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Fedorovo: Prospects for the USSR's Third-Largest Oilfield

A Research Paper

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Information available as of 1 June 1982
has been used in the preparation of this report.

The authors of this paper are
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Global Issues. Comments and queries are welcome

This paper was coordinated with the National
Intelligence Council

~~Top Secret~~
GI 82-10125C
June 1982

Fedorovo: Prospects for the USSR's Third-Largest Oilfield

Overview

After three decades of rapid growth, Soviet oil production has reached at least a temporary plateau at a little more than 12 million barrels per day (b/d), or just over 600 million metric tons per year. Production is currently declining at most of the giant and supergiant fields that generated the steady increases of the 1960s and 1970s. To offset this decline, the USSR must work much harder than in the past, particularly if it is to meet its 11th Five-Year Plan goal of 12.6 million b/d by 1985. The outcome of the Soviets' efforts will hinge, in large measure, on the performance of a number of fields in western Siberia, the largest oil-producing region in the USSR

With the possible exception of Samotlor, no field in western Siberia will be more critical to Soviet success than Fedorovo, a supergiant that is already the third-largest producer in the nation. We estimate that Fedorovo originally contained over 23 billion barrels of oil in its reservoirs.[1] According to our analysis, about 6 billion barrels will be recoverable with available technology and with the facilities now being developed at the field

The Soviets have invested considerable resources—in the form of drilling rigs and an expensive gas-lift system purchased from France—in an attempt to maximize output from the field. Our analysis indicates that this effort has succeeded. The current five-year plan calls for production at the field to rise to just under 700,000 b/d in 1982—some 6 percent of national oil output—and to stay at this high level through 1985. We judge that Fedorovo will meet or exceed these goals. Indeed, assuming that drilling and gas-lift installation continue at their current pace, the field could be operated at a production rate 100,000 to 200,000 b/d above these plan target:

We do not anticipate that production from Fedorovo will begin to decrease significantly until 1986 at the earliest. By 1990, however, the field will probably be entering an advanced state of decline, with production around 500,000 b/d and dropping rapidly. The Soviets might then consider initiating an enhanced recovery program for portions of the field or

[1] Savuysk, a small oil pool ecologically related to Fedorovo, is included in oil-in-place and production estimates

expanding development to less productive reservoirs. In either case, such an effort could temporarily moderate the decline, and, with a sufficient resource commitment, might possibly restore production to the level of the late 1980s

In spite of the inevitable decline in production at the end of this decade, Fedorovo has been a welcome bright spot for the Soviets on what appears to be an increasingly troublesome oil horizon. The Soviet Ministry of Petroleum Industry has amassed sufficient personnel and equipment for the field to achieve its production potential without the need for heroic measures or additional major investments. Its success in developing Fedorovo has played a key role in Moscow's continued ability to maintain national oil production near the 12-million-b/d level.

Fedorovo: Prospects for the USSR's Third-Largest Oilfield

From World War II into the late 1970s, the USSR maintained consistently high rates of growth in petroleum production. Since then, Soviet oil production has stagnated at slightly more than 12 million barrels per day (b/d) or just over 600 million metric tons per year. The reasons are numerous: a decline in exploitable reserves, the remote locations of newer oil deposits, drilling problems, and serious equipment shortcomings in exploration and fluid-lift operations. Nevertheless, Moscow needs to maintain positive rates of growth in oil production to fuel its domestic economy, to gain badly needed hard currency from exports, and to provide energy to its client states in Eastern Europe, Cuba, and Southeast Asia. The Soviet desire to keep oil output growing is also motivated by a desire to maintain the first-place position of the USSR in world oil production, which we believe has become a matter of national prestige and—in Soviet eyes—a symbol of the superiority of the Soviet economic system.

To reach its 11th Five-Year Plan goal of 12.6 million b/d by 1985, the Soviet Union needs, among other things, to slow or postpone the inevitable declines in production at the large mature fields that generated the steady production increases of the 1960s and 1970s. To date we have assessed the current performance and predicted future recovery for three such fields—Samotlor, Romashkino, and Arlan. Our analysis indicates that, despite the best Soviet efforts, production from these three fields alone could fall by as much as 1 to 2 million b/d below 1980 levels by the middle of this decade.

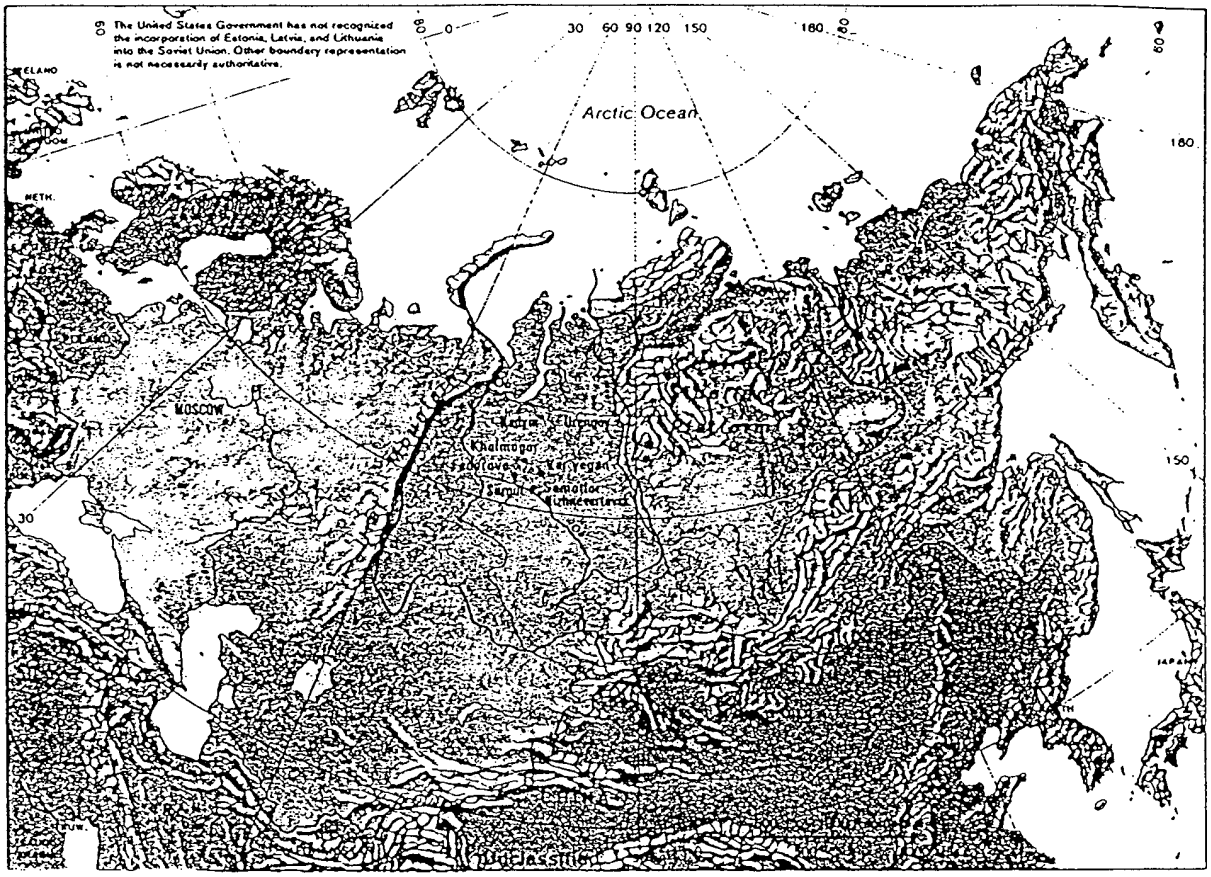
The new production needed to cover the decline from established fields and to add the nearly 600,000 b/d specified in the 11th Five-Year Plan must come from a number of young fields, most of them in western Siberia. Fedorovo, already the third-largest oil producer in the country and second largest in western Siberia, is one of these key fields (figure 1)

