separated by the Irrawaddy river and lie in the anticlinal structures directed NNW-SSE. The Yenangyat-Sabe oil field lies in the same anticlinal structure several miles north of Lanywa. The anticlinal structure shows a strong asymmetry with 25°~80° in the east wing and 3°~23° in the west wing and contains a large reverse fault in the east wing of the anticline. At the top of the anticline, containing the oil fields, Okhmintaung reservoirs are outcropped and the main oil reservoirs are the sandstones in the upper Padaung clays which contain 35 sheets of reservoirs with a thickness of between 10 feet and 50 feet each at depths ranging from 1,200 feet to 3,700 feet.

The total number of exploratory wells drilled from the pre-war period to date amounts to about 1,100 and the total production to the end of 1975 was 142 million barrels and the balance of recoverable reserves is only 5 million barrels.

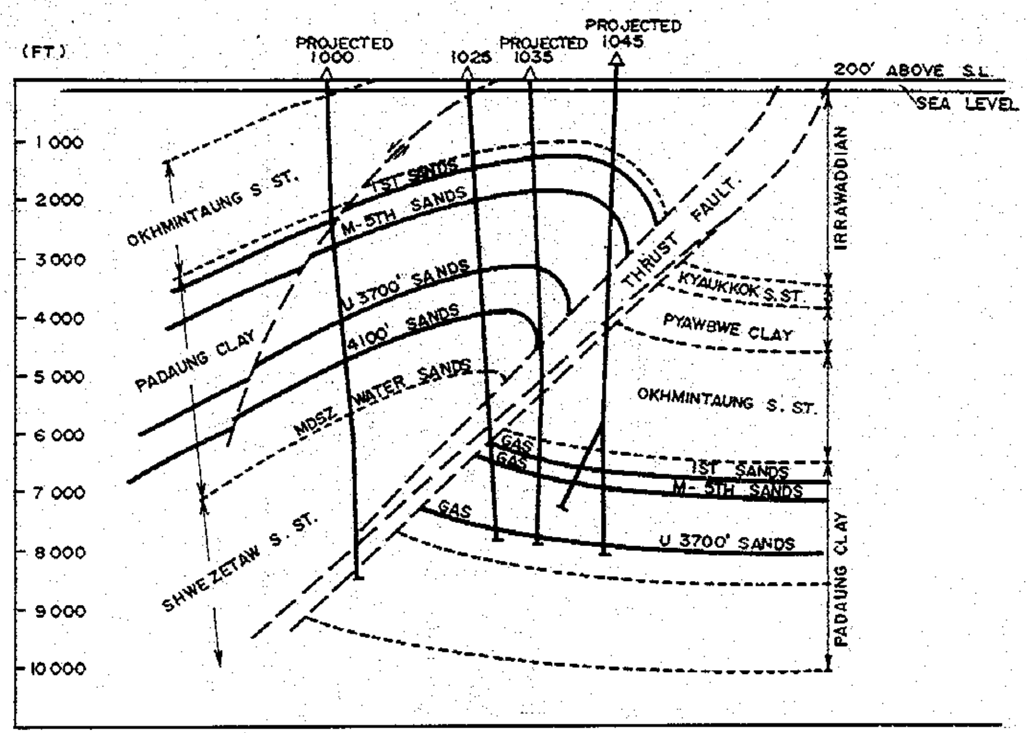
The oil production as of the end of 1975 was 988 b/d and the total number of production wells is 148 wells which are broken down as 5 flowing wells and 143 pumping wells.

The deep exploratory wells of Chauk oil field go down to the Shwezetan formation, but the sandstone in this part of the field contains only edge water.

The geological stratigraphy around the oil fields is as follows:

Stratigraphy	Thickness (feet)
Irrawaddy sands	10,000
Kyaukkok sands	600
Pyawbwe clays	1,100
Okhmintaung sands	1,700
Padaung clays	3,600
Schwezetan sands	over 3,000

FIG. 2-13 CROSS SECTION OF CHAUK OIL FIELD



The thicknesses of the main reservoirs of Chauk oil field are as follows:

Name of oil reservoir	Thickness of reservoir	Porosity	Permeability (Air)
Stray sands	40'		
A sands	140 - 160'	22.8%	306 - 1,265 md
1st "	130 - 160'	25%	1,370 md
2nd "	20 - 45'		
3rd "	110 - 120'		
4th "	80 - 100'		
5th "	120 - 150'		
6th "	} 280'		
3,000' "			
3,300' "	90 - 110'		
3,700' "	150 - 175'		
4,100' "	200'		
Total	1,460'		

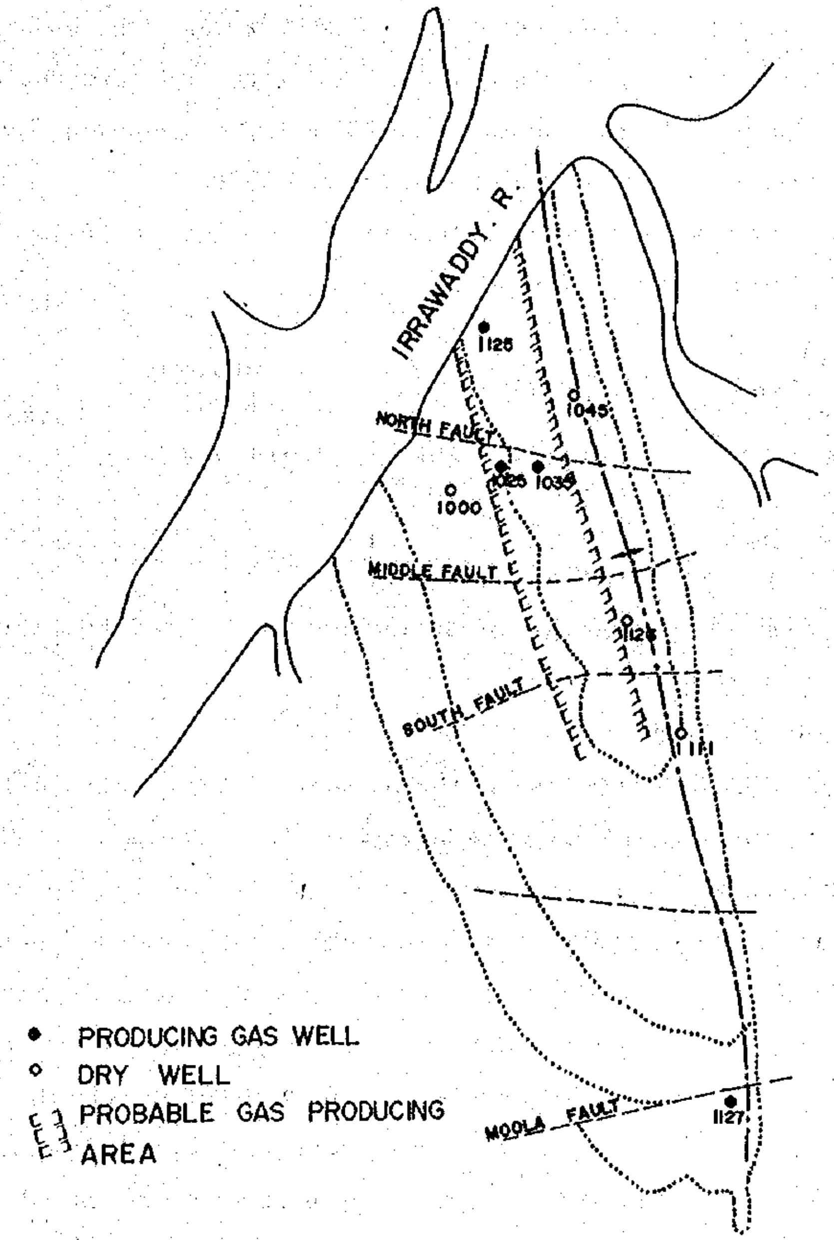
Chauk subthrust gas field

In 1960 three deep exploratory wells were drilled and gas fields were discovered in the subthrust structure of Chauk oil field.

Three wells are as follows:

Chauk No. 1025 well	8,635'
No. 1045 well	8,410'
No. 1045 well (side track)	2,284'

FIG. 2-14 CHAUK OIL FIELD



It was made apparent that oil reservoirs in the Suprathrust lay in the subthrust by the drilling of No. 1025 well. Further, it was confirmed that the 3,700 feet reservoir contained water and this reservoir does not contain oil but gas, by the drilling of No. 1045 well for the purpose of increasing oil production by development of this oil field.

The components of this gas are methane (95.96%), ethane (2.02%), propane (0.69%) and butane & heavier (1.33%). The production capacity per well is about 1.5 - 2 MMCF/D. The gas reservoir in the subthrust consists of three main gas reservoirs, namely, 1st sands, M-5th sands and 3,700 feet sands and supplies gas to a fertilizer plant completed at Sale in 1970.

The total gas amount supplied for 3 - 5 years by September 30, 1973 was 3,939,533 MMCF.

Gas well	Producing zone	Cumulative amount	B.H.P.
No. 1125	7,884' - 7,890' 7,910' - 7,925'	3,910.094 MMCF	3,403 psi
No. 1145	4,370' 7,495 - 7,550'	571.555 MMCF	3,204 psi

In 1975 gas production of Chauk subthrust was 2,800 MMCF.

2.5.3 Mann oil field

The Mann oil field lies in the northern extension of the Minbu anticline and in 1967 gravity exploration was made in this area. The Minbu anticline plunges toward the north, but it was estimated from survey results that the anticlinal structure extends to the northern area of the Mann river. In 1968 a seismic survey was made in this area and the result was studied in August of the same year. The existence of a cross cut fault which cuts the anticline from east to west was confirmed and a proposed site for the wildcat was decided by estimating the probability of oil field formation in a fault trap.

The first wildcat well in 1969 discovered oil, and production began in 1972. 16 exploitation wells (80%) were successfully drilled from a total of 20 exploitation wells drilled from 1971 to 1972 and each produced 266 b/d on average.

FIG. 2-15 PRODUCTION HISTORY (MANN)

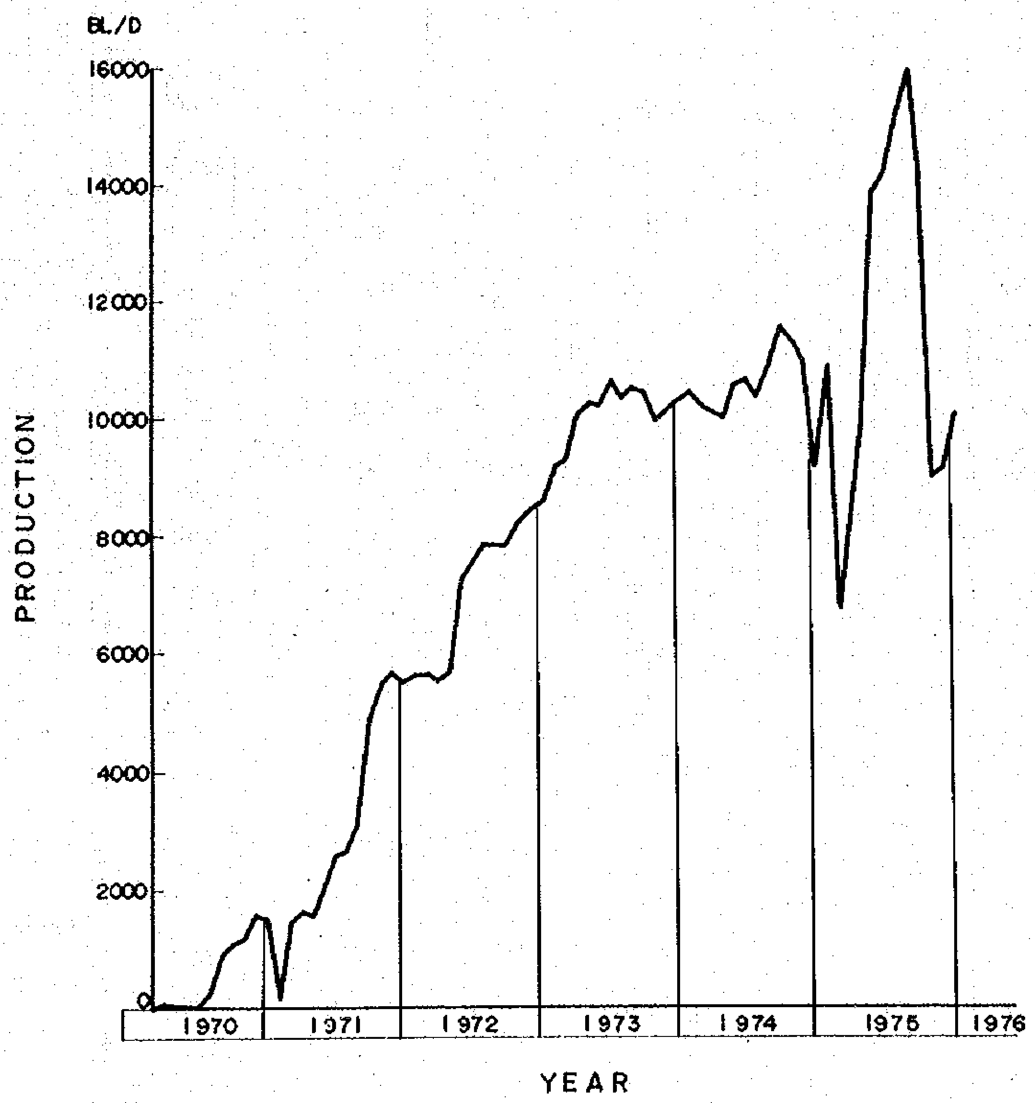


TABLE 2-17 WELLS DRILLED IN MANN OIL FIELD

Well No.	Termination Depth (Ft)	Reservoir Depth	Bean	GOR	Tub. Press. (PSI)	Production (BL/D)
7	4,280	3,800	26/64	381	350	483
15	5,885	3,700	24/64	419	-	786
		3,800	"	523	490	580
16	4,700	3,700	"	425	-	613
		3,800	"	186	330	456
18	3,500	3,300	18/64	5,212	350	120 (Water 330)
19	4,569	3,900	"	226	250	195 (Water 84)
20	4,010	L.3,300	Abandoned			
21	3,500		Abandoned			
22	2,612		Abandoned			
23	4,102	3,700	20/63	474	-	630
		3,800	"	679	445	535
24	6,000	4,100	"	1,690	350	142
26	4,219	3,900	"	351	-	111
28	5,500	3,800	18/64	1,150	-	355
		3,900	"	2,208	780	381
29	7,200		Abandoned			
30	2,447	3,300	18/64	-	-	13 (Water 3)
32	5,200	3,800	20/64	337	350	412
33	3,700	3,300	18/64	-	-	14
34	3,600	4,800	20/64	-	190	108
35	6,614	U.4,500	"	659	450	214
		L.4,500	"	2,111	450	153
37		4,400	"	-	1,140	55 (Water 14)
39		4,800	"	586	340	311

