Petroleum Production in 1961*

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Introduction

Following 1960, the year of 1961 was another year of remarkable progress for the Japan's Petroleum Mining Industry. Japan Petroleum Exploration Company (Japex.), of which the Government being the major stockholder, completed its 5 year Petroleum Exploration Program in 1960 and further conducted exploration and development activities during this year as the 1st year of the 3 year Exploration Program. Teikoku Oil Co., Ltd. (Teiseki), Japan's largest natural gas producer who also holds as much crude oil production as Japex, also endeavoured to develop both natural gas and crude oil. Above all, the success in Kubiki and Sekihara oil and gas fields resulted in by far the greater production than in 1960. Also, the discovery of potential gas zone by Nippon Mining Co., Ltd. (Nikko) on the seashore of Nakajo, Niigata prefecture, is worthy of special description this year.

Geological Survey

Exploration activity in Japan is described in this paper dividing its territory into following 4 districts; Hokkaido, Tohoku, Kanto, and other area. In Hokkaido, like last year, various types of survey were made with the major emphasis placed on the prospecting of oil traps in Cretaceous formation.

Geological survey in Tohoku district including Niigata prefecture was further activated by the successive discovery of oil and gas in the past 2 or 3 years and a series of promising areas for test drilling has been discovered.

In Kanto district, Teiseki conducted natural gas exploration in Chiba prefecture and the actual production is going to be initiated in the near future. Attention was also being paid to the other prefecture in this district...Saitama, Gumma and Tochigi, etc. This area deposited

thick Miocene formation which is main oil bearing formation in Japan. Gravity and seismic survey and structure drilling was being carried out by Teiseki and Japex, and the time is gradually getting ripe for its active exploration in companies with the tendency to carry out the deep drilling from around next year.

Geological survey in 1961 in the above referred districts is tabulated below.

Table 1. Number of Geological Survey Party in 1961.

Kind of survey	District				
	Hokkaido	Tohoku	Kanto	Other area	Total
Surface Survey	25	37	19	8	89
Structure Boring	2	7	4	0	13
Seismic Survey	4	21	2	0	27
Gravimetric Survey	2	6	3	2	13
Magnetic Survey	1	0	1	0	2
Geo-Chemical Survey	1	1	0	0	2

Exploratory Drilling and its Major Results

Number of exploratory drilling in 1961 is shown in Table 2. The characteristic feature of this year was the fact the exploratory wells were concentrated in Niigata. This indicates that the exploratory wells gathered in Niigata because of the continuing success in the past 2 or 3 years.

Table 2. Number of exploratory wells in 1961

District	Number of well
Hokkaido	5
Aomori Pref.	1
Akita Pref.	5
Yamagata Pref.	3
Niigata Pref.	24
Shimane Pref.	1
Total	39

Major results of exploratory drilling operation in 1961 are shown below.

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Fig. 1

Hokkaido

Tonika SK1 was drilled last year to explore oil zone in Cretaceous formation about 60 km south east Sapporo in the oil producing area of central Hokkaido. Yufutsu SK1 was drilled down to 4,010 m this year, 20 km south of Tonika SK1, however, this well was abandoned failing to reach Cretaceous formation.

Promising structures were discovered this year by gravimetric, magnetic and seismic surveys as the result of intensive prospecting in the Cretaceous formation in the hilly area of the eastern part of Ishikari plain and the Kushiro and Nemuro areas in the eastern part of Hokkaido where large scale structures are expected to exist. Exploratory wells shall be drilled in these areas next year.

Tsuchizakioki Oil Fields

At Tsuchizakioki oil field, about 2,500 m off the shore of Akita City which started crude oil production since last year, 2 wells succeeded in Katsurane formation at the approximate depth of 550 m.

However, due to the sand trouble and water encroachment exploratory drilling in southern

block turned out to be a failure. At Wakimotooki, northern extension of this oil field, two exploratory wells, Wakimoto SK1 (1,300 m) and SK2 (1,700 m) were drilled showing that these wells are right on the wing of the structure. Exploratory drilling will be started again from this spring at Wakimotooki.