Geologic Setting

Fedorovo Oilfield is located in the West Siberian Basin—at 3.4 million square kilometers, one of the largest structural-sedimentary basins in the world (figure 2). The basin deepens asymmetrically to the north and is traversed by major rivers meandering northward across a marshy, lake-strewn plain to the Arctic Ocean. Environmental conditions in the basin are harsh, especially in the central and northern parts, where most of the oil and gas fields are located. Winters are frigid, and activity in the summer months is hampered by swampy, poorly drained terrain. These conditions seriously inhibit the establishment of the required transportation infrastructure and commonly limit offroad vehicular traffic to the winter months when the ground surface is frozen. The permafrost conditions in the northern half of the basin and the recurrent freezing and thawing of the surface force the Soviets to use expensive construction techniques in the oilfields of the region. Wells must be clustered on large drilling pads designed to withstand the severe environment and to reduce the expense and ease the construction of well sites.

The geologic history of the West Siberian Basin makes it one of the more favorable locations in the world for accumulation of hydrocarbon deposits. The basin has had a quiet, relatively undisturbed tectonic history under geologic conditions conducive to petroleum formation and accumulation. The sedimentary rock layers are thick and fairly uniform, consisting of marine and continental sediments of the Jurassic, Cretaceous, and Paleogene overlaid by a veneer of more recent glacial, lake, and alluvial deposits. Excellent petroleum source beds—particularly the Bazhenov shale—and numerous subsurface structural features necessary to trap and accumulate oil from the source beds are present in most of the basin. One notable feature is the Khanty anticlize, a dominant

Figure 1
West Siberian Basin: Selected Oilfields



subsurface structure that forms a regional oil migration and collection system. Superimposed on this regional high are additional uplifts, such as the Surgut and Nizhnevartov arches, which in turn contain localized and smaller individual domes and structural features. The Fedorovo structure, site of the Fedorovo and Savuysk oilfields, is one of a number of smaller uplifts on the Surgut arch containing oil and natural gas (figure 2).

[redacted] We conducted a [redacted] analysis of the Fedorovo structure to supplement and to validate the geologic information found in the Soviet literature.

[redacted]

[1] Because Fedorovo and Savuysk are located on the same uplift, are producing from the same pay zone, and are being developed with similar strategies, we decided to assess them as one field. Unless specifically stated otherwise, all analysis pertaining to Fedorovo also includes Savuysk

Methodology

An assessment of the production potential of any Soviet oilfield is hindered by a paucity of open-source production and reserves data. Data on reserves have been state secrets since World War II, and access to this information is highly controlled even within the Geology and Petroleum Ministries. Field-by-field production figures, sparse since 1974, virtually disappeared several years ago when Moscow became aware that the United States was scrutinizing its oil industry.

To overcome this lack of information, we have developed methodologies that allow us to estimate with some confidence the reserves, current production, and future yields of Soviet oilfields. Considerable geologic and reservoir data are available in Soviet scientific and technical literature and from Intelligence Community sources. [ ], in conjunction with these other sorts of data, can be used to track field development and estimate oil in place and reserves. Finally, we can use a variety of both simple and sophisticated techniques of reservoir engineering analysis to estimate field performance and recovery potential under different development scenarios.

Because Fedorovo is a relatively young field without a lengthy production history, we elected to employ a modified material-balance approach rather than attempting more complex modeling. This approach treats a petroleum reservoir as a single, uniform tank of fluid (oil, water, and gas) and does not attempt to account for variables such as fluid flow within the reservoir or individual wellbore effects. If reasonably accurate estimates of reservoir rock and fluid characteristics, oil in place, and historical production are available, the material-balance technique affords a means of inventorying reservoir fluids at various time intervals in the production life of a field and calculating the amount of oil produced under different recovery strategies. Material-balance analysis can accurately predict near-term production but often overestimates long-range production rates by not anticipating and accounting for reservoir problems that occur as a field ages

[ ]

Soviet geologic cross sections show that oil migrated into these structural highs, where it was contained by less permeable overlying sediments. The average thickness of the sedimentary cover in the area of these highs is 3,000 meters, with the pay zones located below 1,800 meters. The best producing zone at Fedorovo is the BS_{10}, located at a depth of 2,200 meters (figure 5). This highly productive and widespread reservoir produces in all parts of the field and contains approximately 43 percent of the original oil in place at the field. The shallower AS_{4-1} horizon is even more widespread than the BS_{10} but appears to have much poorer reservoir properties. The BS_1 and BS_2 reservoirs contain oil in thin and discontinuous pay zones; the other hydrocarbon-bearing reservoirs at Fedorovo contain mostly gas or only localized oil pools