TABLE 2–18

Well No.
Sand

PRODUCTION HISTORY
Field MAIN OIL FIELD

Square
Block

No. of welds	Date		Oil			Gas		Gas oil ratio cu.ft/bl	Water			Water cut %	Water oil ratio
	Month	Year	B.P.D.	Barrels per month	Cumulative barrels	Mcf per month	Cumulative mcf		B.F.D.	Barrels per month	Cumulative barrels		
	Apr.	1970	43.7	1311	1311	2560.0	2560.0	1953					
	May		–	–	1311		2560.0	–					
	Jan.		–	–	1311		2560.0	–					
	July		16.6	515	1816	347.4	2907.4	675					
	Aug.		229.7	7122	8938	8277.3	11185.9	1162					
	Sept.		926.0	27780	36718	22636.3	33821.6	815					
3	Oct.		1073.7	33286	70004	26149.5	59971.1	794					
5	Nov.		1173.2	35197	105211	33112.8	93083.9	940					
6	Dec.		1592.6	49370	154581	51114.6	144198.5	1035	6.1	188	188		
6	Jan.	1971	1488.5	46144	200725	89920.3	234118.8	1948	1.8	55	243		
	Feb.		161.1	4510	205235	4220.3	238339.1	935	13.2	369	612		
7	Mar.		1411.1	43745	248980	47999.3	286338.4	1097	7.3	225	837		
7	Apr.		1604.8	48143	297123	59808.6	346147.0	1242	5.1	152	989		
7	May		1578.7	48939	346062	54189.6	400336.6	1184	15.2	470	1459		
	June		2030.7	60919	408981	60635.4	460972.0	1153	57.8	1878	3194		
10	July		2591.3	80330	487311	87281.8	548253.8	1081	32.1	996	4190		
10	Aug.		2615.2	81070	568381	84386.0	632639.8	1041	30.6	947	5137		
12	Sep.		3151.2	94535	662916	99538.8	732178.6	1053	41.7	1251	6388		
15	Oct.		4918.9	152487	815403	105186.8	837365.4	690	230.1	7132	13520		
16	Nov.		5435.2	163057	978460	104538.6	941904.0	645	176.5	5294	18814		
18	Dec.		5660.8	175485	1153945	123679.6	1065583.6	705	185.7	5758	24572		
18	Jan.	1972	5551.9	172108	1326053	131747.0	1197330.6	765	165.7	5137	29709		
18	Feb.		5633.9	163383	1489436	119753.2	1317083.8	733	150.0	4561	34060		
20	Mar.		5646.6	175044	1664480	139154.8	1456238.6	795	139.6	4328	38388		

No. of welds	Date		Oil			Gas		Gas oil ratio cu.ft/bl	Water			Water cut %	Water oil ratio
	Month	Year	B.P.D.	Barrels per month	Cumulative barrels	Met per month	Cumulative mcf		B.F.D.	Barrels per month	Cumulative barrels		
21	Apr.		6555.3	196659	1861139	169040.2	1625278.8	860	134.9	4046	42343		
23	May		6568.9	203638	2064777	212036.7	1837315.5	1040	140.0	4341	46775		
24	June		7234.2	217025	2281802	229407.6	2066723.1	1057	140.5	4216	50991		
26	July		7531.0	233461	2515263	248827.1	2315550.2	1066	122.0	3783	54774		
27	Aug.	1972	7866.3	243856	2759119	237889.0	2553439.2	976	116.1	3599	58373		
28	Sept.		7872.2	236167	2995286	243510.5	2796949.7	1031	113.2	3396	61769		
30	Oct.		7878.8	244242	3239528	279433.4	3076383.1	1144	109.5	3393	65162		
32	Nov.		8266.5	247995	3487523	322350.9	3398734.0	1300	93.6	2807	67969		
33	Dec.		8473.0	262663	3750186	364931.9	3763666.9	1389	91.1	2825	70794		
35	Jan.	1973	8588.8	266251	4016437	404026.9	4167692.8	1518	68.0	2108	72902		
36	Feb.		9142.3	255983	4272420	409273.0	4576955.8	1599	78.2	2196	75098		
39	Mar.		9270.3	287378	4559798	517513.3	5094479.1	1801	113.4	3516	78614		
38	Apr.		10029.3	300873	4860671	553963.6	5648442.7	1841	123.3	3700	82314		
36	May		10291.9	319048	5179719	584017.4	6232460.1	1831	149.5	4635	86949		
40	June		10221.5	306644	5486363	625046.0	6857506.1	2038	170.8	5295	92244		
42	July		10652.7	330240	5816603	706270.0	7563776.1	2139	249.9	7746	99990		
44	Aug.		10357.9	321097	6137700	656141.0	8219917.1	1043	238.9	7169	107159		
45	Sept.		10521.2	315637	6453337	604314.2	8824231.3	1915	224.9	6971	114130		
44	Oct.		10452.2	324019	6777356	641387.9	9465619.2	1979	185.6	5727	120000		
45	Nov.		9985.3	299560	7076916	606958.4	10072577.6	2026	151.8	4555	124555		
44	Dec.		10134.2	314160	7391076	642533.6	10715111.2	2045	197.4	6118	130673		
46	Jan.	1974	10339.7	320532	7711608	667809.6	11382920.8	2083	284.0	8804	139477		
	Feb.		10439.0	286682	7998290	633904.3	12016825.1	2211	376.9	10554	150031		
49	Mar.		10292.4	319067	8317357	710296.7	12727121.8	2226	421.8	13077	163108		
48	Apr.		10192.2	305766	8623123	688532.6	13415654.4	2252	362.5	10875	173983		
52	May		10024.2	310749	8933872	716989.1	14132643.5	2307	335.0	10385	184368		
50	June		10624.6	318738	9252610	723376.8	14856020.3	2270	671.5	20146	204514		

No. of welds	Date		Oil			Gas		Gas oil ratio cu.ft/bl	Water			Water cut %	Water oil ratio
	Month	Year	B.P.D.	Barrels per month	Cumulative barrels	Met per month	Cumulative mcf		B.F.D.	Barrels per month	Cumulative barrels		
50	July		10695.0	331546	9584156	742241.9	15598262.2	2239	574.5	17811	222325		
51	Aug.		10366.6	321364	9905520	762096.2	16360358.4	2371	536.5	16632	238957		
52	Sept.		10937.3	328119	10233639	748972.4	17109330.8	2283	553.5	16605	255562		
53	Oct.		11568.6	358627	10592266	722964.3	17832295.1	2016	510.2	15818	271380		
55	Nov.		11301.6	339049	10931315	587867.4	18420162.5	1734	393.9	11816	283196		
59	Dec.	1974	10948.0	339389	11270704	705682.0	19125844.5	2079	357.1	11085	294281		
57	Jan.	1975	9208.7	285452	11556156	531255.6	19657100.1	1861	319.3	9899	304180		
58	Feb.		10910.7	305500	11861656	524808.6	20181908.7	1718	301.8	8910	313090		
61	Mar		6769.9	189559	12051215	301496.7	20483405.4	1591	336.1	10440	323530		
68	Apr.		8287.1	256901	12308116	498581.6	20981987.0	1941	394.5	11835	335365		
62	May		10059.8	311853	12619969	548550.9	21530537.9	1759	389.8	12084	347449		
62	June		13894.7	416841	13036810	648435.2	22178973.1	1556	429.7	12891	360340		
62	July		14319.3	443899	13480709	680626.3	22859599.4	1533	404.2	12529	372869		
64	Aug.		15252.8	472837	13953546	734864.7	23594464.1	1554	403.1	12497	385366		
66	Sept.		15984.0	479521	14433067	690872.4	24285336.5	1441	404.0	12120	397486		
67	Oct.		14211.1	440543	14873610	639800.8	24925137.3	1452	396.4	12289	409775		
70	Nov.		9013.7	270412	15144022	306537.9	25231675.2	1134	396.5	11896	421671		
71	Dec.		9157.0	283867	1527889	313729.2	25545404.4	1105	348.6	10806	432477		
73	Jan.	1976	1008.4	312594	15740483	339741.8	25885146.2	1087	309.2	9584	442061		

2.5.3.1 Original oil in place.

The original oil in the Mann oil field is estimated to have been 390 million barrels as shown in Table 2.19, with each block and reservoir calculated individually using the volumetric method. The conditions are satisfied in Tables (1)-(3) for the probable reserves and in Tables (4) and (5) for the proved reserves.

(1) Rock characteristic (EC) shows hydrocarbon.

(2) Side wall core plus conventional core shows hydrocarbon.

(3) Testing results of some wells.

(4) Fluid contacts are defined.

(5) Production behavoir is available.

TABLE 2-19 RESERVES AND RESERVOIRS IN MANN OIL FIELD

Formation	Sand	North of 'A' Fault	Fault Block(10^3BL)				South of SLB Fault	Reserves (10^3BL)		
			A-B	B-C	C-D	D-SLB		Proved	Probable	Total
Kyaukkok	2,200'			4,366*				4,366		4,366
	2,300'			4,043*					4,043	4,043
	U.2,400'			3,701				3,701		3,701
	M.2,400'			7,710	3,408*	456		8,166	3,408	11,574
	L.2,400'			7,710	4,009*				11,719	11,719
	Total							16,233	19,170	35,403
Pyawbwe	2,700'				15,586			15,586		15,586
	2,800'				18,607			18,607		18,607
	3,000'				746*				746	746
	3,200'				11,579**			4,229	7,350	11,579
	U.3,300'				17,765*				17,765	17,765
	M.3,300'				4,681			4,681		4,681
	L.3,300'				17,264**	10,095		24,281	3,078	27,359
	3,600'		1,062*	12,398*	11,897	1,304		11,897	14,764	26,661
	Total							79,281	43,703	122,984
Okhmintaung	3,700'	3,169*	1,801	26,602	21,347			49,750	3,169	52,919
	3,800'	3,587	2,646	25,465	26,593			58,291		58,291
	3,900'		1,642	7,559	3,432	1,292		13,916		13,916
	Total							121,957	3,169	131,126
Padaung	4,000'		525*	2,177*	2,527*	1,756		1,756	5,229	6,985
	U.4,000'	154*	4,280	3,395	2,574	636		10,885	154	11,039
	L.4,000'		2,140*	1,940	1,475	4,097		5,142	4,510	9,652
	U.4,300'					1,520		1,520		1,520
	L.4,300'					597*			597	597
	U/L4,300'		1,945*			136		136	1,945	2,081
	4,400'	4,592	7,232	6,199	3,617**	910		21,174	1,374	22,550
	4,500'	5,748	10,108	3,645	4,135**			23,266	370	23,636
	4,600'	1,970*	5,180*	2,927*	651*				10,728	10,728
	4,700'A	2,094	2,339					4,433		4,433
	4,700'B	2,710*	1,221*						3,931	3,931
	4,700'C		888*						888	888
	4,700'D		525*						525	525
	4,700'F		700*		506			506	700	1,206
	5,100'?						6,863	6,863		6,863
	Total							75,681	30,951	106,634
TOTAL								293,154	96,993	390,147

* Probable   ** Partly Probable

2.5.3.2 Production status

Mann oil field produced 15,427,889 barrels up to the end of 1975 since the start of production in April 1970. The number of production wells as of February 1976 was 75 with a capacity of about 17,000 b/d, but the transport of crude oil by water on the Irrawaddy river is limited in the dry season, so that the production capacity is limited to about 12,000 b/d during this period.

The main producing reservoirs lie at depths of 3,700 feet and 3,800 feet and the production from these formations reached 9,209,007 barrels by the end of 1975. Pressure maintenance in this reservoir has been performed from December 1974 by the Peripheral method of water flooding by each fault and by block.

The present amount of water injection is 800 b/d for 4 injection wells. Gas injection from the top of the structure has been conducted and 4 MMCFD of gas have been injected by two gas injection wells. Gas and water injection are scheduled to be gradually applied to the other reservoirs.

2.5.3.3 Calculation of crude oil recovery by water flooding at 3,700 feet and 3,800 feet.

The reasons why these two formations of oil reservoirs were selected for the water injection are that (1) they were the most prolific oil sands and are anticipated to have about 112 million barrels of oil in place, (2) both reservoirs have very large declines of pressures inside the A-C and C-D fault blocks, (3) the pressure of oil reservoirs has already neared the bubble point, (4) displacement energy is mainly due to solution gas drive, and (5) the character of reservoir rocks and flows is appropriate for the water flood method and the estimation of crude oil recovery by water flood shows good results.

1) Situations of primary oil reservoirs

Reservoirs	Fault block	Pressure of reservoirs
3,800' reservoir	C - D	2,313 psi at 4,800' ssl
	B - C	2,518 psi at 4,800 ssl
3,700' reservoir	B - C	original gas cap
	C - D	no gas cap

2) Lateral development of reservoirs.