In order to investigate the under sea structure of Tsuchizakioki oil field, Sarukawaoki, Michikawaoki, Fukuraoki, and Kubioki, Repeatable Acoustic Seismic Sources (RASS) was carried out by an American Company, Marine geophysical Service International Inc. and valuable data were obtained.

Shonai Plain

Exploratory Drilling in Shonai plain, Yamagata prefecture, this year was quite active in succession to last year. Amarume oilfield which discovered prolific oil reservoir last year, is now making a long stride this year as a productive field. Japex found an oil trap by seismic survey at Oishi about 10 km north of Amarume, and in November this year discovered a gas formation between 1,130 m-1,190 m by exploratory drilling that has resulted in 30,000 m³/d of gas. Although there is reported some sand trouble, exploratory work will further be continued.

Teiseki has been conducting exploratory drilling in the vicinity of Sakata city since 2 years ago. In December this year, Niibori R3 that was drilled 4 km south of Sakata city discovered a potential gas reservoir which reportedly produced 170,000 m³/d of gas with 12.5 mm choke. Development of oil and gas in Shonai plain with Sakata city in the center will be put on its orbit in the light of all those fine results.

Nakajo Gas Field

There is a town called Nakajo-machi 65 km north east of Niigata city along the coastal line of the Japan Sea.

Existence of gas seepage in the nearby seashore had been known from the early days and in 1936 a shallow exploratory well was drilled. This well, when reached the depth of 300 m, produced gas, but the drilling was continued after shutting off the gas formation since that well was seeking for oil. Finally the drilling was suspended as there was no oil down below. However, the demand for natural gas so rapidly increased in recent years that the exploration for natural gas was started again. In 1956

Nikko-R1-1 produced 3,920 m³/d of water dissolved gas that accompanied 2,250 m³/d of water from 740 m–796.80 m.

Fig. 2

From this time on, development of water dissolved gas has been continued in this field and total gas production reached to 280,000 m³/d with 15 bases and 56 wells.

However, NIKKO being convinced of the presence of free gas reservoir lying underneath this water dissolved gas field, carried out a seismic survey around to north with its center about 1,000 meters towards the inland from the seashore.

Nikko drilled NK1 aimed to the center of supposed anticline with great success : this well which started drilling in June 1961 with the scheduled depth of 3,000 m, found a gas reservoir having an effective thickness of over 15 meters just under 1,770 m and completed with a productive capacity of 180,000 m³ of gas (tubing pressure 143 kg/cm²).

Encouraged by the success of NK1, Nikko spudded NK2 about 430 m from NK1 on the line which supposedly crosses the anticline. NK2 was drilled to the depth of 2,000 m, and by Schlumberger's test proved two other new gas reservoirs ; reservoir I (830 m–845 m) and reservoir III (1,811 m–1,816 m) besides reservoir II (1,705 m–1,749 m) which had been found by NK1.

By the completion of reservoir III (5 m thickness) NK2 produced about 100,000 m³/d gas (tubing pressure 130 kg/cm²) and turned out an excellent producer. According to the Schlumberger's test, reservoirs I and III were estimated more productive than the already completed reservoir of NK1. Consequently, the deep free gas zones in Nakajo gas field is considered to develop as one of the biggest gas reservoirs in Japan. Nakajo gas will be supplied as raw material to Nakajo Factory of Kyowa Hakko Gas Chemical Industry Co., near the town of Nakajo about 10 km from the field.

Sekihara Gas Field

In 1960, Japex drilled two exploratory wells

on the hill about 7 km west of Nagaoka in Niigata prefecture based on the result of seismic survey, and found a gas reservoir at the depth of about 820 m, on the lower part of Haizume zone. After this lease was handed over to Teiseki, Teiseki drilled R3 about 700 m south east of SK1 and found 800 m zone, and further reached andesitic agglomerate in the Nishiyama formation where they found a great gas reservoir.