Figure 2
West Siberian Basin: Khanty Anticlize
and Other Structural Features

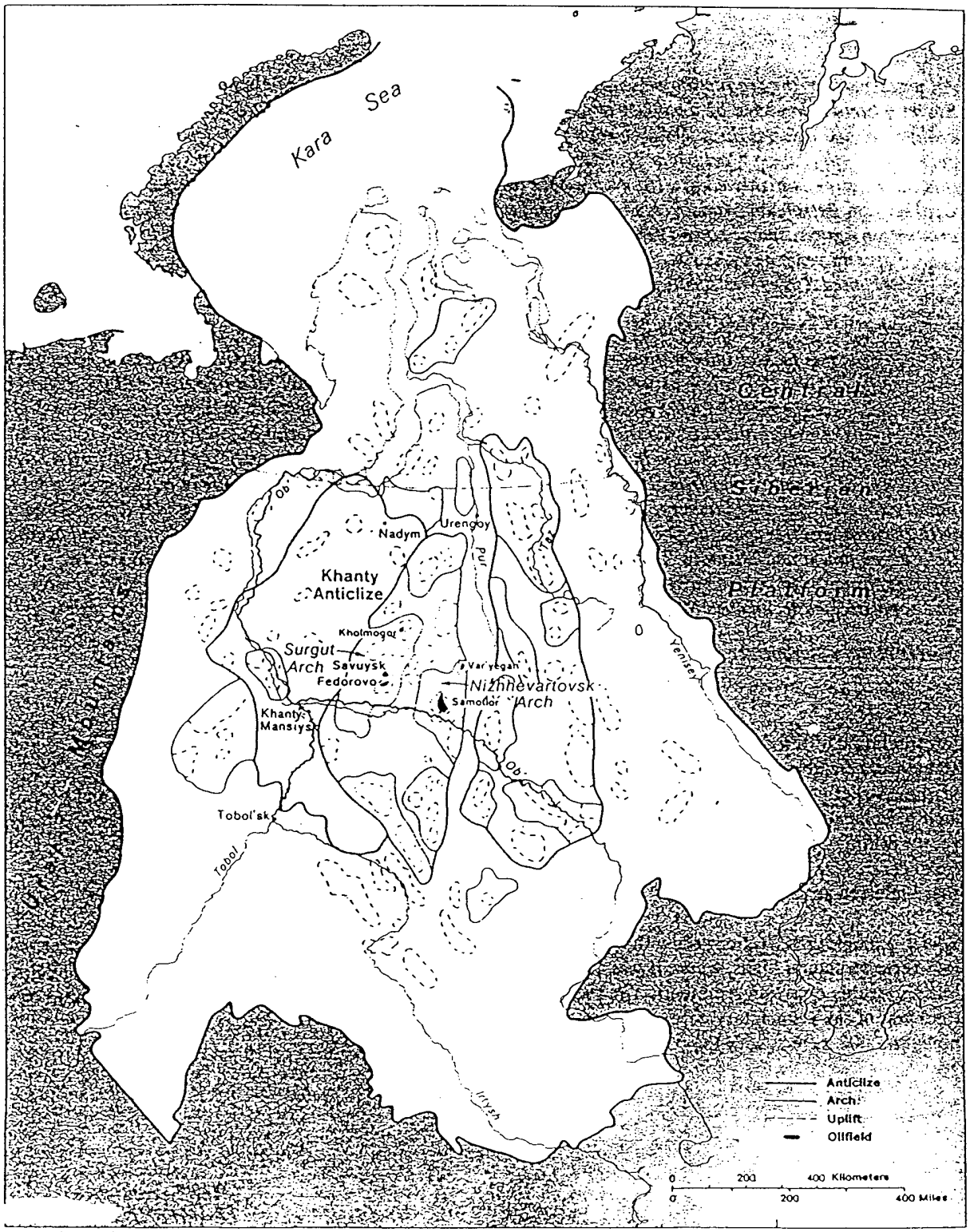


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Figure 3