The 3,700 feet reservoir has one or two sheets of shale streaks in the northern part, and 3 or 4 sheets in the far northern part. The 3,800 feet reservoir has more shale streaks and the most homogeneous sand bodies with significant sand in wells (48, 31, 23, 37, 68).

The oil water contact inclines at 8 - 10 degrees to the west and the oil column of the western part becomes 400 - 900 feet thicker than that of the eastern part.

3) Reservoir engineering aspect

(i) (A - B) fault block: No. 35, 56 well, only 3,800 feet reservoir for No. 76 well.

(ii) (B - C) fault block

3,700 feet reservoir: 600 b/d of initial production by No. 3 well in September 1970.

1,883 b/d at peak production by No. 15 well and No. 27 well as of October 1971 and a gas-oil ratio of 2,546 cf/b (6 wells, September 1973).

167,000 barrels of production up to September 1974 and 230,000 barrels of production up to December 1975.

Producing wells at present are No. 3, 15, 27, 49, 46, 42, 24, 17 and 31.

3,800 feet reservoir: 412 b/d by No. 4 well as of November 1970 and gas-oil ratio of 1,443 cf/b.
No. 14 well drilled (3800' and 3900') as of July 1971.
No. 3 well drilled as of September 1971.
At present 36 acres/well, 8 wells (4, 14, 15, 28, 31, 42, 49, 46)
Peak production of 1,667 b/d, gas-oil ratio of 3,082 cf/b (September 1973)
157,000 barrels of cumulative production as of October 1974.
190,000 barrels of cumulative production as of December 1975.

(iii) C-D fault block

3,700 feet reservoir: 600 b/d production was started by No. 16 well (3,700 feet reservoir and 3,800 feet reservoir) as of September 1971, gas-oil ratio of 424 cf/b
Present production of 2,082 b/d by 11 wells (No. 2, 5, 7, 16, 23, 37, 38, 51, 68, 85, 87), gas oil ratio of 1,358 cf/b. 127,000 b/d of cumulative production up to October 1, 1974.
210,000 b/d of cumulative production up to the end of 1975.

3,800 feet reservoir: Production was started by No. 16 well as of September 1971, 451 b/d of production, gas-oil ratio of 215 cf/b.

13 wells (2, 7, 16, 23, 32, 37, 41, 43, 47, 68, 85, 86, 38), 36 acres/well, 164,000 barrels of cumulative production up to September 1974.

4) Primary performance

(i) B-C fault block

3,700 feet reservoir: Original pressure 2,599 psi at 4,700 feet bubble point pressure 2,000 psi by PVT test of No. 3 well.

3,800' reservoir: No. initial PVT, No. 4 well, original pressure of 2,518 psi at 4,800', 412 b/d of production, gas-oil ratio of 1,443 cf/b. From the result of PVT at 3,700 feet reservoir and No. 4 well at 3,800 feet reservoir, it was assumed that there would be no gas cap. According to the calculation of depletion drive by Schilthuis method, recovery factor resulted in 32.7%.

(ii) C-D fault block

3,700 feet reservoir: No. PVT

3,800 feet reservoir: From PVT of No. 7 well, original reservoir pressure 1,750 psi at 3,250 feet bubble point pressure 1,315 psi. Active gravity segregation is considered in both reservoirs.

3,700 feet reservoir: Gas cap plus solution gas drive.

3,800 feet reservoir: Solution gas drive plus some gravity drive first recovery of 32% at 3,700 feet reservoir and of 25.5% at 3,800 feet reservoir for the original oil in place.

5) Recovery factor with water flooding

The following results were acquired by Stiles method.

(i) Estimation of recoverable reserves by water flooding (Table 2-20)

TABLE 2-20 WATER FLOODING DATA

	3800 ft Formation		3700 ft Formation	
	A - C Block	C - D Block	A - C Block	C - D Block
Pv = Pore Volume ($x10^6$BBL)	37.806	36.866	36.008	28.72
Oil in Place (N) ($x10^6$STB)	22.330	22.897	21.049	17.30
Cum. Production (NP) ($x10^6$STB)	1.695	1.825	1.950	1.400
$So = \left[\frac{1-Sw}{Boi} - \frac{Np}{PV}\right] \times Bo$ (Oil Saturation at Start of water flood (Jan. 1, 1975))	0.7398	0.7361	0.7235	0.7196
Oil in Place at start of water flood (Jan. 1, 1975)	20.641	21.070	19.100	15.897
Residual Oil Saturation	0.33	0.33	0.33	0.33
Mobil Oil at Start of Water flood ($x10^6$STB)	11.434	11.624	10.388	8.607
Es (Aerial Sweep Efficiency)	0.9	0.9	0.9	0.9
Recoverable Oil	10.291	10.462	9.349	7.746
Sg = 1-Sw-So(Sw = 0.205)	0.0552	0.0589	0.0715	0.0754
Fill up Volume ($x10^6$STB)	2.087	2.171	2.575	2.165
Injection Rate x Well Numbers	540 x 5	500 x 6	540 x 5	500 x 6
Fill up Time (Days)	773	724	954	722

(ii) Results of calculation by Stiles method

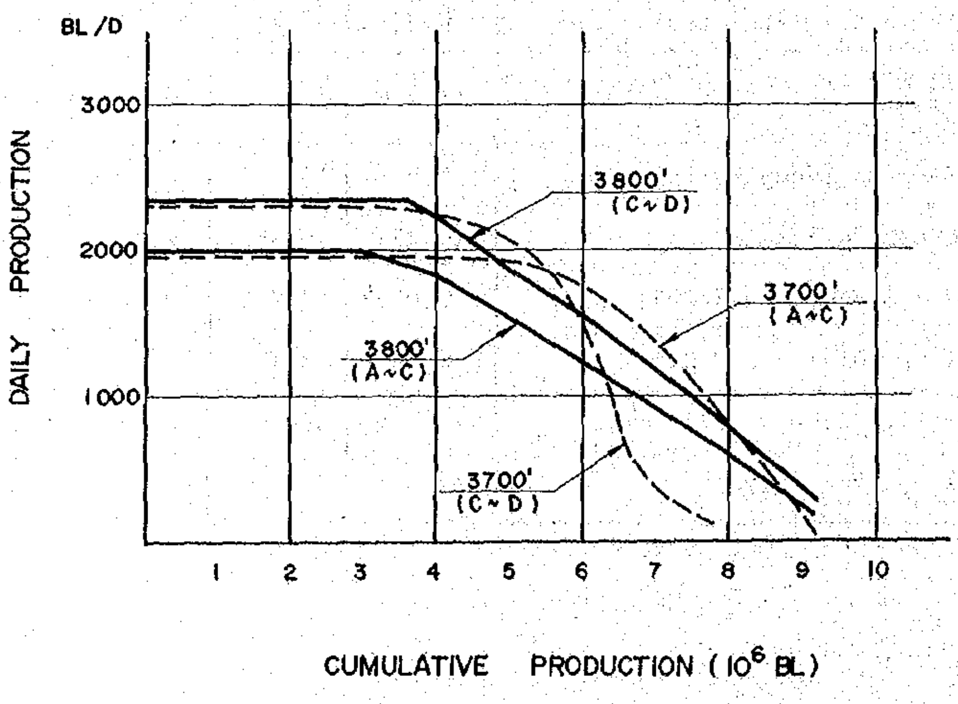
Based on the Estimation of (i) and assuming that economic limit will be up to water cut of 96%, the results were acquired and shown in Table 2-21.

TABLE 2-21 RESULTS FROM STILES METHOD

Name of reservoir	Block	Cumulative production from Jan., 1975 1,000 BL	Cumulative production 1,000 BL	Recovery factor %
3,700'	A-C	9,069	11,019	52.4
"	C-D	7,514	8,163	51.5
3,800	A-C	9,468	11,163	50.0
"	C-D	9,625	11,451	50.0

The forecastings of production performance for each reservoir are shown in Fig. 2-16.

FIG. 2-16 WATER FLOOD PERFORMANCE ESTIMATE (MANN)



2.5.3.4 Recoverable reserves of Mann oil field

In reference to the appraisal of the crude oil recovery ratio to 3,700 feet and 3,800 feet reservoirs, recoverable reserves by reservoirs at the first recovery and the secondary recovery are calculated in Table 2-22.

TABLE 2-22 RECOVERABLE RESERVES (MANN)

Reservoir	Number of producing wells	Producing wells (Dec.,1975)	Original deposit	Probable reserves (10^3BL)			Cumulative production (1975 end)	Recoverable reserves after 1976		
				Primary recovery	Secondary recovery	Total		Primary recovery	Secondary recovery	Total
2,200/2,400	4	4	35,403	10,621	7,080	17,701	381,226	10,240	7,080	17,320
2,700/2,800										
3,000/3,200	21	28	112,984	36,897	24,599	61,496	2,821,176	34,076	24,599	58,675
3,300/3,600										
3,700/3,800	14	24	111,210	33,363	22,239	55,602	9,209,007	?	?	46,393
3,900	1	1	20,901	5,921	4,179	10,100	741,334	5,180	4,179	9,359
4,000										
4,100		2	20,691	5,173	4,138	9,311	8,380	5,165	4,138	9,303
4,300	1	1	4,198	1,049	840	1,889	517,076	532	840	1,372
4,400/4,500	4	8	46,186	11,548	9,189	20,737	127,383	11,421	9,189	20,610
4,600		1	10,728	2,682	2,146	4,828	971,268	1,711	2,146	3,857
4,700			10,983	2,744	2,199	4,943	8,438	2,206	2,199	4,405
4,800							529,474			
5,100/others	2	2	6,863	6,863	1,716	3,087	113,127	1,603	1,371	2,974
Total			390,147	111,714	77,980	189,694	15,427,889			174,266

2.5.3.5 Estimation of future trend in production

The oil reservoirs of Mann oil field are divided into the following groups and the future trend of production is estimated for each group.

Group	Reservoirs
I	2,200', 2,400'
II	2,700', 2,800', 3,000', 3,200', 3,300', 3,600'
III	3,700', 3,800'
IV	3,900', 4,000', 4,100'
V	4,300', 4,400', 4,500'
VI	4,600', 4,700', 4,800', 5,100'

The number of exploitation wells per year was taken from the plan proposed by MOC. The estimated production trend was calculated for the following three cases.

1: Assuming that water flooding would be applied in all formations. The production rate per well remains steady until the cumulative production reaches 10% of oil in place and thereafter declines linearly.

2: Assuming application of methods as in case, 1, but that production rate declines linearly from the start of production.

3: Assuming that water flooding methods are applied only to the 3,700 ft and 3,800 ft reservoirs and that other reservoirs are recovered by natural depletion. The production rate is similar to case 2.

TABLE 2-23 NUMBER OF EXPLOITATION WELLS

Year	Reservoir Group	Number of wells
1976	I, II, III	35
1977	II	35
1978	II	35
1979	IV	30
1980	IV	30
1981	V	20
1982	V	20
1983	V	20
1984	VI	20
1985	VI	20
Total		265

FIG. 2-17 PRODUCTION ESTIMATE (MANN)

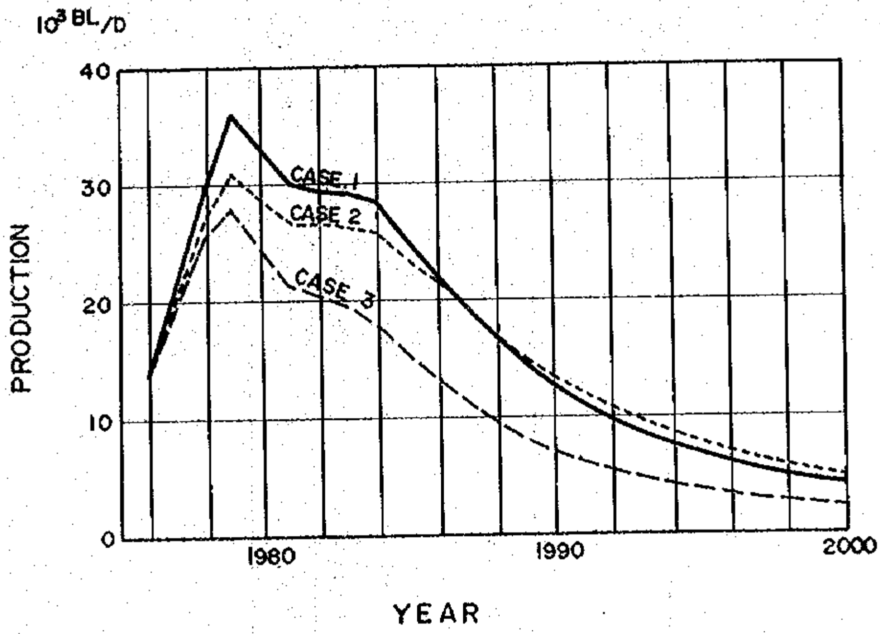


TABLE 2-24 RESERVES (MANN)

Formation	Total Pay Zone Thickness Ft	Initial Original Deposit 10^3STB			Primary Recovery Reserve 10^3STB			Additional Recovery by water & gas Injection	Total Recovery 10^3 STB	Cumulative Production up to Jan.1, 1976 10^3STB	Future Recovery 10^3 STB
		Proved	Probable	Total	Proved	Probable	Total				
Kyaukkok	114	16,233	19,170	55,403	4,870	5,751	10,621	7,080	17,701		
Pyawbwe	204	79,281	43,703	122,984	23,785	13,112	36,897	24,600	61,497		
Okhmintaung	100	121,957	3,169	125,126	36,589	950	37,539	25,000	62,539		
Padaung	237	75,683	30,951	106,634	18,921	7,736	26,657	21,300	45,957		
Total	655	293,154	96,993	390,147	84,165	27,549	111,714	77,980	189,694	15,428	174,266

2.5.4 Minbu oil field group

The Minbu oil field was discovered by BBP in 1910. The Minbu anticline is located in the south or Yenangyaung and the structures correspond to the western trend of Chauk-Yenangyaung.