This well completed between 1,127.5 m–1,130.5 m and produced 150,000 m³/d with 15 mm flow choke.

Then the substantial development of this gas field was started and R5 and R6 were drilled 900 m north of R3, and R8 800 m south of R3, which was proved to have the effective thickness of over 100 m having prolific reservoir unique in Japan. Now Teiseki is planning to explore the width and extension of this structure.

Katakai Gas Field

In 1960, Japex drilled SK1 about 15 km south-south-west of Nagaoka city and discovered a prolific gas reservoir in Nishiyama formation 990 m below the surface. This year JAPEX drilled three test wells ranging SK2, 3, 4. SK2, drilled on the anticline 700 m south of SK1 and completed between 991–1,072.9 m, produced about 9,000 m³/d of gas with two stage choke of 8 mm and 9 mm. SK4, drilled on the anticline about 900 m north of SK1 and completed between 1,068 m–1,089 m, produced about 100,000 m³/d of gas. SK3 was drilled about 400 m east-south-east of SK1 on a line crossing the anticline and proved that there was a fault between this well and SK1.

As a test well in Ojiya succeeded as a gas well in 1960, its extension well is being planned in further south between Katakai SK2 and Ojiya.

Kanto District

In Kanto district, exploration work has been carried out only for the water dissolved gas in Chiba prefecture.

As Teiseki found a good water dissolved gas reservoir in Naruto district last year, they established a development program and set up a schedule to drill 36 wells. By the end of the year 28 wells were completed to attain a production capacity of 100,000 m³/d. In 1962 these gas will be supplied to industrial users as fuel.

Besides this, Teiseki also drilled exploratory wells at Sakura, Yotsukaido and Anegasaki and found prolific gas reservoirs both in Sakura and Yotsukaido which were comparable to Naruto.

Especially in Yotsukaido, because of the convenience of discharge of produced water, gas production and sales will be initiated during 1962.

Kanto Natural Gas Company devoted mainly to the exploration around Mobara gas field which is the main field it owns. Also an extensive exploration work for water dissolved gas is being carried out by one company along Kujukuri beach.

Development of Proved Oil and Gas Field in Japan

In 1961, as the newly found oil and gas field which are found after the intensive exploratory drilling in recent years came to the production stage, oil and gas production continued to increase from last year

In Japan there are about 30 oil and gas fields of both large and small sizes now under operation. Following is the development of several new oil and gas fields in 1961.

Sarukawa Oil Field

This oil field was discovered in 1958 about 40 km northwest of Akita City and 16 wells were drilled by 1960 for the purpose of investigating productive area, geological structure and properties of oil bearing formation. In 1961, more wells were drilled ranging from SK17 to SK30, increasing the production on one hand and attaining the analysis of the field on the other hand.

Sarukawa Oil Field has a long slender structure running from north to south which can be divided into three blocks, south, center and north. At first, they explored the southern extension of south block by SK17, SK18 and SK19 respectively and found that the southern edge of the structure declined toward south. These three wells were completed in I zone and each wells produced about 13 kl/d of oil and 1000 m³/d of gas. SK21 and 22 were drilled in central block, but these wells were not so productive.

Eight wells ranging from SK23 to SK30 were drilled in north block for the purpose of further exploration and exploitation. Of these, SK25 was dual completion of II and III zones. As a result, 23kl/d of oil and 1,800 m³/d of gas were produced with 3.4 mm choko from IIb and 7kl/d of oil and 1,075 m³/d of gas with 3 mm choke from III.

As the northern part of this field extends into sea, SK29, a directional well was drilled seaward from the coast of extreme north to examine the northern extension of this field.

Japex invited an engineer from Eastman Oil Well Survey Co. in U.S.A. for the purpose of improving technique of Japanese directional drilling.