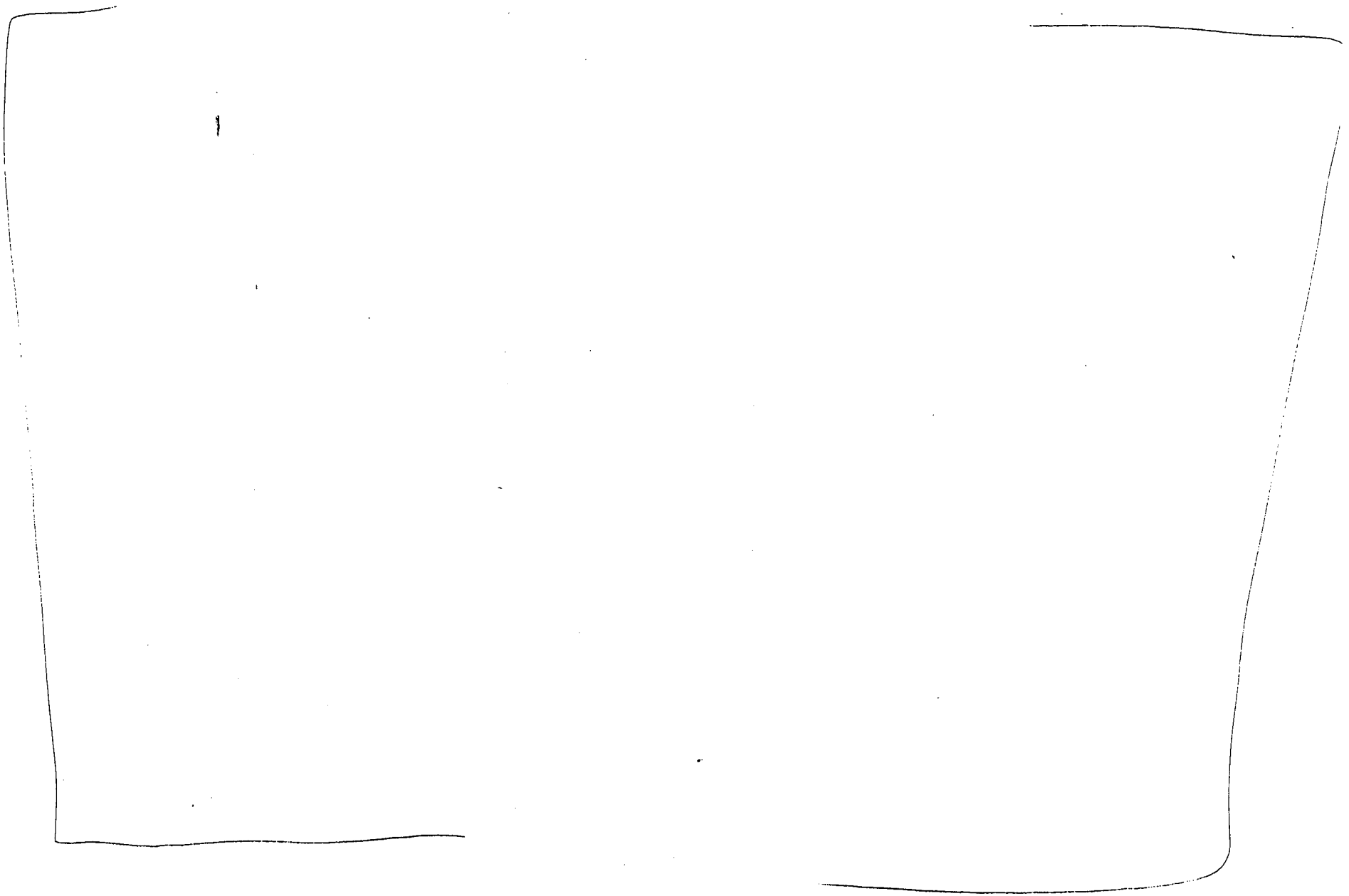


Figure 4
Subsurface Structure of BS_{10} Reservoir
at Fedorovo and Savuysk

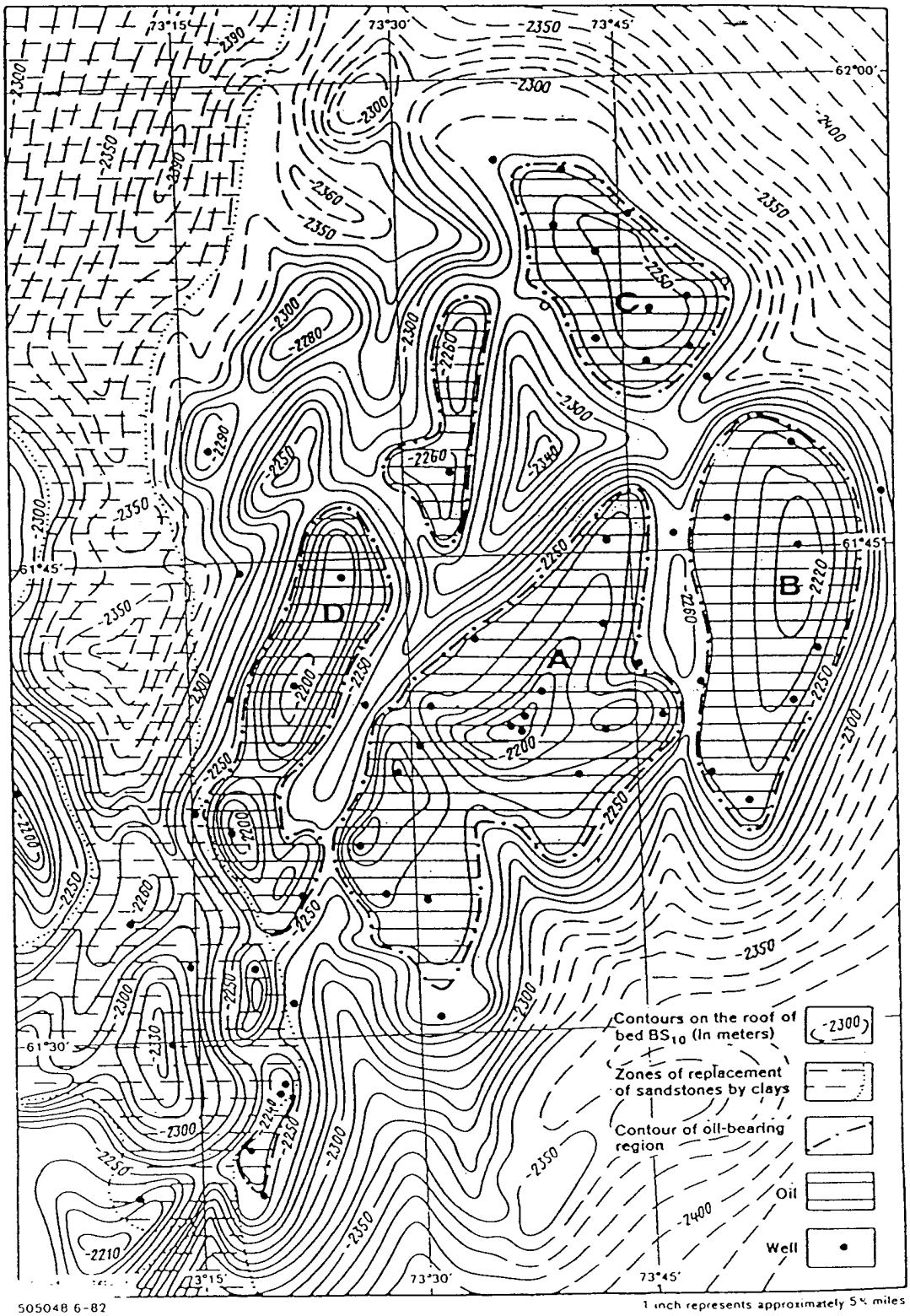
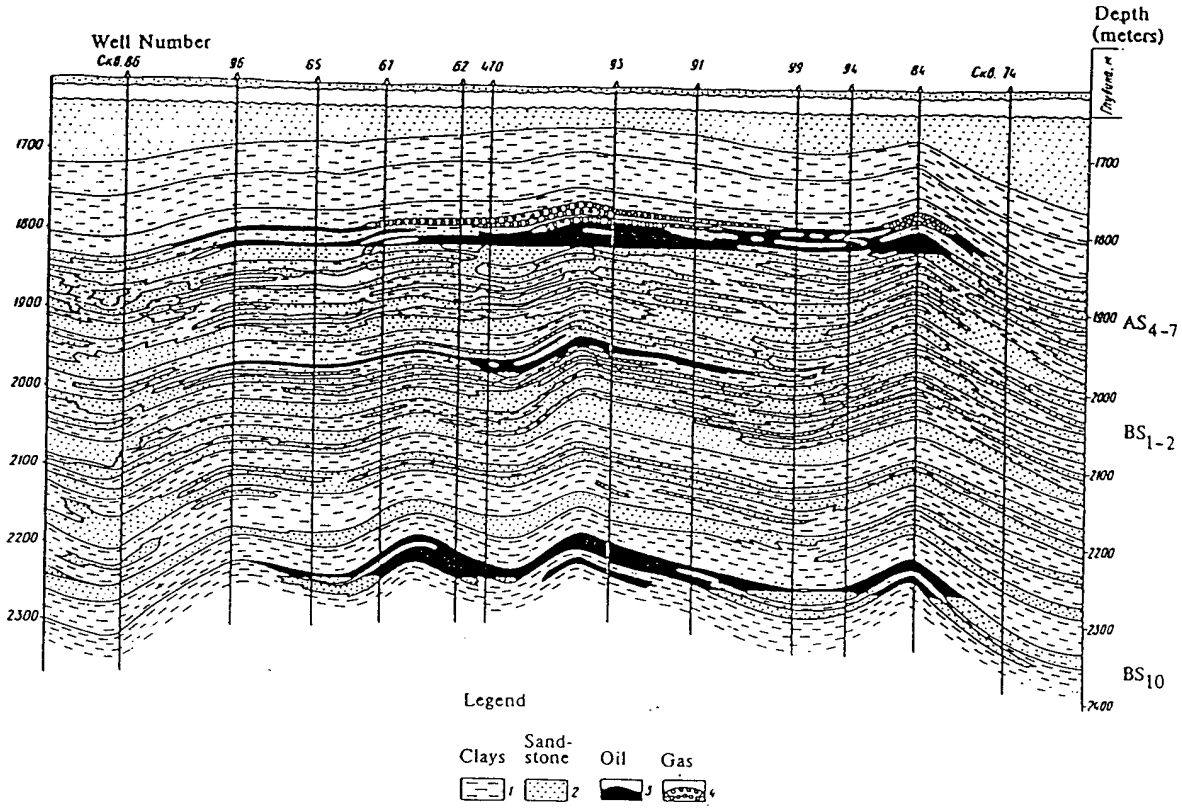


Figure 5.