The structures are long in the north-south direction, but very complicated and 6 oil fields were discovered on the anticline.

These are, from the north, as follows:

1. Shawellinban oil field
2. Taukshabin "
3. Palanyon "
4. Tontaung "
5. Yethaya "
6. Pepi "

These oil fields were developed in the pre-war period and a small amount was produced there even in the post-war period.

The total production to the end of 1942 amounted to 3,315,482 barrels.

The Minbu anticline extends for 20 miles and the anticlinal axis is directed NNW-SE with sharp inclination on both wings, particularly on the west wing with an inclination of 50 - 60 degrees.

The oil accumulation exists at the top of this asymmetric structure.

In the shallow oil fields developed in the pre-war period oil accumulated in the high portion of the nose structure which declines to the north. Palanyon oil field has oil accumulation in the high points of the north side which declines to the south.

A very small amount of oil was found in the lower part of the thrust in the western flank in 1960.

TABLE 2-25 OIL PRODUCING STRATA IN MINBU OIL FIELD GROUP

Name of field	Oil producing strata	Initial daily production/well	Depth(Ft)
Shwelinban	Upper Padaung, Okhmintaung, Pyawbwe	Padaung:20-50b/d, Pyawbwe:100-200b/d	600'-1,500'
Taukshaban	Padaung, Pyawbwe		500'-2,000'
Palanyon	Upper Padaung, Okhmintaung, Pyawbwe on the subthrust		2,600'-2,700'
Tontaung	Padaung	20-100b/d	600'-1,200'
Yethaung	Kyaukkok	10-50b/d	200'- 600'
Yethaya	Kyaukkok	200b/d	500'-1,500'

2.5.4.1 Exploration of deeper reservoirs in the Minbu area

6 oil fields were found in reservoirs shallower than 1,500 feet in the Minbu area in the pre-war period, and crude production was performed, but a wildcat well was recently drilled to explore the deeper reservoirs in this area.

Pepi area : Pepi No. 1 well drilled recently discovered the following gas reservoirs.

Test interval	Oil and gas production
6,200' - 6,250'	trace of oil and gas
5,085' - 5,110'	no flow
5,050' - 5,070'	19,260 CF/2HR
5,020' - 5,035'	18,060 CF/2HR
4,830' - 4,840'	0.393 MMCF/D
4,720' - 4,735'	0.37 MMCF/D
4,675' - 4,705'	0.41 MMCF/D
4,635' - 4,645'	0.1488 MMCF/D
4,588' - 4,596' }	0.477 MMCF/D
4,606' - 4,622' }	
4,280' - 4,300'	0.1904 MMCF/6HR
3,662' - 3,672'	1.551 MMCF/D
3,525' - 3,540'	0.9392 MMCF/D
3,235' - 3,310'	not tested
2,680' - 2,700'	1,586 MMCF/D
1,025' - 1,040'	water

Chapter 3.

PETROLEUM REFINERY INDUSTRY

Chapter 3

PETROLEUM REFINING INDUSTRY

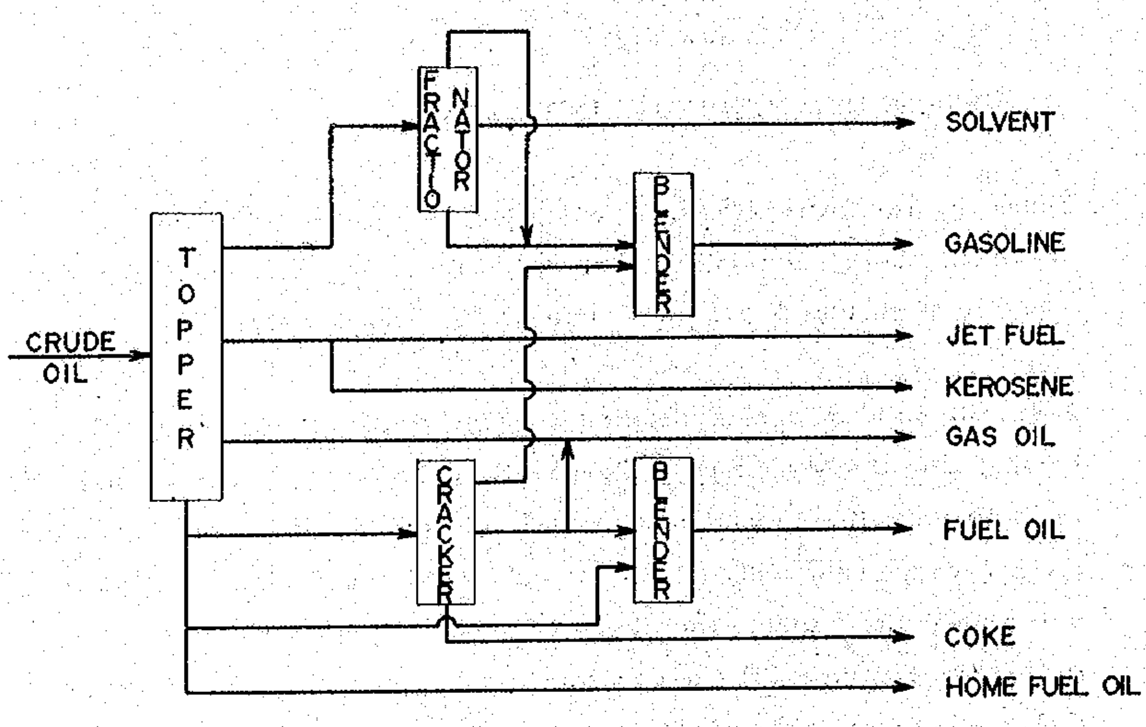
There are two refineries in Burma, one is Syriam and the other is Chauk. Both refineries are in operation with crude oil processing capacity of 20,000 BPSD and 7,000 BPSD respectively.

From the point of organization, the refineries had been operated belonging to the Myanma Oil Corporation, however, when the government organizations were reorganized on April 1, 1975, they became the property of the Petrochemical Industry Corporation which is sub-organization under the Ministry of No. 2 Industry. Furthermore, the Myanma Oil Corporation is under the Ministry of Mines and is at present operating for development and production of crude oil.

The Syriam Refinery is located on the opposite side of the city of Rangoon across the Rangoon River. The refinery facilities have been reconstructed from those which remained following the War. The refinery began operations again in 1957 and since that time several works for reinforcement and expansion have been made which has enabled it to reach its present scale of production.

The main refining facilities are Topper, Gasoline Fractionator, Cracker and simplified block flow of the refinery is shown in Fig. 3 - 1.

FIG. 3-1 SIMPLIFIED BLOCK FLOW OF SYRIAM REFINERY



The curde oil processed at the Syriam Refinery is domestic crude produced from oilfield, in Central Burma, the core of which is the Mann oilfield. The domestic crude oil of Burma is a low sulfur oil (Mann crude oil contains 0.11 wt% of S), and light fractions have a high content of aromatics and naphthene and heavy fraction is paraffinic.

As shown in the foregoing block flow, the refining scheme of the Syriam Refinery is comparatively simple. As the crude oil has a low sulfur content, desulfurizing processes are unnecessary; also straight run gasoline from Topping Unit has a high octane number and it is not necessary to improve its octane number by Reforming process.

So one can manufacture its product only by the addition of lead. Further, the refining processes for the main products are herewith explained briefly;

- Gasoline

  Straight run gasoline from the Topper is fed to the Gasoline Fractionator where several types of solvents and motor gasoline are fractionated separately. Motor gasoline of 79 ON is manufactured by adding about 0.8 cc/gal-TEM to gasoline fraction from Gasoline fractionator which has about 69 ON without lead.

- Kerosene

  Although smoke point of kerosene fraction is low, a smoke point improver has not been provided, and kerosene product has a smoke point of 19 mm or 20 mm. It may be added that the smoke point is limited as 23 mm if we follow JIS specifications, and kerosene product in Japanese market has a smoke point of 24 mm or 25 mm.

- Gas Oil

  Gas oil fraction is fairly rich in naphthene and the cetane number is comparatively low. However, in actual fact, product is being manufactured without measures for desulfurization and cetane improvement. Even so, finished gas oil product has a low sulfur content of below 1.0 wt%.

- Fuel Oil

  As environmental problems are not so serious in Burma as of yet, and as domestic crude oil has a low sulfur content, fuel oil does not require desulfurization. However, from the point of view of handling, only pour point presents a problem in manufacturing. In actual fact, topped crude from Topping Unit is to be cut back to within 50% of gas oil, and then flow improver should be added to obtain a product with a pour point of 75° F. Further, in order to increase production of gas oil which has high demand, topped crude should be cracked with Coker. The by-products of coke are partly used as fuel but most of this coke is exported to Japan which makes use of it in electrode production as it has the special feature of being low in sulfur.

The land area of the Syriam Refinery is 550 acres, the product shipping terminal is located about 2.5 km from the site and is served with 15 pipelines which run from the refinery. At the product shipping terminal there are a pier for the receiving of crude oil, two piers for product shipping, a pier for lubricating oil, a pier for receiving cargo and a pier for general usage making a total of six in all. However, in this region, there is a difference in tide level of approximately 7 meters, therefore, most of these piers are of pontoon type.

The refinery itself is built on a spacious area of land and each facility has been laid out with plenty of room. There are approximately 10,000 persons working at the refinery including personnel employed in the maintenance shops. Thus the refinery itself is the core industry supporting the Syriam area, the population of which is said to be approximately 90,000 persons. As the various facilities of the refinery, most of them, are old and simple as mentioned before, however, the Lube Blending Unit, API Separator and Crude Oil Tanks (with a storage capacity for about twenty days) and a part of the product shipping facilities have been installed over the last several years with new facilities.

In the case of the Chauk Refinery, it is said that the refinery started its operation in 1952 with old facilities transferred from Syriam refinery. The refining facilities at the Chauk Refinery are almost the same as those at Syriam, however, the main difference is that at the Chauk Refinery there is a Dewaxing Unit instead of a Coker Unit, by which the wax contained can be extracted from fuel oil fraction and a wax product obtained.

Further, the Chauk Refinery is closely connected with the surrounding oilfields, and for instance, fuel gas used at the Chauk Refinery is obtained from the surrounding oilfields. Further, the Chauk refinery is the core industry of the surrounding area much the same way as the Syriam Refinery is.

Although the existing facilities at both refineries are comparatively old, the crude oil produced in Burma has, fortunately, a low sulfur content and is the so-called "sweet crude". Therefore, in this case, the worry of corrosion caused by sulfuric compounds is less. There is also a plentiful supply of labour for work at the refinery and maintenance. At present, the operations at the refinery are in good order with an average rate of 86.1% during the period 1971 to 1974.

However, as mentioned before, both refineries at Syriam and Chauk are fairly old from the point of view of equipment and, if both refineries wish to maintain their present production capability in the future, it will be necessary to reinforce the present facilities with new ones. This fact in itself may be the prime motive for pushing the construction of a new refinery and the realization of concrete plans for same.

The distribution of the products from the Syriam and Chauk Refineries covers the whole of Burma through 21 depots and 267 shops which act as distributors. The main depots are at Danidaw and Mandalay.

The performance of distribution is as summarized in Table 3 - 1. The geographical distribution map is as summarized in Fig. 3 - 2.