SK29 was the directional well drilled under the instruction of the engineer from U. S. A., reaching a deviation distance of 680 m to the north within the depth of 1,077 m and its largest angle of drift was 60 degrees. This well was completed in zone IIa and produced 8kl/d of oil and 500 m³/d of gas.

Another test well will be drilled for the purpose of confirming the northern extension of this field. Oil bearing zones discovered by now in Sarukawa Oil Field are I, IIa, IIb, IV, V, IX, and XII.

In 1961 zone I and II were mainly developed and the development of deeper formations did not advance. The exploration of Onnagawa formation deeper than Funakawa formation is left to the future.

Higashi Niigata gas Field

Higashi Niigata gas field overlaps on the east part of Niigata gas field famous for water dissolved gas, being situated in the east of Niigata City, and free gas reservoir existing deep in that field has been developed. Since it was said

Fig. 3

that production of water with gas (water is to 1kl as gas is to 1m³) at Niigata gas field causes subsidence of ground in Niigata city, production of dissolved gas has been gradually restricted and now it became about half as that of a few years ago. Free gas without water has been developed, taking the place of water dissolved gas in Niigata city.

Higashi Niigata gas field started when, in 1959, Japex drilled SK1 to the depth of 3,036 m based on the result of seismic prospecting and discovered a potential reservoir. By 1960 SK4 was drilled, and SK5 in 1961. It was, as a result of this, found that the structure of accumulative gas greatly expands from the coast into the sea, and at the same time that it consists of large reservoir. SK2 suspended because of water and SK3 because of sand trouble, and three other gas wells have at present the productive capacity of approximately 230,000 m³/d, and are expected to increase it in the future by virtue of the off-shore development.

Mitsuke Oil Field

The discovery of gas reservoir around the depth of 1,200 m at SK3 drilled by Japex in 1954 became the clue to developing Mitsuke oil field 10 km north-north-east of Nagaoka city in Niigata prefecture. While gas reservoir was developed, in September of 1959 below the depth of 1,800 m at SK7a in Koguriyama green tuff rich oil reservoir was discovered and it produced about 50 kl/d of oil. The development of oil reservoir has been strongly pushed forward ever since. In 1961, continued from last year, width and extension of oil producing area were searched, and further its depth was explored. There were various novel developments notwithstanding that the development of crude oil was unfortunately stopped at the first half of 1961 because of difficulty of transportation. Five wells of SK13a, 18, 19, 20, and 21 were drilled in 1961. Of these SK20 and SK21 were gas wells and the rest were drilled for oil. Mitsuke oil field, at present, divided into two blocks of east and west. SK13a was drilled at the west and of west block to observe the oil producing limit. Though zone II, major oil zone in the Mitsuke oil field, was tested, it was abandoned because of water flow with oil. Water level was for the first time confirmed at the same well and it was located in the depth of 2,040 m below the sea-level. Being drilled at the north end of west block, SK18 brought about the production of

74kl/d of oil and 11,000 m³/d of gas with choke 5 mm after the completion of zone IIb between 2,036 m and 2,042 m. At this result, west block was found to be further expanded to the north. SK19 is the most remarkable success in this year. This well, the exploration at the southern part of west block, was drilled to the depth of 2,200m. Zone II which is until now major oil reservoir around the Mitsuke oil field became gas cap and new III, IV and V zone were discovered instead. Zone III has 35 m of effective thickness below 1,730 m, while IV has 60 m of that below 1,955 m and V has 25 m below 2,150 m. Of these IV zone has produced 83.8 kl/d of oil and 15,000 m³/d of gas with choke 5 mm after completed between 1,955 m and 2,004 m. As the result of drill stem test it is confirmed that III has almost the same capacity as IV. SK19 made it clear that west block extends further to the south-east, and at the same time there is expected the possibility of existence of new oil reservoir at further depth. This fact is a very hopeful one for Mitsuke oil field.