Geological Profile of Fedorovo Oilfield



Oil in Place and Reserves

The amount of original oil in place in an oilfield must be known or estimated in order to assess the field's production potential. We estimate that at the time it was discovered Fedorovo contained approximately 23 billion barrels of oil. We arrived at this figure by calculating the volume of the oil-bearing strata in the structural highs and then adjusting for the volume occupied by gas, water, and the rock itself. Some 9.8 billion barrels of this oil were located in the BS_{10} horizon, with the remaining 13.2 billion barrels in the AS_{4-7}. Because the other oil-bearing horizons are of very poor quality, we excluded them from the calculations

The USSR claims an average recovery rate of 43 percent of original oil in place in fields where water injection is used for secondary recovery—a figure that is quite high even by US standards. In reality, Soviet recovery rates are often considerably lower because of the inability of Soviet drillers to devise workable solutions to inevitable reservoir problems. We believe that the quality and homogeneity of the BS_{10} reservoir at Fedorovo will allow an ultimate recovery rate of 30 percent or higher—enough to place recoverable BS_{10} reserves at over 3.0 billion barrels. These large recoverable oil reserves in the BS_{10} alone would put Fedorovo in the giant field category [1]

Traditional Soviet drilling and well-completion practices make estimating recoverable reserves in the AS_{4-7} a more difficult task. The Soviet drilling industry has not perfected the multiple completion technology that allows simultaneous extraction of oil from more than one pay zone through only one wellbore. At present, nearly all the wells at Fedorovo have been drilled into the deeper and higher quality BS_{10} reservoir, and we believe that over 90 percent of the production is currently coming from that pay zone. As wells into the BS_{10} become depleted, we believe the Soviets will probably plug them just below the AS_{4-7} horizon and reperforate the well casings to produce oil from the AS_{4-7}. With no flow rates or production history for the AS_{4-7}, there is no way to evaluate the quality of the reservoir or to estimate its recoverable reserves with great accuracy. Its poorer reservoir properties, however, should make the recovery percentage considerably lower than that obtained in the BS_{10}. A recovery factor as low as 20 to 25 percent would still add another 2.6 to 3.3 billion barrels to the 3 billion barrels in the BS_{10}—enough to raise Fedorovo into the supergiant category.

Field Development and Production History

The rate at which the USSR is able to extract the estimated 5.6 to 6.3 billion barrels of reserves at Fedorovo largely depends on how the field is developed and produced. With one exception—an expensive gas-lift system now being installed—the Soviets have basically followed their traditional methods of field development at Fedorovo and have experienced many of the same problems previously encountered at Samotlor and other fields in the basin. In keeping with standard Soviet practices, Fedorovo is being worked intensively in an attempt to maximize current production.

The Soviets drilled the first successful well in the Fedorovo area in 1963. As has been the case with many other western Siberian fields, the remote location, environmental problems, and some confusion over geophysical survey results delayed the start of development drilling until 1971. Initial development drilling then proceeded slowly, primarily because of the special engineering and construction techniques needed in the harsh environment of the field (figure 6). It was not until 1977, when Fedorovo was assigned its own independent oil and gas directorate, that the pace of drilling began to increase rapidly. In that year, the number of production wells jumped from 88 to 208 and total wells from 115 to 244. The high rate of drilling in subsequent years and the fact that 25 rigs are now working in the field indicate a Soviet desire to boost production at Fedorovo as rapidly as possible.

[1] Oilfields with recoverable reserves above 500 million barrels are considered giants. To rank as a supergiant, a field must have recoverable reserves of at least 5 billion barrels

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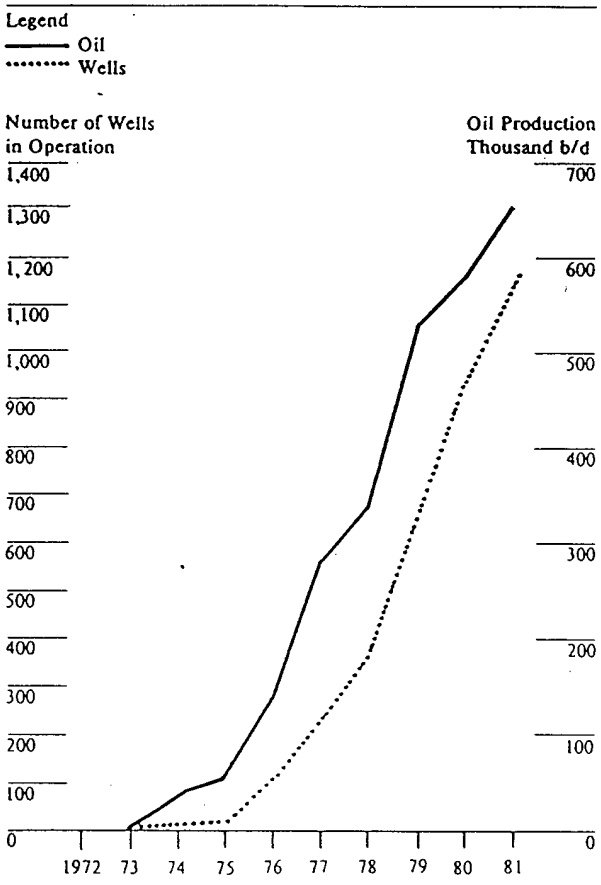
Figure 6

Fedorovo Drilling and Oil Production



Year	Oil Production (barrels/day)	Wells (in Operation)
1973	4,077	a
74	40,164	a
75	60,247	21
76	140,575	115
77	279,142	244
78	343,550	366
79	532,939	a
80	586,631	940
81	667,000	1,150

[a] Unknown.

Although a complete set of year-by-year production figures for Fedorovo is unavailable, a production history can be pieced together [illegible]

[illegible] Production at Fedorovo started in 1973 and began to grow rapidly with the intensification of drilling in 1977 and the onset of production from the Savuysk pool in 1979. We estimate that production from Fedorovo reached 587,000 b/d (29.2 million tons) in 1980 and 667,000 b/d (33.2 million tons) in 1981, when it accounted for nearly 6 percent of Soviet national oil output.