FIG. 3 - 2 DISTRIBUTION OF PETROLEUM PRODUCTS FROM EXISTING REFINERIES

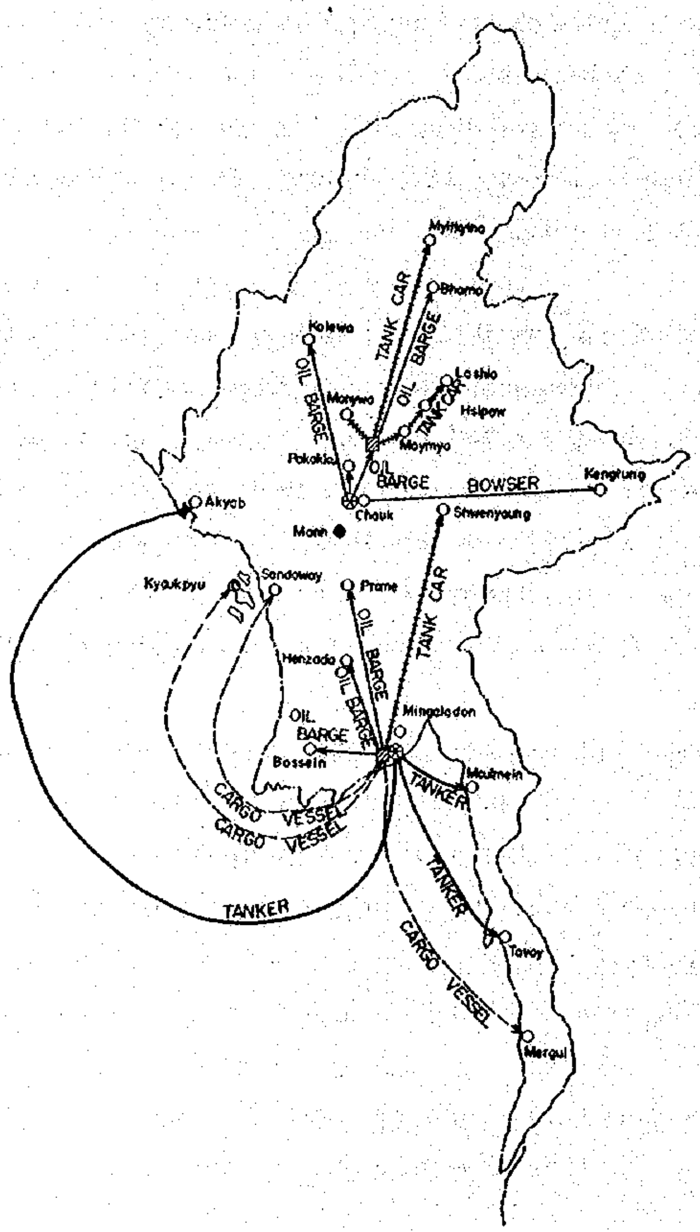


TABLE 3-1 SUPPLY RECORD OF MAIN PRODUCTS

Unit: Thousand IG

		1965 - 66	1966 - 67	1967 - 68	1968 - 69	1969 - 70	1970 - 71	1971 - 72	1972 - 73
MG	Lower Burma	3,025	17,715	17,576	17,695	19,071	19,414	20,376	19,527
	Central & Upper Burma	20,667	27,976	27,785	28,237	27,115	27,617	29,322	27,763
	Total	23,692	45,691	43,361	45,932	46,186	47,031	49,698	47,290
	Thousand U.S. Barrels	676	1,305	1,296	1,312	1,319	1,343	1,420	1,350
KERO	Lower Burma	4,129	20,166	22,558	25,265	29,884	28,966	32,358	29,426
	Central & Upper Burma	12,626	27,989	33,637	38,723	39,554	37,757	44,156	39,954
	Total	16,755	48,155	56,195	63,988	69,438	66,723	76,514	69,380
	Thousand U.S. Barrels	478	1,375	1,605	1,828	1,983	1,906	2,186	1,982
GO	Lower Burma	4,603	25,524	26,778	28,062	31,477	36,363	38,887	37,908
	Central & Upper Burma	18,617	28,563	28,204	31,601	30,867	36,273	35,051	29,709
	Total	23,220	54,087	54,982	59,663	62,344	72,636	73,938	67,617
	Thousand U.S. Barrels	663	1,545	1,571	1,704	1,781	2,075	2,112	1,932
FO	Lower Burma	332	24,189	16,806	17,847	17,594	22,377	21,021	26,167
	Central & Upper Burma	4,168	4,553	5,064	5,810	6,409	6,478	13,713	16,904
	Total	4,500	28,742	21,870	23,657	24,003	28,855	34,734	43,071
	Thousand U.S. Barrels	129	820	624	676	686	824	992	1,230
	Grand Total M Bbls	1,946	5,045	5,096	5,516	5,769	6,148	6,710	6,494

The route of the main product distribution is the longitudinal one which connects Upper, Central and Lower Burma using the Irrawaddy River as the main transportation waterway. The distribution is carried out by large or small size oil barges and cargo vessels which ply up and down the river. Cross country conveyance is carried out by a variety of land transport.

The transportation and distribution of oil products is under the juri-sdiction of the Petroleum Products supply Corporation (PPSC) which is sub-organization of Ministry of No. 2 Industry. Further, the Petroleum Products Supply Corporation is not only in charge of all the actual facets of transportation and distribution, but also supervise each depot.

The oil storage capacity for each depot is summarized in Table 3 - 2.

TABLE 3-2 TANK CAPACITY OF DEPOTS

(In Thousand Imperial Gallons)

Depots	Motor Gasoline	Superior Kerosene	Diesel Oil	Fuel Oil
MAIN DEPOT				
Mandalay	5 x 25	5 x 6	1 x 80	3 x 20
	2 x 30	1 x 50	1 x 8	1 x 50
	1 x 2,000	1 x 1,000	1 x 1,000	1 x 80
	-	1 x 42	1 x 42	-
Total	2,185	1,122	1,130	190
SUB DEPOT				
Myitkyina	2 x 10	-	2 x 4.4	-
Total	20	-	8.8	-
Maymyo	2 x 12	1 x 12	1 x 12	-
Total	24	12	12	-
Monywa	2 x 12	-	1 x 10	-
Total	24	-	10	-
Hsipaw	1 x 12	-	-	-
Total	12	-	-	-
Lashio	5 x 12	1 x 10	2 x 12	-
Total	60	10	24	-
MAIN DEPOT				
Danidaw	4 x 30	2 x 50	1 x 50	3 x 50
	4 x 50	1 x 400	1 x 50	-
	-	-	1 x 400	-
Total	320	500	500	150
SUB DEPOT				
Prome	4 x 40	2 x 40	2 x 40	-
	-	1 x 50	3 x 50	-
Total	160	130	230	-
Akyab	1 x 120	1 x 100	1 x 50	-
	-	-	12 132	-
Total	120	100	182	-
Moulmein	1 x 220	1 x 175	1 x 180	2 x 5
	-	-	2 x 5	-
	-	-	1 x 60	-
Total	220	175	250	10
Tavoy	3 x 50	2 x 50	1 x 200	-
Total	150	100	200	-
Bassein	1 x 50	1 x 50	3 x 50	-
Total	50	50	150	-
Shwenyaung	2 x 25	1 x 20	1 x 40	-
	1 x 40	-	1 x 20	-
	2 x 9	-	-	-
Total	108	20	60	-

Chapter 4.

DEMAND FOR PETROLEUM PRODUCTS

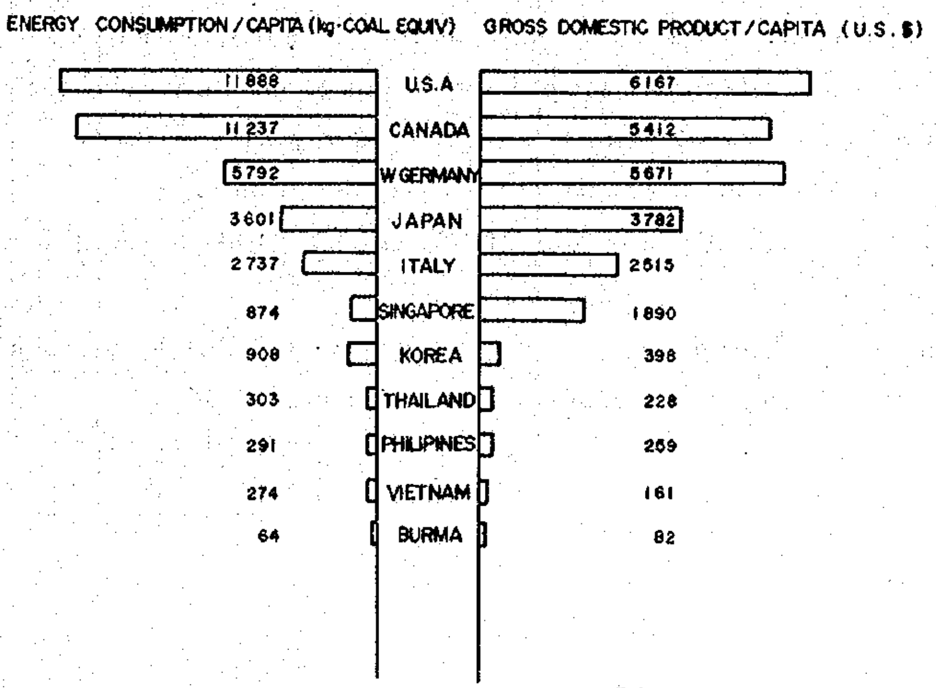
Chapter 4

DEMAND FOR PETROLEUM PRODUCTS

The consumption of energy and the Gross Domestic Product (GDP) in Burma are of a considerably low level when compared with those of other countries.

These indexes are as shown in Fig. 4 - 1, and show the comparison with neighbouring countries.

FIG. 4 - 1 ENERGY CONSUMPTION AND GROSS DOMESTIC PRODUCT OF THE WORLD



FIGURES SHOW ACTUAL RECORD IN 1973

In the same Fig. 4 - 1, there is a comparison with economically advanced countries and, as can be seen, the economical position of Burma is at a comparably lower level as far as the comparative discussion is made based on statistics issued by United Nations.

In other words, if we take 1973 as an example, the GDP per capita in that year was $82 U. S. and the consumption of energy was the equivalent of 64 kg of coal per capita.

With regard to the data concerning the demand for petroleum products, the supply record for the principal petroleum product is as shown in Table 3 - 1 which indicates annual records by area. Production record of domestic crude oil and import record of crude and product are summarized in Table 4 - 2.

Major products for domestic demand are motor gasoline, kerosene, diesel oil, and fuel oil. Besides these, there are solvents, aviation gasoline, jet fuel, coke which is produced at the Syriam Refinery, and parafin wax which is a by-product of the Chauk Refinery: the final two products are, however, mainly for export.
The major petroleum products in high demand is motor gasoline which occupied 22.6%, kerosene 31.7%, diesel oil 31.3%, and fuel oil 14.4%.
According to the production records at Syriam and Chauk, yield of the above-mentioned four products for crude oil is 85%.

TABLE 4–1 GROSS DOMESTIC PRODUCT AND ENERGY CONSUMPTION IN ASIAN COUNTRIES

Year	Burma		Indonesia		Thailand		India		Philippines	
	GDP	Energy Consumption	GDP	Energy Consumption	GDP	Energy Consumption	GDP	Energy Consumption	GDP	Energy Consumption
1960	61		77		96		77		165	
1963	67		74		112		74		181	
1970	78	57	107	112	180	256	104	179	255	292
1971	76	63	118		187		118		278	
1972	68	59	124		198		124		292	
1973	82	64	130	146	228	303	-	188	259	291

Unit
Gross Domestic Product : U.S $/capita
Energy Consumption : Kg-Coal Equivalent/capita

TABLE 4–2 CRUDE PRODUCTION & IMPORTS OF CRUDE OIL AND PETROLEUM PRODUCTS

(Thousand U.S. Barrels)

Year	(A) Crude Production	(B) Crude Import	(C) Products Import	(A + B) x 0.85 + C Products Total	Products Supply
1965	4,425	2,689	101	6,148	-
1966	4,380	1,874	45	5,361	5,045
1967	4,380	1,160	382	5,091	5,096
1968	6,954	764	105	6,665	5,516
1969	6,899	1,808	253	7,654	5,769
1970	6,150	1,712	151	6,834	6,148
1971	6,935	1,902	57	7,568	6,710
1972	7,430	0	1,217	7,533	6,494
1973	7,811	502	347	7,413	-
1974	7,463	1,921	82	8,058	-

Remark: Products Supply Record includes figures of major four products, Motor Gasoline, Super Kerosene, Gas Oil and Fuel Oil.

As use of petroleum products, motor gasoline is used for most vehicles except bowsers, trucks and busses which have diesel engines as shown in Table 4 - 3. Kerosene is used mostly for home use such in the kitchen or for lighting. Diesel oil is used mainly for various forms of transportation and as an industrial fuel for generators. Fuel oil is only used for industrial purposes.

The supply status for the consumer is as shown in Table 4 - 4. The method of distribution for these oil products is through a variety of channels such as depots, sub-depots, gasoline station and small distributor of shop to the consumer.

TABLE 4–3 NUMBER OF CAR REGISTERED

Type of Car	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Saloon Car	13,872	14,186	14,536	14,932	15,004	15,214	15,395	15,609	15,725	16,014
Jeeps	9,862	9,873	9,918	9,971	10,009	10,192	10,270	10,406	10,566	10,631
Station Wagons	593	599	599	630	1,000	1,272	1,602	2,030	2,250	2,334
Vans	3,024	3,214	3,382	3,592	5,420	6,448	7,073	7,543	8,139	8,720
Bowsers/truck	16,906	18,157	19,185	19,662	22,292	23,942	24,916	25,837	26,449	27,668
Buses	6,200	6,337	6,498	6,716	6,837	6,981	7,183	7,312	7,485	7,525
Three-wheeled Cars	2,117	2,122	2,122	2,122	2,122	2,175	2,175	2,175	2,175	2,175
Motor Cycles	5,441	5,523	5,581	5,645	6,675	7,283	7,921	8,248	9,287	9,579
Others	1,160	1,317	1,705	1,707	1,719	1,747	1,730	1,819	1,863	1,917
Total	59,179	61,322	63,526	64,977	71,078	75,254	78,315	80,979	83,939	86,563

TABLE 4-4 1974/75 SALES OF PETROLEUM PRODUCTS TO MAJOR CONSUMERS

(Thousand Imperial Gallons)

Products	Public Sector	State Sector			Other State Organizations	Co-operative	Total
		Agriculture and Forests	Industry	Transport and Communication			
Motor Gasoline	42,528	922	369	1,858	7,854	639	54,170
Superior Kerosene	19,699	27	76	50	371	40,177	60,400
Diesel Oil	25,114	5,649	7,895	17,786	8,072	1,001	65,517
Fuel Oil	1,304	9	18,839	12,511	2,288	201	35,152

In economically advanced countries, various economic analysis methods are taken to estimate the demand in petroleum products. Suffice to say, these methods, when applied to Burma are inadequate in demand forecasing. The main reason for this is that in Burma there is an economic structure which is quite different from other countries in which the aforementioned economic analysis is developed and applied. Therefore, any such analysis in the case of Burma would, as mentioned before, be inadequate and even misleading.

For example, the economic analysis method of using Inter-industries, if applied, is inadequate in Burma at the present stage as the basic industry of the country itself is in the process of construction, therefore, the relationship with the various industries is, in itself, varied, along with the development of future industry.

Further, as stated already, the per capita consumption of energy is very low and, as Burma's economic structure is quite different from other countries, the present demands and/or latent demands are difficult to analyze precisely and basic economic data are difficult to prepare statistically.

As a matter of fact, although our survey was carried out at the refinery site, the necessary data for analizing the problems of supply and demand could not be obtained as desirable format for such purpose of applying conventional economic analysis method. This is because of the different structure of the demand and the unique supply.

Under the aforementioned circumstances, several methods for demand forecast were discussed. As a result, the following basic method was applied in order to get some idea of future demands.

1) In estimating demands, the rate of increasing demand would have an upper and lower limit and the average value would indicate a mean rate of increases.
2) The upper limit for the increase in demands was settled at 4.5% per year, which was the percentage aimed at for the Gross Domestic Production in the 2nd continuous four years economic development plan initiated in 1974.
3) The lower limit for the increase in demands was settled at 2.3% per year, which was the rate arrived at when estimating the increase in population. (The estimated increases in population is based upon the records for 1970 - 1973).
4) The mean demand increase rate was settled at 3.5% per year.