As stated before, oil development in this year finished with SK19. SK20 and SK21 were drilled for gas wells. That is, SK20 in the west block and SK21 in the east block were drilled at the center of each block, and both produced about 200,000 m³/d of gas after the completion of zone I (condensate reservoir).

Mitsuke oil field has now productive capacity of 1,000 kl/d of oil; it is, however, producing no more than 600 kl/d on account of the facilities for the transmission.

Kubiki Gas Field

Teiseki Kubiki gas field in the vicinity of Naoetsu city in Niigata prefecture is not only confirmed to be a major gas field in Japan by virtue of the exploration and exploitation in 1960, but also is found to be a major oil field in 1961. Kubiki gas field consists of four structures of Katamachi, Kuroi, Meiji and Asahi, having oil and gas zones of A, B and I to V. Of these Ic and Ie are largely oil reservoirs and the others, gas reservoirs.

Kuroi R17 should be worthy of special remark among the exploration drillings in 1961. As oil zone in the Katamachi structure—Ie being discovered in 1959—was intensively developed around the center of that structure in 1960, without getting any good result, it was about to be given up. However, in 1961, it was gradually getting a good deal of oil as the development was transferred to south-west.

Kuroi R17 was then drilled 3,000 m south-west of the center of Katamachi structure to look the connection with Kuroi structure. Through this successful oil well, it is recognized that oil producing area ranges from Katamachi to Kuroi and from structural view point, oil reservoir in Katamachi structure extends to Kuroi. Condition of the oil zone was clarified later by the exploitation well drilled between them.

The result of Katamachi R54 should be specified as the exploration that expanded the width of oil producing area. This well was drilled and produced oil in the inner land 1,000 m east of the previous oil producing area. Successive R56 and R57 verified the structure expanding the productive area into the inner land, while oil zone had been believed to be existing only under the sea till then.

Oil zone of here are Ic and Ie, and have large oil productive capacity as compared with the oil zones developed around the center of Katamachi structure in 1960. Therefore, crude oil production at Kubiki gas field increased to 4 times in 1961. Katamachi R57, for example, produced 46kl/d of oil with 9.5 mm choke after completion of reservoir Ic in October, and above

As regards gas reservoir, the expected result was achieved by developing the gas reservoir found in 1960. As for exploratory drilling, that of Kuroi structure would deserve special note. Though the structural complication of Kuroi area had prevented the development, by the exploratory well Kuroi R19, the real picture of structure was perceived and it gave great direction to the development in the future. Kuroi R19 was drilled to off-shore by directional drilling and produced 30,000 m³/d of gas and 6 kl/d of oil. As a result of drilling this well it turned out that the substance of Kuroi structure existed far out in the sea, that all drilled near the Kuroi coast up to now was just in the fringe of substantial structure, and that some part regarded in the past as Kuroi structure was the extension of Katamachi structure.

The Kuroi structure was found to extend from south to north in right angle towards the coast. It was expected that the structure upheaves at the land approaching to the coast after it once subsides.

So, Kuroi R25 was drilled at the location 1,000 m toward inland from the coast, and four promising gas reservoirs were discovered by the depth of 1,640 m and after completion of the reservoir between 1,240 m and 1,244 m, gas of 90,000 m³/d was produced with 6.3 mm choke. It was, thus, proved that Kubiki gas field greatly extends into the land.

Excellent gas reservoir with 40,000 m³/d of gas was discovered at the depth of 700 m in zone B₂ of Asahi R9 drilled in Asahi structure. The prospect of developing Asahi structure was firmly established, and at the same time shallow zones of Katamachi and the other structure came to reevaluated.

Having such prospect for the tremendous increases of gas output from Kubiki gas field, Teiseki made a contract with Tokyo Gas Company in August 1961 to furnish town-gas in Tokyo across the main land of Japan. The construction of the Japan's longest 330 km 12" gas pipeline between Kubiki and Tokyo was inaugurated on the 11th of November, and the gas supply is expected to start in Autumn 1962.