The development plan designed for Fedorovo [illegible] is similar to those at other western Siberian fields. Water injection has been used to stimulate the recovery process since the early stages of development. The Soviets rely on waterflooding to maintain reservoir pressure and improve production and ultimate oil recovery. A water injection program at a field the size of Fedorovo requires a huge volume of water, which, under ideal circumstances, should match as closely as possible the chemical and temperature characteristics of the reservoir water. Despite reservoir problems that have occurred at Samotlor and other fields, at Fedorovo the Soviets are apparently injecting some surface water into the reservoir after only minimal treatment. Although we are not aware of any reservoir damage yet, the use of surface water without filtering and proper chemical and heat treatment can cause equipment maintenance problems and can reduce the amount of oil ultimately recovered

Another problem the Soviet Union has frequently encountered with water injection is prematurely high water cuts from producing wells.[4] So far, however, this problem has not occurred at Fedorovo. [illegible] the 1980 watercut for the field as a whole was only 21 percent, a reasonable figure for a field in Fedorovo's current stage of development

[4] The watercut is the proportion of water in the mixture of water, oil, and gas extracted from a production well. As the watercut rises, an increasing volume of fluids must be lifted from the wells to produce a given amount of oil

At Fedorovo the Soviets have also continued their practice of developing and producing oil from the largest and most promising geologic structure before delineation drilling is completed[ ]This practice may be responsible for some of the early confusion and conflicting estimates of the production potential of Fedorovo. Sector A (as delineated in figures 4 which encompasses the most promising structure, was developed first and is the most intensively drilled area of the field. [

Drilling activity in sectors B, C, and D lags behind that in sector A. Nevertheless, sectors B and C have already been drilled close to the margins of their respective structural highs and will probably be the scene of intensive development drilling during the next several years. Sector D, the least developed area, will probably not be drilled as densely as the rest of the field because of the presence of several large lakes. The Soviets normally build causeways terminated by manmade islands to drill in freshwater lakes, an expensive and laborious process that is not started until development is well under way. It is instructive to note that at Fedorovo, a field critical to the USSR's near-term oil production goals, the Soviets seem to have made no efforts to employ new technologies that would allow cheaper and more effective drilling in these lakes

The only significant departure from normal Soviet field development strategy has been the installation in the Fedorovo sector of the field of a gas-lift system bought from France.[1] The Soviets have stated that the Savuysk pool is not scheduled for gas lift. Wells under gas lift are made to flow faster by the injection of compressed gas into the bottom of the hole, thereby lightening the fluid column and increasing total fluid production out of individual wells by as much as 30 percent. A field under gas lift will not necessarily produce more oil over its lifetime than one exploited with mechanical pumps and water injection, but it will produce a larger percentage of its oil earlier in its history. Gas lift also permits the production of larger volumes of fluid, which tends to stabilize oil output as watercuts increase with time.

[ ]oil industry sources indicate that the USSR originally planned to install a 300-well gas-lift system in 1977, at about the time when Fedorovo became the locus of an independent oil and gas association and the pace of drilling began to increase. According to these same sources, that plan was discarded and replaced by a more ambitious one calling for the installation of gas lift in 330 wells in 1981 and 370 additional wells in 1982. By comparison, Samotlor, a supergiant field currently producing five times as much oil as Fedorovo, is slated for only 1,200 gas-lift wells.

Last year the Soviet Minister of Petroleum Industry announced on two occasions that the Fedorovo gas-lift project was falling behind schedule. [ ]that the implementation of gas lift will not occur as originally planned. Three of the four main compressor stations have been constructed along with the gas treatment facilities and the pipelines to transport recovered gas to the compressor stations. Installation of the downhole equipment and the pipelines to transport compressed gas to the individual wellheads, however, is well behind schedule. At the current rate of installation of downhole equipment, the full system will not be operational until the end of 1984 or so. Pipeline installation will probably progress at a comparable rate, allowing gas lift to begin in increments some time in 1982. The Soviets are attempting to compensate for the loss of production caused by the delayed gas-lift installation[ ]an infill drilling program is under way in sector A, the oldest part of the field where production may have begun to decline. The greater density of producing wells in that sector will achieve the same effect as gas lift—an increase in oil production.

Production Forecast

Annual production at Soviet oilfields is normally keyed to goals contained in national five-year plans, and Fedorovo is no exception. Oilfield production chiefs are expected to meet plan goals and often to

[1] The Soviets first tried gas-lift methods in 1969 at Pravdinsk Oilfield, using a system of their own design. They obtained uneven results there and at several subsequent gas-lift projects at othe oilfields involving domestically developed techniques

Fedorovo Oil Production Forecast [a]

Barrels Per Day [a]

Year	Current Five-Year Plan Goals	At Subsequent Rate Implied by Current Plan Goals	At Maximum Efficient Rate (MER) [b]
1981	665,122 [c]		739,649
1982	692,836		803,369
1983	692,836		829,663
1984	684,803		899,181
1985	668,737		884,613
1986		666,647	771,310
1987		627,410	675,476
1988		583,986	596,340
1989		545,370	526,831
1990		506,083	469,593
1991		454,196	420,801
1992		411,124	379,811
1993		372,863	342,521
1994		334,671	311,671
1995		301,272	281,272
1996		273,166	255,166
1997		245,316	230,816
1998		221,692	209,192
1999		200,267	189,267
2000		180,015	170,015

[a] 7.33 barrels = 1 metric ton.
[b] The maximum efficient rate is the highest rate at which an oil well or oilfield can be produced without damaging the reservoir or decreasing yield and ultimate recovery.
[c] Actual 1981 production was 667,000 b/d.

exceed these goals through "counter plans" unless the extra production might cause a premature decline and consequent plan shortfall later in the production life of the field. The current plan for Fedorovo calls for yearly average production to rise from 587,000 b/d in 1980, the last year of the 10th Five-Year Plan, to a high of 693,000 b/d in 1982, and to stay at or near this level over the rest of the 11th Five-Year Plan period (see table

Our engineering analysis indicates that Fedorovo already has the capacity without gas lift to exceed the 1982 target of 693,000 b/d. Sufficient drilling rigs and drill pads are in place at the field to support continued drilling at a rate equal to that of the past several years. If the new wells are indeed drilled, Fedorovo will be able to maintain production at or near the present level through 1985 (figure 8). Moreover, with the addition of the extra capacity provided