With regard to the aforementioned standard of estimates, further information should be added, that is, it is well known that the relationship between the growth rate of the gross domestic product and the increase in energy consumption can be used as a yardstick to measure future demands. This relationship, if precisely arranged, can be used as a basic data of demand forecast.

For example, the relationship between Gross Domestic Production and energy consumption based on the records for European countries and Japan is shown in Fig. 4 - 2. In the relationship between the two, the following equation is usually defined :

$$\text{Modulus of Elasticity} = \frac{\text{Increasing Rate of Energy Consumption}}{\text{Growth Rate of Gross Domestic Production}}$$

The modulus of elasticity in economically advanced countries is 1.0 or so, and the modulus of elasticity in developing countries is above 1.0, which is well known to economists.

In the record of Burma, the expansion of gross domestic production was 4.1% in 1970, 2.4% in 1971, 1.1% in 1972, 3.0% in 1973 respectively. However, 4.5% of growth rate of GDP is only target aimed at in the 2nd continuous economic four year plan, if the elasticity is taken at 1.0 for convenience sake, the rate of 4.5%, may be allowed as an adequate figure for the upper limit of the increasing rate of demand.

Further, the rate of increase in population may also be taken as an adequate measure for the lower limit in the increase rate of demand, by the simple fact that the consumption on energy per person is comparatively low in Burma.

When we refer to the increase in demand over the past ten years, we find that there is an average of more than 3.0%. So, the forecasted mean demand increase rate of 3.5% per year is considered as proper figure.

The capacity of the new refinery is to be discussed and defined in the following chapter. The capacity of the new refinery and its connection with the aforementioned results of the demand forecast is as shown in Fig. 4 - 3. In Fig. 4 - 3., the capacity of the new refinery was taken as 25,000 BPSD, and the service factor of the refinery as 90%.

Again refering to Fig. 4 - 3., if a demand forecast curve is drawn from a basic starting point in 1974, it can be read that it is impossible to fulfill present demands in 1976 by existing refining capacity. Refining capacity will be capable of fulfilling the demands by 1989 if the new refinery can start production in 1981 with a capacity of 25,000 BPSD when we consider that there is an average yearly increase in demand of 3.5% and that the Chauk Refinery will decrease its capacity to the half.

By kind of products, demand forecast was taken as follows :

Gasoline	1.6% per year
Kerosene	3.5% per year
Gas Oil	5.0% per year
Fuel Oil	2.4% per year

In the above, the increase in the demand for gasoline was estimated based on the number of vehicles in a given period. Korosene was estimated by averaging the demand for all kinds of oil. Gas oil demands was estimated based on the expected increase in diesel engines. Fuel oil increase was taken same as lower limit of demand forecast considering past record.

FIG.4 -2 GROSS NATIONAL PRODUCT AND ENERGY CONSUMPTION PER CAPITA

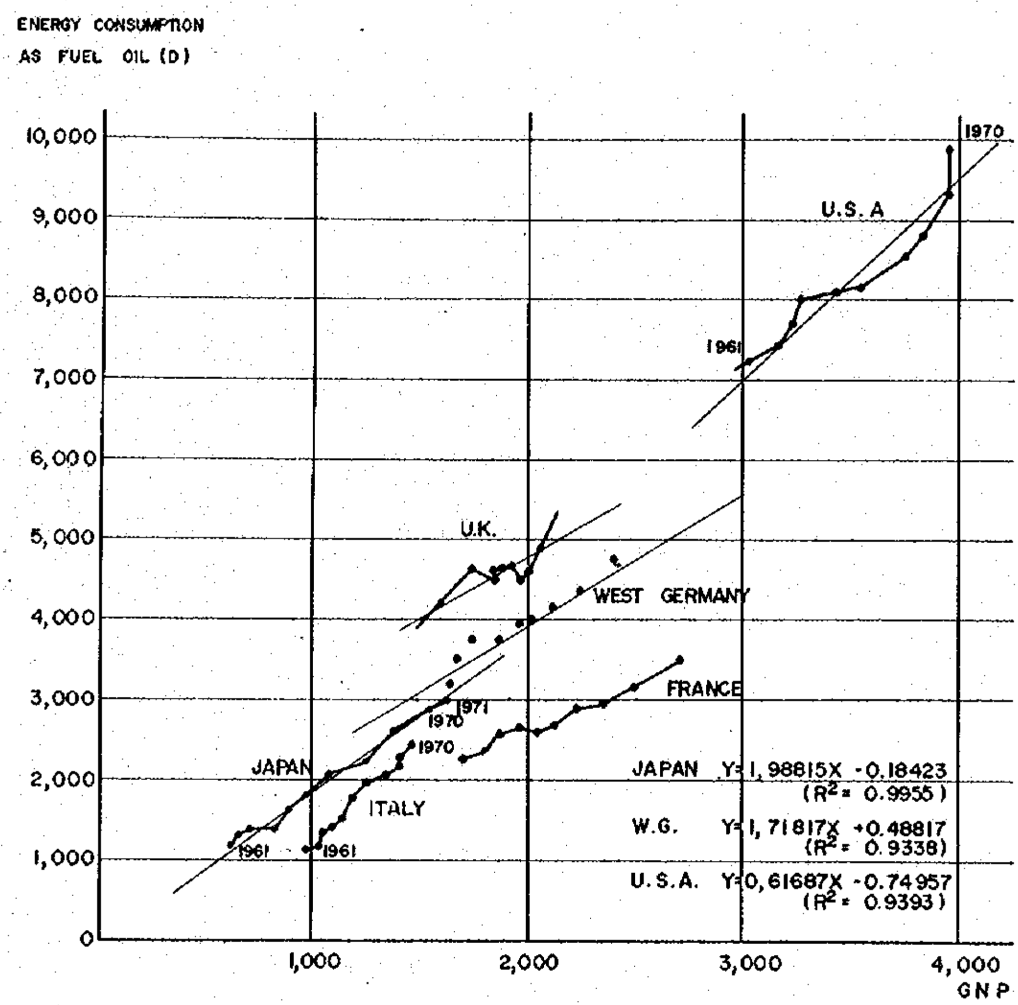


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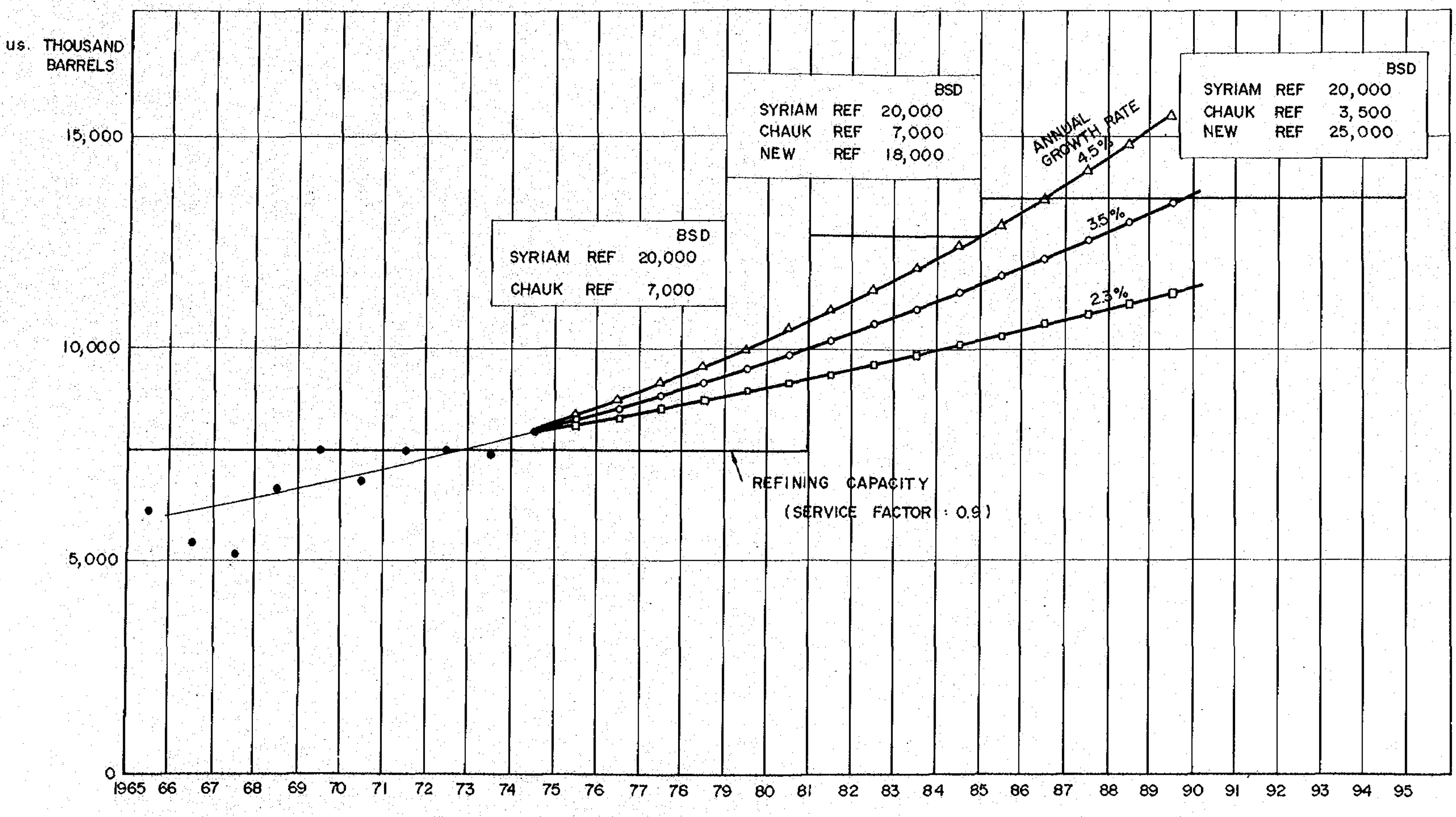
FIG. 4 - 3 FORECAST OF PETROLEUM PRODUCT REQUIREMENT vs. REFINING CAPACITY



Chapter 5.

BASIC PROJECTION FOR PLANNED REFINERY

Chapter 5

BASIC PROJECTION FOR PLANNED REFINERY

5.1 Crude Processing Capacity

1) Factors to be considered for determining crude processing capacity

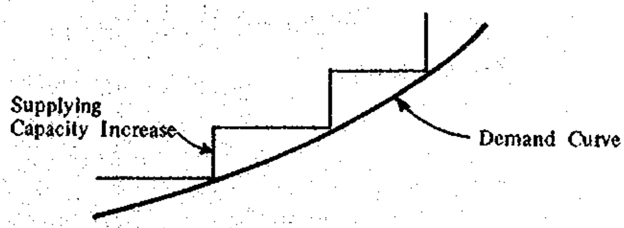
Generally, following factors shall be considered when crude processing capacity is going to be determined.

- Demand for petroleum products
- Availability of crude
- Scale effect
- Coordination with other refineries

(a) Demand for petroleum products

The most important factor to be taken into account for determining the refinery's supplying capacity is the demand for petroleum products.

When the demand for the next several years is forecasted to exceed the present supplying capacity, it is realized to plan the construction of a new refinery to meet the forecasted demand. In this case the fact that the demand increase forms an uptrend curve, while the supplying capacity increase is inevitably made step-wise as shown below should not be forgotten.



Naturally, there always exists some difference between the demand and supplying capacity and it becomes maximum at the time of new refinery's start-up.

Accordingly, if the new refinery's supplying capacity is planned to be too large as compared to the demand, the refinery would suffer from extremely low rate operation for some years after the start-up which brings uneconomical result to the refinery.

(b) Availability of crude

When importation of crude is planned, only import availability shall be studied. Generally, it is not predicted that importation of crude from international market would meet any difficulty in the near future.

However, when locally produced crude is planned to be fed to the refinery, the availability of crude depends specifically on the condition of production and development of the reserves concerned.

(c) Scale effect

In general, the following exponential equation exists between the plant construction cost and the scale.

$$C = A \left(\frac{S'}{S} \right)^{n}$$

C = cost of the planned plant

A = cost of a known plant

S = scale of a known plant

S'= scale of the planned plant

n = cost index

In the case of a refinery, "n" usually falls within the range of 0.6 to 0.8. As seen from the above equation, construction cost does not linearly increase with the increase of the scale, namely, the larger the plant is selected, the more it is economically constructed. That is one of the reasons why huge refineries exist and are under construction in industrially advanced countries or in the Middle East where large quantity of crude is produced.

In Japan, in view of the above fact, the usual economic scale is considered to be more than 100,000 BPSD.

(d) Coordination with other refineries

Where refineries are left under complete free competition, this factor is meaningless. However, a certain national policy on refineries would affect strongly on the determination of the planned refinery's capacity.

2) Factors related to the determination of the planned refinery taking into account specifically the Burmese present situations

(a) Demand for petroleum products

Chapter 4 describes the present and future demand for petroleum products in Burma. As shown in the study (Fig. 4-3), the present demand already exceeds the manufacturing capacity. The demand and supply gap would increase year by year and a small scale refinery would become necessary within the several years to come if the demand increase with the annual rate of 3.5% would continue.

If it is allowed to cover the gap by import for several years, a certain reasonable scale refinery would possibly be constructed. However, as crude is available in Burma it is natural to plan to utilize indigenous crude for the feed to the planned refinery as early as possible. Taking the above into account the scale of planned refinery cannot be anything but small one.

Further, taking the following facts into consideration together with transportation cost of petroleum products to the market, the refining capacity in Central and Upper Burma would be analized ideally at around 60%.

- Result of analysis on division-wide present petroleum products consumption shown in Figure 5.1 which indicates the consumption in Central and Upper Burma approximately at 56% and in Lower Burma at 44%.