Production of Crude Oil and Gas in 1961

Petroleum mining industry in Japan has a history of about 70 years. Though the industry kept the constant petroleum production for these years, the rate of domestic production against its consumption has dropped down year by year because of the increased consumption of petroleum of late years. But the production of crude

Fig. 4

all Kuroi R26 flowed 128 kl/d of oil with 9.5 mm choke in December.

oil and gas in Japan has been showing a trend of sharp increase since last year and the increase of the production is continuing in this year, too.

Crude Oil

Comparison of the average daily production of the main oil field and of all Japan between November 1960 and November 1961 is shown Table 3. Crude oil production of all Japan increased by 13 percent in November this year compared with that of last November. However, since the production of Mitsuke oil field is being slowed down due to the lack of transportation facilities, it can be said that the actual production has increased by 30 %.

Table 3. Comparison of Crude Oil Production

	Average Daily Production	
	Nov., 1960	Nov., 1961
Sarukawa Oil Field	138 kl/d	222 kl/d
Yabase "	758	638
Amarume "	—	88
Mitsuke "	495	568
Kubiki Gas Field	66	241
Others	467	423
All Japan	1,925	2,170

Natural Gas

Comparison of inflammable natural gas production (except coal-mine gas) between November 1960 and November 1961 is shown in Table 4 by prefecture and all Japan. This table shows that the average daily production has increased by about 23 percent in 1961 compared with that of 1960.

Table 4. Comparison of Natural Gas Production

	Average Daily Production	
	Nov., 1960	Nov., 1961
	1,000 m ³ /d	1,000 m ³ /d
Hokkaido	23	17
Akita Pref.	415	494
Yamagata Pref.	7	14
Niigata Pref.	1,273	1,653
Kanto District	562	641
Others	58	67
All Japan	2,338	2,886

The Activities Outside the Country

Arabian Oil Co., Ltd.

Following the discovery of oil reservoir by R1 in November 1960, both International Drilling Co. and Sea Cat Drilling Co. conducted

their drilling against Bahrain Zone in 1961 and completed 24 wells by the end of that year. Each of these wells has a capacity of more than 1,000 kl daily. Among these wells, R24 was dually completed in both lower part and upper part of Bahrain Zone with tubing and casing respectively and the total production capacity of this well was proved to be more than 2,000 kl per day.

Temporary offshore loading facilities using five T-2 tankers were almost completed in February 1961, and in April the first shipment was made by ocean tankers. Afterwards, crude oil was smoothly shipped amounting to about 1,200,000 kl by the end of the year. Originally, crude oil was shipped from 8 wells through these facilities. In December, one more well was connected with this system.

While the temporary offshore loading facilities are now in operation, the construction of permanent production facilities were commenced at the beginning of this year. These permanent production facilities consisting of four flow stations and one gathering station at sea are designed for daily crude oil production of 33,000 kl and its transportation to the shore by 26" transmission line of about 42 km. And these permanent production facilities are planned to separate gas from crude oil by separator on the shore and to ship crude oil to ocean tankers by constructing a loading dock at about 5 km offshore.

North Sumatra Oil Development Cooperation Company

North Sumatra Oil Development Cooperation Company was established to cooperate in the rehabilitation and development of both Rantau and Paluh Tabuhan oil fields in North Sumatra which are owned by Permina Oil Company of the Republic of Indonesia. The year of 1961 was the second year of this program. According to the development program, the second year production was supposed to reach 1,300,000 kl, but the production was not more than 1,000,000 kl as the rehabilitation of the production was delayed by the fire-fighting and wind-up of R78 in Rantau oil field. But gradually these works have been put on the road and the first new well is going to be completed shortly. After the workover, producing wells of Rantau oil field reached 98 wells. With 2 more wells at Paluh Tabuhan, about 3,500-4,000 kl of oil is produced daily from 100 wells.