Figure 8

Fedorovo Production Forecast at Plan Rate

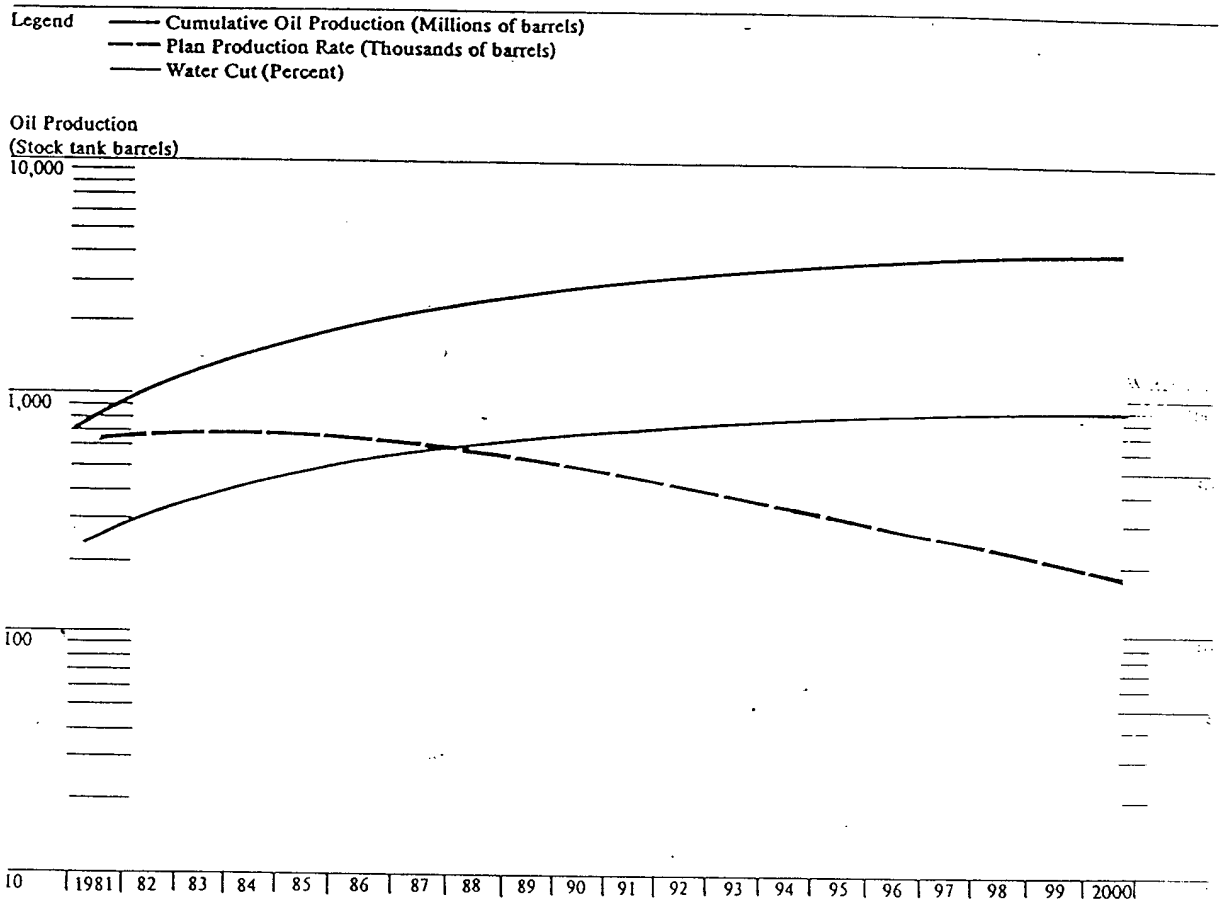
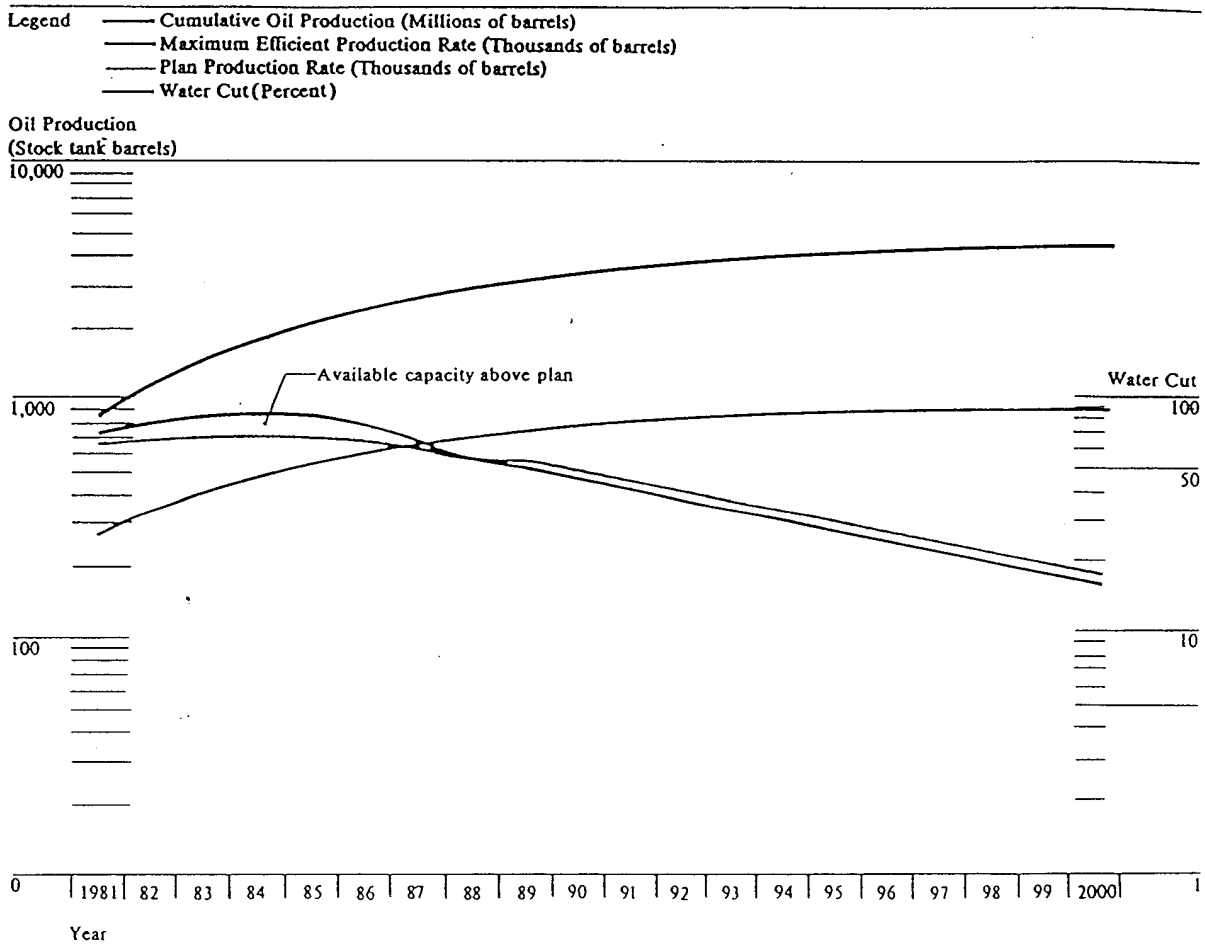


Figure 9

Fedorovo Production Forecast at Maximum Efficient Rate



by the gas-lift equipment—now installed in some 200 wells with 18 additional wells being converted each month—Fedorovo should be able to exceed plan goals during this period. The upper limit, or maximum efficient rate (MER), at which the field could be operated during the remainder of the current five-year plan is represented in figure 9. Operating at the MER, the Soviets could attain a production plateau at a level some 100,000 to 200,000 b/d above the plan goals without a rapid and premature production decline during the 12th Five-Year Plan.