- Burmese Government policy on development of Central Burma and accompanying consumption increase probability in Central and Upper Burma.

(b) Availability of crude

In Burma, crude is domestically available and produced crude is now fed to existing Syrium and Chauk refinery. Crude has seldom been imported in recent years. Under such circumstances, when determining the scale of planned refinery, crude production capability should thoroughly be taken into consideration.

As described in Chapter 2, production increase of crude is possible, should the necessary investment for development be conducted. Proposed alternative development and production plan described in Chapter 2 is considered to be the most suitable one both economically and practically corresponding to the future demand increase.

(c) Economic scale

As already described, in general, the larger the plant is constructed, the more it becomes economical. However, in the case of Burma, the construction of a refinery with such a huge scale as 100,000 BPSD is out of the boundary of possibility in the light of absolutely small demand for the petroleum products. Huge scale refinery would only result in unefficient operation of the plant and in the end prove uneconomical.

(d) Coordination with other refineries

At present, Syrium refinery (20,000 BPSD) and Chauk refinery (7,000 BPSD) are in operation, however, the latter has already exhausted and will face close-down or decrease of production. When considering the scale of planned refinery, this point should also be taken into consideration.

3) Determination of the scale of planned refinery

After thorough examination of the aforementioned points, the scale of planned refinery is focussed in the range of 20,000 to 30,000 BPSD.

Considering the probable close-down or decrease of production of Chauk refinery, the scale of 20,000 BPSD leaves insecurity of meeting the demand. The scale of 30,000 BPSD may be a little larger than needed if such factors are taken into consideration as foreseeable difficulty of transportation of the machinery and equipment during the construction, predicted lower operation rate after the start up of the plant, bigger capital investment requirement which are all caused by selecting the scale of 30,000 BPSD.

In conclusion, the recommendable scale of planned refinery is considered to be 25,000 BPSD.

5.2 Selection of Plant Site

Oil refineries of the world are located either in coastal regions, as in Japan, or in inland areas, as in the U. S. A. and Europe. All sorts of factors must be considered in selecting a plant site, and the plant must be constructed in a site which is considered to be most favorable on the whole. These factors are classified into two kinds. One is consisted of the factors relating to the final economic evaluation of the plant, namely to cost. The other consists of those factors which are not directly related to the cost, such as the factors concerning the problems of environment as well as all sorts of governmental policy.
These factors are all very important to the country concerned, and so the two major categories of factors must be thoroughly studied.

As mentioned earlier, there are two refineries in Burma at the present time. One is the Chauk refinery and the other is the Syriam refinery. The former is located near the central region of Burma and the latter belongs to the category of seaside oil refinery.

What place should be selected as most favorable for the construction of the third oil refinery? According to the plan of the Burmese side, the Mann area near the oil producing area, which is on the west coastal region of the Irrawaddy River, has been designated as the site for the new refinery. However consideration should also be given to the pros and cons of establishing the new refinery in the coastal region, as in the case of Syriam.

The following items must be studied in selecting the site for an oil refinery:

- Crude oil producing area and the cost of crude oil transportation.
- Market for finished products and the cost of their transportation.
- Plant construction cost.
- Weather and seismic conditions.
- Availability of utility.
- Procurement of labor.
- Environmental problems.
- Problems concerning governmental policy.

With the above factors in mind, let us make a comparative study of the Mann area and the Syriam area. For the sake of convenience, Syriam area will be taken as an example of the coastal region. As to the economic comparison, please refer to Appendix-1.

1) Crude oil producing area and the cost of crude oil transportation
Crude oil as raw feed to the new oil refinery is planned to be supplied from oil fields near Mann. The reserve and the volume of supply have been mentioned in Chapter 2. Since the

crude oil is produced near Mann, Mann is favorable, as plant site, from the standpoint of transportation cost of the oil and Syriam is very unfavorable. At the present time, barges are used in transporting crude oil to the Syriam oil refinery. However, there are some difficulties in transporting oil even to the present oil refinery of 20,000 BPSD. If the new refinery is to be constructed in Syriam, approximately 400 miles of pipeline must be laid or a further increase of barges would be necessary.

2) Market for finished products and the cost of their transportation

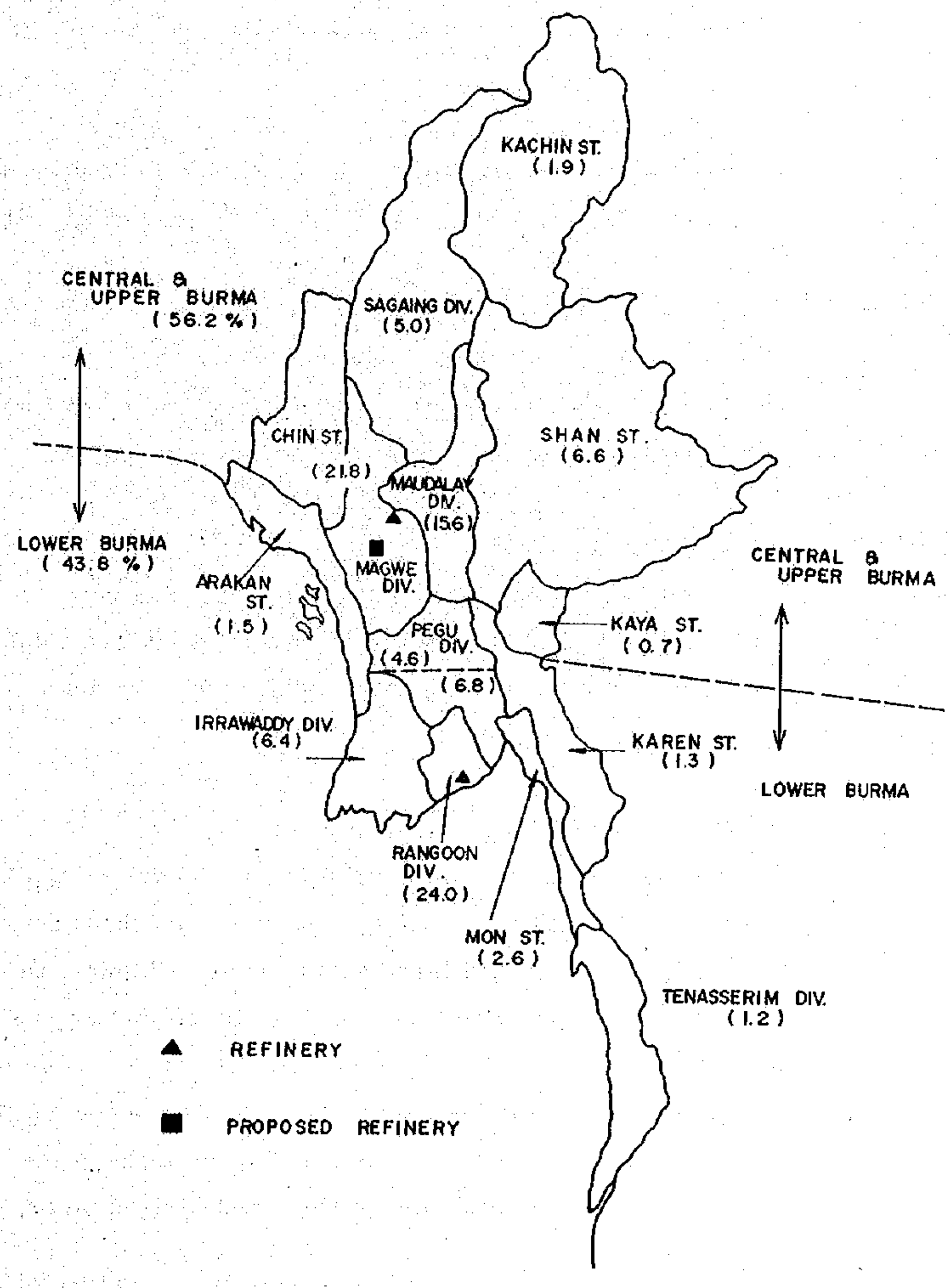
The market for the products of the present two refineries was mentioned in 5.1. Namely, as can be seen in Fig. 5-1, approximately 56% of the main products are consumed in Central and Upper Burma and approximately 44% are in Lower Burma. As a result of the Government's development plan of Central Burma, the consumption in Central and Upper Burma is expected to rise even upto approximately 60% of the entire consumption in Burma. Considering the wearing-out of Chauk refinery, almost all of the products of the new oil refinery will be sent to Central and Upper Burma.

As described above, from the view-point of the transportation cost of finished products Mann will be more favorable than Syriam.

3) Plant construction cost

At Syriam refinery there is some space which is not being used. Furthermore, there are vast paddy fields nearby which, if desired, could be used for the construction of an oil refinery. If the new refinery is to be set up in Syriam, construction cost will be reduced in the following points.

FIG. 5-1 REGION-WISE SALES OF PETROLEUM PRODUCTS (%)



Access road

Facilities for water intake and treatment

Transportation of plant machinery and equipment

Maintenance shop

Shipping facility for products

In this respect Syriam is more favorable than Mann.

4) Soil condition

Bearing capacity of soil seems to be lower in Syriam than in Mann. Therefore, the foundation work at Syriam will be costly.

5) Weather and Seismic conditions

Regarding weather and seismic conditions, there will not be nay difference between Mann and Syriam.

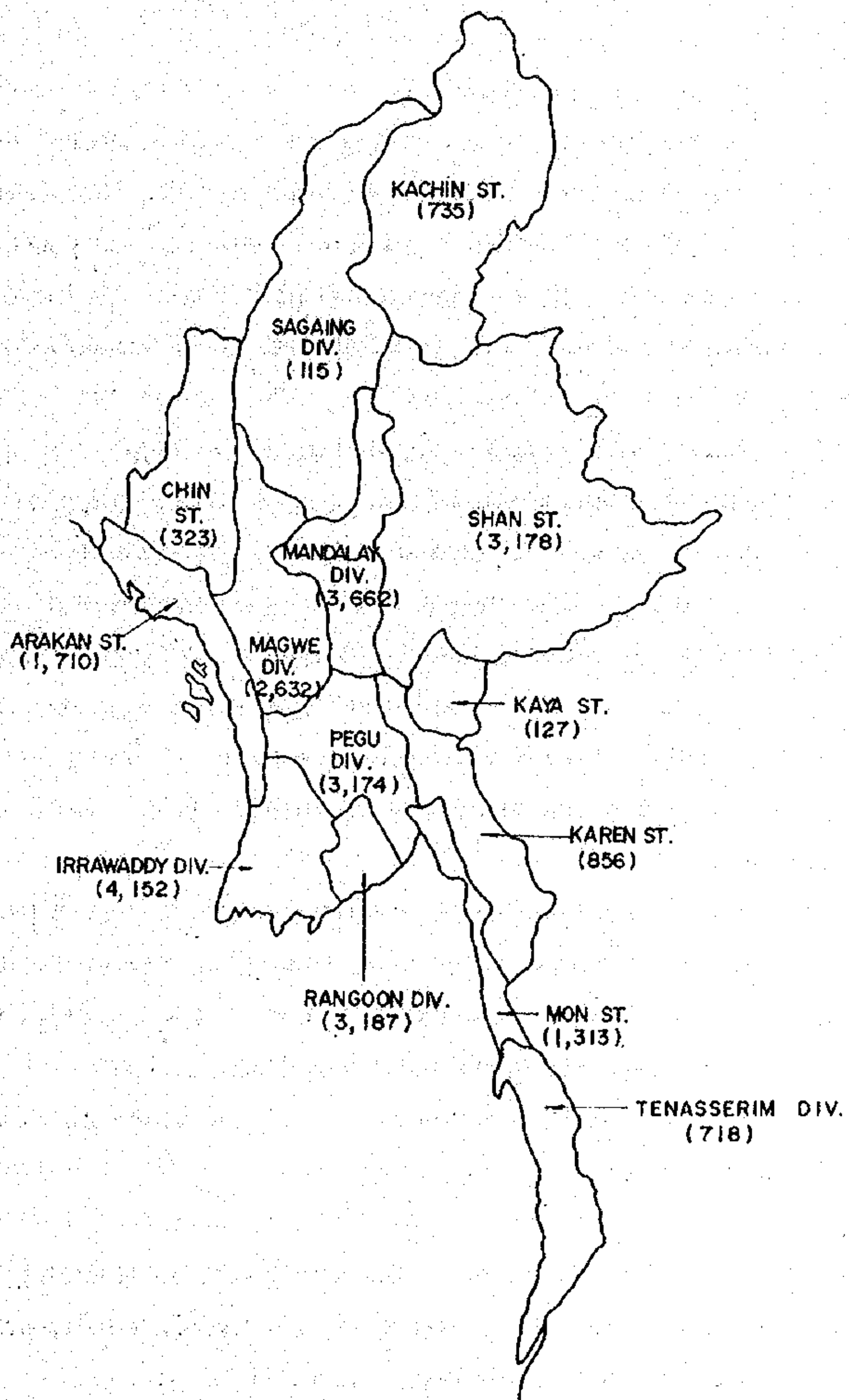
6) Availability of utility

In the case of Mann, it will be necessary to lay power transmission line to Mann, which will be costly. Water intake, too, will require some expense. Syriam will be more favorable in this respect.

7) Procurement of labor

As shown in Fig. 5-2, the population of Magwe State, to which Mann belongs, is not scarce. It seems that the procurement of general labor will be easy in Mann. On the other hand, the procurement of skilled labor and engineers seems to be easier in Syriam than Mann. However, in view of the fact that an oil refinery is now running successfully in Chauk, near Mann, it seems possible to procure the necessary labor, including engineers and skilled labor, at Mann.

FIG. 5 - 2 REGION - WISE POPULATION
(1 000 PERSONS)



8) Use of associated gas

As Mann is located near oil fields, it is possible, if so desired, to utilize associated gas which is now being flared in vain. Mann is more favorable than Syriam in this respect.

9) Environmental problems

At the present time, Rangoon is a beautiful city where pollution is not observed. In this respect, the construction of an oil refinery in Syriam, which is close to Rangoon, will have some effect on environmental problems. On the other hand, there is almost no fear of environmental problem at Mann.

10) Problems concerning governmental policy

The Burmese Government is now putting emphasis on the development of the west bank of the Irrawaddy River. One of the reasons is to prevent the concentration of factories and the population in large cities as Rangoon. Another reason is the development of Central Burma in relation with the future development program of the country. In this respect, Mann will conform with the government program.

Taking into consideration the factors cited above and the economic comparison in Appendix-1, the survey team has arrived at the conclusion that the Mann area is more advantageous as the plant site than Syriam and other adjoining places.

As to which part of the Mann area is most favorable as the plant site, studies will be made below.

The geographical features of the Mann area is outlined in Fig. 6-8. As a whole the area is higher than the eastern coast, and few places are flooded even during the rainy season.

The oil refinery needs a level ground of about one square kilometer for its construction. Besides, Burma is planning to establish a petrochemical complex utilizing surplus naphtha to be produced by the new refinery. When the execution of this project in the future is taken into account, it will need a level ground of several square kilometers. The sites A and B in Fig. 6-8 may well satisfy the conditions just mentioned. Both places are flat and have a sufficient area, but site A is superior to B in the following points:

1) Site A is more convenient for the transportation of the product.
2) Site A is more convenient for discharging waste water.

For the reasons mentioned above, the survey team has selected site A as the plant site for the present. However, the land and geological surveys must be performed before starting the construction. The site is located at a place of about 8 kilometers south of Minbu town. The site is of a level ground running along the western shore of the Irrawaddy River and stands about 50 meters high above the surface of the water. The site is linked to the artery along the western shore of the Irrawaddy River by a gravel road about 3 meters wide.

The site is a state-owned land, which is used as a farm except during the dry season. The land, however, can be used as plant site by paying a small sum of compensation. Being slightly elevated as described earlier, it may require considerable labor force for adjusting and expanding the road and for carrying in the equipment at the time of plant construction. However, there is not any difficulty for the adjusting and expanding of the road as well as for the carrying in of the equipment.
There will be no problem for laying the pipeline of crude oil.
For discharging waste water a small river running south of the site can be used. The water of the river not being used for drinking,

waste water can be discharged into the river after being treated to some extent.

For the construction of jetties to be used for water intake and shipping of the product, there is a favorable place facing the sandbank south of Minbu town.

The plant site is not far from the shore and there is only one road to cross, to get there, and no large village exists there. This being the case, it is easy to construct pipelines to carry out the liquid products. Shipping of such a solid product as coke is also easy. As the site being fairly far away from the town and city, no pollution problem may occur.

The site being located at elevated place as described above, it will need some more power to carry the auxiliary raw materials and industrial water to the site. As no problems exist other than those, the place is considered suitable as the plant site.

Chapter 6.

FACILITIES PLAN

Chapter 6

FACILITIES PLAN

This Chapter contains the design bases and the design considera-tion used in making a facilities plan of the Refinery.

First of all, the starting point for planning and design began with the collection of basic data.
With regard to that, the informations and data were gathered from those submitted by the Burmese side and the Survey Team established only the informations and data that were not offered by the Burmese side.

Then, a basic policy regarding planning and design was set forth on the basis of the beforementioned informations and data.
As for the basic policy, the Survey Team made an overall decision, not only satisfactorily reflecting the intentions of the Burmese side but also taking into account the actual results of existing Burmese refineries together with the actual state of refinries in Japan.

In addition, the detailed planning and design of such facilities as process, utilities and off-site was carried out placing more emphasis on the following points;

- to be operated easily and safely
- to need less maintenance
- to be economical

6.1 Design Basis

6.1.1 Crude Oil

The crude oil processed at the Refinery is entirely Mann crude oil produced in the Mann area of Central Burma.

Mann crude oil, compared with Middle East crude oil, is lower in sulfur and, moreover, is higher in yield of middle distillates such as naphtha, kerosene, gas oil.
The excellent features of Mann crude oil makes it extremely suitable for the Burmese domestic market as seen from the forecast of demand.

The assay of Mann crude oil which was submitted by the Burmese side is mentioned in Table 6-1. However, new analysis of this data is to be done for actual planning and design of the Refinery in consideration of circumstances surrounding the active development of Mann oil field from now on, because the before-mentioned data are the old result of analysis done several years ago.

Furthermore, the crude oil will be supplied to the Refinery by pipeline from the M/F tank farm.

TABLE 6-1 CRUDE ASSAY

1) Summary of Crude Oil

Crude Source		Mann
Specific Gravity	(60°F/60°F)	0.8408
	°API	36.8
Sulfur Content	wt.%	0.11
Pour Point	°F	85
Viscosity	cst (100°F)	3.945
Carbon Residue	wt.%	0.8
Ash Content	wt.%	0.005
Water	vol.%	Trace
Water & Sediment	vol.%	0.3
Salt Content	Lb/1,000 Bbl	5.0
Distillation	°F	
Type		U 76
IBP		122
5 vol.%		195
10		231
20		298
30		370
40		442
50		520
60		595
70		673
80		760
90		852
95		915
EP		948

2) Basic Breakdown

(a) Summary

	Distillation Cut Range (°F)	Yield on Crude (vol. %)
LPG	C_1-C_4	1.2
L't Naphtha	C_5	1.6
H'y Naphtha	C_6-320	18.8
Kerosene	320-480	16.7
Gas Oil	480-680	30.0
Residual Oil	680^+	31.7

(b) Light End Product

	Yield on Crude (vol. %)
Ethane	-
Propane	0.11
i-Butane	0.37
n-Butane	0.65
i-Pentane	0.88
n-Pentane	0.76

(c) Naphtha Fraction

Cut Range	°F	C_6-320
Specific Gravity		0.7587
Sulfur Content	wt.%	0.002
Total Nitrogen	wt. ppm	0.47 ± 0.2
* Hydrocarbon Type		
P	vol. %	36.0
N	vol. %	50.7
A	vol. %	13.3
Distillation	°F	
Type		D86
IBP		178
5 vol. %		192
10		198
20		204
30		210
40		216
50		224
60		233
70		243
80		254
90		272
95		287
EP		327
Recovery	vol. %	99.0
Bottoms	vol. %	1.0

Note: Star marked item was supplemented by the Survey Team.

(d) Kerosene Fraction

Cut Range	°F	320-480
Specific Gravity		0.8123
Sulfur Content	wt. %	0.009
Mercaptan Sulfur	wt. %	0.0008
Smoke Point	mm	20.3
Freezing Point	°F	-70
Flash Point	°F	114
Color	Saybolt	+20
Corrosion Cupper Test 122°F, 3 hr		2B
Hydrocarbon Type		
P	vol. %	78.1
N	vol. %	-
A	vol. %	21.9
Distillation	°F	
Type		D 86
IBP		320
5 vol. %		336
10		342
20		350
30		358
40		367
50		378
60		390
70		403
80		418
90		438
95		454
EP		482
Recovery	vol. %	99.0
Bottoms	vol. %	1.0

(e) Gas Oil Fraction

Cut Range	°F	480-680
Specific Gravity		0.8607
Sulfur Content	wt. %	0.07
Pour Point	°F	35
Viscosity at 100°F	cst	4.228
Carbon Residue	wt. %	<0.01
Distillation	°F	
Type		U. 1
IBP		485
5 vol. %		500
10		508
20		520
30		530
40		540
50		552
60		564
70		580
80		598
90		624
95		645
EP		680
Recovery	vol. %	99.0
Bottoms	vol. %	1.0

(f) Fuel Oil Fraction

Cut Range	°F	680+
Specific Gravity		0.9024
Sulfur	wt. %	0.16
Pour Point	°F	130
Viscosity	cst (160°F)	17.84
	cst (210°F)	8.527
Carbon Residue	wt. %	2.91
Distillation	°F	
Type		U. 76
IBP		700
5 vol. %		735
10		751
20		774
30		791
40		804
50		820
60		840
70		868
80		933
90		1050
95		1130
EP		
Recovery	vol. %	95.0
Bottoms	vol. %	5.0

6.1.2 Product

The kinds of products and their quality are mentioned in Table 6-2.

They are according to the presentation of the Burmese side, but because specifications for naphtha and petroleum coke were not offered, they were established by the Survey Team. In addition, the following points regarding the two products of LPG and fuel oil were considered.

1) Only butane will be produced as LPG product, and propane will be used as home fuel inside the Refinery because the vapor pressure of 6 Kg/cm^2 (at 40 °C) specified by the Burmese side, is too low to use propane as product.

2) Because the pour point of topped crude from Topping Unit, which is estimated approximately as 130 °F, is higher and can hardly meet the specified figure of 75 °F for fuel oil, in order to decrease the pour point, it was planned to blend topped crude and gas oil in an equal proportion, and then to add a flow improver thereto, considering the result at existing refineries in Burma.

TABLE 6-2 PRODUCT SPECIFICATION

1)	LPG		
	Vapor Press. (40 ° C)	Kg/cm^2	6.0 Max.
	Sulfur Content	%	0.02 Max.
	Composition	mole %	
	Ethane & Ethylene		
	Propane & Propylene		
	Butane & Butylene		90 Min.
2)	Motor Gasoline		
	Research Octane No.		86 Min.
	Reaction		Neutral
	Distillation	° C	
	10%		70 Max.
	50%		125 "
	90%		180 "
	97%		205 "
	Residue	%	2 "
	Vapor Press. (100 ° F)	psi	9 "
	Existent Gum	mg/100 ml	5 Max.
	TEL	ml/I.G.	2.4 Max.
3)	Kerosene		
	Reaction		Neutral
	Flash Point	° F	80 Min.
	Sulfur Content	%	0.002 Max.
	Smoke Point	mm	24 Min.
	Copper Strip. Corrosion (50 ° C, 3 hr)	ASTM	1 Max.
	Colour	Saybolt	+20 Min.

4) Diesel Oil

		H. S. D.	L. D. O.
Reaction		Neutral	Neutral
Flash Point	° F	150 Min.	150 Min.
Pour Point	° F	40 Max.	45 Max.
Residual Carbon Content in 10% Residual Oil	%	0. 2 Max.	0. 02 Max.
Cetane Number		46 Min.	46 Min.
Diesel Index		48 Min.	48 Min.
Viscosity (Redwood @ 100° F)	Sec.	40 Max.	40 Max.
Sulfur Content	%	1. 0 Max.	1. 5 Max.
Calorific Value	Btu/Lb.	19, 000 Min.	18, 750 Min.

5) Fuel Oil

Flash Point	° F	150 Min.
Viscosity (Redwood @ 100° F)	Sec.	600 Max.
Pour Point	° F	75 Min.
Water Content	vol. %	0. 5 Max.
Ash Content	wt. %	0. 1 Max.
Sulfur Content	wt. %	3. 5 Max.
Calorific Value	Btu/Lb	18, 500 Min.

6.1.3 Site Condition

The Mann area of Central Burma is considered as the proposed construction site of the Refinery. The necessary site conditions for planning and design of the Refinery are listed below, which are submitted by the Burmese side.

1) Site Information - Explained in Table 6 - 3.
2) Climatic Conditions - Explained in Table 6 - 4.
3) Utility Information - Water necessary for the Refinery will be taken from the Irrawaddy River. The conditions of the river and physical properties of the water are explained in Table 6 - 5.

TABLE 6-3 SITE INFORMATION

1) Refinery	
Site Location	Mann Area 560 Km from Rangoon 8 Km from Minbu Town 5 Km from Irrawaddy River
Elevation	River Water Level + 160 feet
Undulation	Flat
Bearing Value of Soil	2 t/ft^2
2) Minbu Terminal	
Site Location	Minbu Area near Irrawaddy River 5 Km from Refinery Site
3) M/F Tank Farm	
Site Location	Minbu Area 16 Km from Refinery Site

TABLE 6-4 CLIMATIC DATA

1) Temperature (based on 10 years observation) 1964 ~ 1973.

   (a) Maximum dry bulb (°C) : 45.2

   (b) Minimum dry bulb (°C) : 7.0

   (c) Number of days with max. temp. above 25°C in a year 158 days.

2) Relative humidity (based on 10 years observation)

   (a) Maximum (%) : 100

   (b) Minimum (%) : 26

3) Wind (based on 10 years observation)

   (a) Maximum wind velocity : 52 mile/hr
   Temporarily, wind speed as high as 100 mph can occur in months from March to May.

   (b) Direction of prevailing wind in annual is from : N. E

4) Rainfall (based on 10 years observation)

   (a) Maximum recorded rainfall in one hour (mm) : 144

   (b) Maximum recorded rainfall in 24 hours (mm) : 193

   (c) Average number of rainy days in a year : 60

   (d) Maximum snow depth (mm) : None

5) Provisions for earthquake shall conform to
   K value to be taken as 0.15

6) Provisions for lightning are required.

7) Provisions for sand storm are required.

TABLE 6-5 UTILITIES INFORMATION

1)	Water Source	Irrawaddy River
2)	Water Level	
	Highest	1,989 cm + River Bed (14-9-1974)
	Lowest	416 cm + River Bed (26-3-1974)
3)	Available Capacity	No Limitation
4)	Temperature	15 - 35°C
5)	Physical Properties	
	ph	7.80
	Turbidity Degree	200 - 500
	Total Hardness ($CaCO_3$)	70.0 ppm
	Calcium ($CaCO_3$)	19.1 ppm
	Magnesium ($CaCO_3$)	8.9 ppm
	Na^+	12.0 ppm
	K^+	1.5 ppm
	Suspended Solid	1,400 ppm
	Disolved Solid	48.0 ppm
	HCO_3^-	106.1 ppm
	CO_3^-	2.0 ppm