For the MER to be reached, the gas lift must start up in increments as the downhole equipment is installed, and it must operate at its design capacity. The Soviets will probably achieve an incremental startup of the gas lift. They have reported that one of the compressor stations at Fedorovo is already operating, implying that part of the field is now under gas lift. We think it unlikely, however, that the gas-lift equipment will be operated at peak efficiency. Moreover, some 10 to 15 percent of the wells at Soviet oilfields are normally shut in at any one time for routine maintenance or repairs. Thus, production from Fedorovo will probably fall somewhere between the plan rate and the MER. Nevertheless, the gas-lift program should provide some excess oil-production capacity upon which the Soviets could draw if unexpected problems develop at other fields. There are some indications that Fedorovo will have to draw upon this excess capacity. The Soviet journal *Socialist Industry* reported in January, for example, that the oilfield workers at Fedorovo are committed to exceed the 1982 plan by some 40,000 b/d.

During 1986-90, the period of the next five-year plan, the BS_{10} reservoir will begin to experience problems, including falling production, higher watercuts, and decreasing reservoir energy. We expect that the Soviets may try to offset these problems by increasing the number of wells on gas lift, intensifying infill drilling, or drilling the lakes to the same density as the rest of the field. None of these options would be cost effective if the resources consumed were to come at the expense of investment at other, younger fields with high-quality reserves. Alternatively, the Soviets could try to drill separate wells into the AS_{4-5} reservoir. That is not a high-quality reservoir, however, and we doubt the Soviets would elect to drill it as long as better reservoirs were available elsewhere.

If no extraordinary measures are taken, the BS_{10} at Fedorovo will be entering an advanced state of decline at the end of this decade. Production will be 500,000 b/d and dropping rapidly. Watercuts will approach 75 percent for the field as a whole and will be higher in older wells. Even though the Soviets will be withdrawing steadily increasing amounts of fluid, they will be extracting decreasing amounts of oil. Nevertheless, during this decade Fedorovo is expected to meet the goals of Soviet planners without heroic measures or major infusions of additional manpower or investment.

Our material-balance analysis indicates that the BS_{10} reservoir will be nearing the end of its producing lifetime in the late 1990s, with 42 to 47 percent of the original oil in place recovered under the present water injection program. This figure, which is somewhat higher than the recoveries we have calculated for other Soviet fields under waterflood, is probably too optimistic. Material balance does not account for interwell effects such as water channeling and premature water breakthrough, which can increase water production and lower the oil-recovery percentage. The Soviets experience these kinds of problems at most fields where they employ water injection. At Fedorovo, such problems would probably begin reducing production after 1985. For this reason, we doubt ultimate recovery will exceed 35 to 40 percent of the original oil in place in the BS_{10} reservoir

At some point in the 1990s, the Soviets will probably try to slow or temporarily reduce the production decline at Fedorovo. They will have two options: either plugging back the wells above the BS_{10} reservoir and beginning production from the same wells in the shallower AS_{4-5} horizon, or using an enhanced recovery program in the BS_{10}. The sizable amount of oil left in the BS_{10}—some 6 billion barrels—and the quality of the reservoir as well as likely improvements in enhanced recovery technology lead us to believe that an enhanced recovery program will be the option chosen at Fedorovo

Among the enhanced recovery techniques now available, carbon dioxide (CO_2) injection and polymer flooding offer the most promise for increasing recovery from the BS_{10}. Assuming adequate CO_2 supplies were available, a CO_2 program potentially could recover another 5 to 15 percent of the remaining oil in place.[4] A Soviet decision to implement a CO_2 program, however, would probably be heavily influenced by the results of a similar program now being considered for a section of the much larger Romashkino field in the Urals-Volga oil-producing region. Polymer flooding is equally promising and would probably be more cost effective. The technology is relatively simple, the increased cost of production moderate, and the potential recovery percentage equal to that obtained in CO_2 injection.[5]

Neither of these techniques has yet been fully proved in the field, even in more technologically advanced countries such as the United States. If the Soviet oil industry were to apply either process in the near future, its success would be problematic without Western assistance. By the 1990s, however, as technology evolves and the Soviets gain more experience with enhanced recovery techniques, the situation might be different. In any case, a decision to initiate an enhanced recovery process would ultimately depend on which of two fundamentally different development strategies the USSR chooses to emphasize for its petroleum industry during the rest of this decade. The Soviets could decide to concentrate their efforts and investment resources on finding and developing new fields in new areas, in which case Fedorovo would cease to be a significant oil producer in the late 1990s. Alternatively, they could decide to utilize their available manpower, capital, and equipment to sustain production at existing fields. The BS_{10} reservoir at Fedorovo would then become a leading candidate for enhanced recovery.

[redacted]

[4] CO_2 injection (or flooding) can be used by itself or in conjunction with waterflooding to maintain pressure and sweep the oil in a reservoir toward the production wells. Unlike water, CO_2 mixes well with oil, forming a fluid that moves more easily through the pores in the rock.

[5] Polymer flooding involves the injection into a reservoir under waterflood of a solution of specially designed chemicals—either polysaccharides or polyacrylamides—to improve the ability of the waterflood to sweep the oil toward the production wells.

Outlook

The Soviet Union clearly suffered a number of setbacks in developing Fedorovo. Early field development was slower than expected, the gas-lift installation fell behind schedule, and the Soviets achieved no major technological breakthroughs or procedural innovations. Our analysis indicates, however, that despite these setbacks, the Soviet Petroleum Ministry has now amassed enough personnel and material at the field to maximize oil production soon. Fedorovo should easily achieve its 11th Five-Year Plan targets. If no major setbacks occur in the drilling and gas-lift programs, the field should be able to achieve production levels some 100,000 to 200,000 b/d above the plan. Thus we anticipate that Fedorovo will be a welcome bright spot for the Soviets on what may be an increasingly troublesome oil horizon. If similar successes are achieved at other key western Siberian fields, Soviet near-term petroleum prospects will improve considerably, and the potential for a downturn in production in the late 1980s would be lessened.

[redacted]