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Uzen Oilfield: A Case Study of Soviet Mismanagement

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Uzen Oilfield: A Case Study of Soviet Mismanagement

Summary

nformation available s of 1 November 1982 as used in this report.

Discovery of the Uzen oilfield on the Mangyshlak Peninsula in 1961 gave Soviet energy planners high expectations for the potential contribution that it and the other fields in surrounding Kazakhstan would make to national oil production. Development of the petroleum resources of West Siberia had not yet begun, and the Soviets were searching for advantageously located deposits in the western USSR rich enough to replace the Volga-Urals fields when they began to decline. Soviet geologists had assessed the hydrocarbon content of the Caspian Sea basin as high and were looking to the future of Uzen with optimism.

Some 20 years later, however, Soviet literature and other reporting suggest that Uzen oilfield has not met Soviet expectations. Although the field contained enough potential reserves at discovery to place it in the medium-giant category—an oilfield must contain 500 million barrels of recoverable reserves to be considered a giant—Soviet engineers have been unable to overcome recovery problems caused by the complexity of the reservoirs and the poor characteristics of the crude oil. As a result, the reservoirs have been permanently damaged and annual field output has lagged far behind production goals. Our analysis of possible future production scenarios shows that the observed decline of Uzen—the field peaked in 1975—will continue at least through the year 2000. We see no prospects for anything more than a slowing of this trend regardless of any new strategies the Soviets may employ.

In large measure, Uzen provides an excellent case study of how poor field management and the traditional Soviet emphasis on initial high output rates can lower long-term oil production. The Soviets are currently attempting to rehabilitate Uzen with a variety of expensive Western recovery processes and equipment, much of which is inappropriate, according to our engineering analysis. This suggests that developers at other fields in Kazakhstan and perhaps the rest of the country may perpetuate mistakes made at Uzen. In view of the likelihood of continued inappropriate development practices and difficulties in obtaining Western equipment, we doubt that Kazakhstan will offer the USSR a significant source of additional oil production over this decade.

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Background

The Kazakh SSR currently provides the USSR with about 3 percent of its oil supply. Although this contribution is relatively small, open sources indicate that the Soviets regard both the onshore and offshore potential of the entire Kazakhstan–Caspian Sea area as significant (figure 1). Kazakhstan and the Timan-Pechora region of the Komi ASSR are the two areas outside of West Siberia that have shown the greatest growth in petroleum production during recent years, and many Soviet oil experts rate their potential for future increases as high.

Thus far, however, the Soviets have been frustrated in their efforts to make the key oilfields in Kazakhstan meet expectations. The high viscosity and paraffin content of the oil have presented a special, and rather unfamiliar, challenge to Soviet engineers, one that has led them to experiment—often unsuccessfully—with a variety of oil recovery techniques

From an intelligence standpoint the fields of Kazakhstan are of particular interest for two reasons:

- Growth in oil output outside of West Siberia has largely come to a halt at a time when national oil output is in the doldrums. Soviet oil prospects during this decade could improve significantly if the Soviets could turn their luck around in a region where large amounts of oil remain and the production infrastructure is already in place. According to Soviet literature, some Soviet geologists think that Kazakhstan might be such a region.

- The Soviet oil industry has been consistently troubled by its poor execution and faulty field development practices. Nowhere has this been more apparent than at Uzen oilfield in Kazakhstan, which provides a useful case study of the limited ability of the Soviet oil industry to develop difficult oil deposits.

Our Analytical Approach

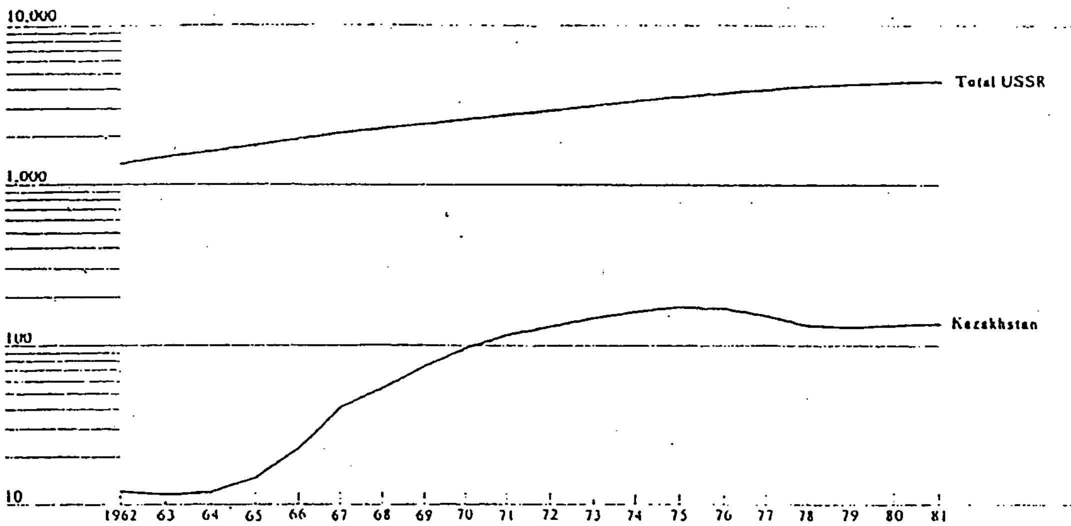
The Soviets have not published detailed field production data for some time, particularly for major oilfields. The little information they have made available has usually been conflicting or simply not credible. [ ] *To make matters worse, the Soviets treat data concerning their oil reserves as a state secret; consequently, we do not know what they currently believe their reserves to be—much less what those reserves might actually be.*

To overcome this lack of information, we have developed methodologies that permit us to estimate current production and reserves at major Soviet oilfields and to project future yields under alternative development scenarios. Our approach involves the application of advanced techniques of geologic and reservoir engineering analysis [ ] *The validity of this methodology rests on the fact that the behavior of an oilfield and its reservoirs is strictly governed by a set of fairly well understood physical laws.*

Uzen Oilfield

Uzen is the largest of a series of major oilfields located near the coast of the Caspian Sea in Kazakhstan's Mangyshlak Oblast (figure 2). The Soviets discovered the Uzen field in 1961 after an extensive exploration program begun before World War II in the Caspian Sea basin. In the early 1960s the Soviets faced an energy supply situation somewhat similar to the one confronting them today. Most of the oil production was coming from a single region, the Volga-Urals, which was reaching its capacity. With

Figure 1
USSR: Oil Production History—Total vs Kazakhstan
Million barrels



growth in national production slowing, Soviet geologists were looking for a series of new, oil-rich deposits—preferably located in the western USSR close to existing production infrastructure and refineries—that could boost growth and eventually replace the output from the Volga-Urals region. At that time, the Soviets had not fully evaluated the potential of West Siberia nor begun production operations there. Soviet literature indicates that Uzen, which appeared to be a possible supergiant, was initially viewed as a field with great promise that would play a significant role in Soviet energy resource planning during the 1960s and 1970:

Oil in Place and Reserves

Our volumetric calculations—[ ]and Soviet geologic maps—indicate that the reservoirs at Uzen originally contained some 7 billion barrels of oil. Nevertheless, the field has been difficult to develop. We know from reports of Soviet and Western geologists who have evaluated the field that production comes from at least 25 individual sandstone reservoirs and that the rock and fluid properties vary widely not only from one reservoir to another but also within each reservoir. Producing oil from such heterogeneous, complex reservoirs presents an engineering challenge that the Soviets have found difficult to meet (figure 3)

The high paraffin content of Uzen oil has also caused problems for the Soviets. Paraffin remains in solution at natural reservoir temperature and pressure but will

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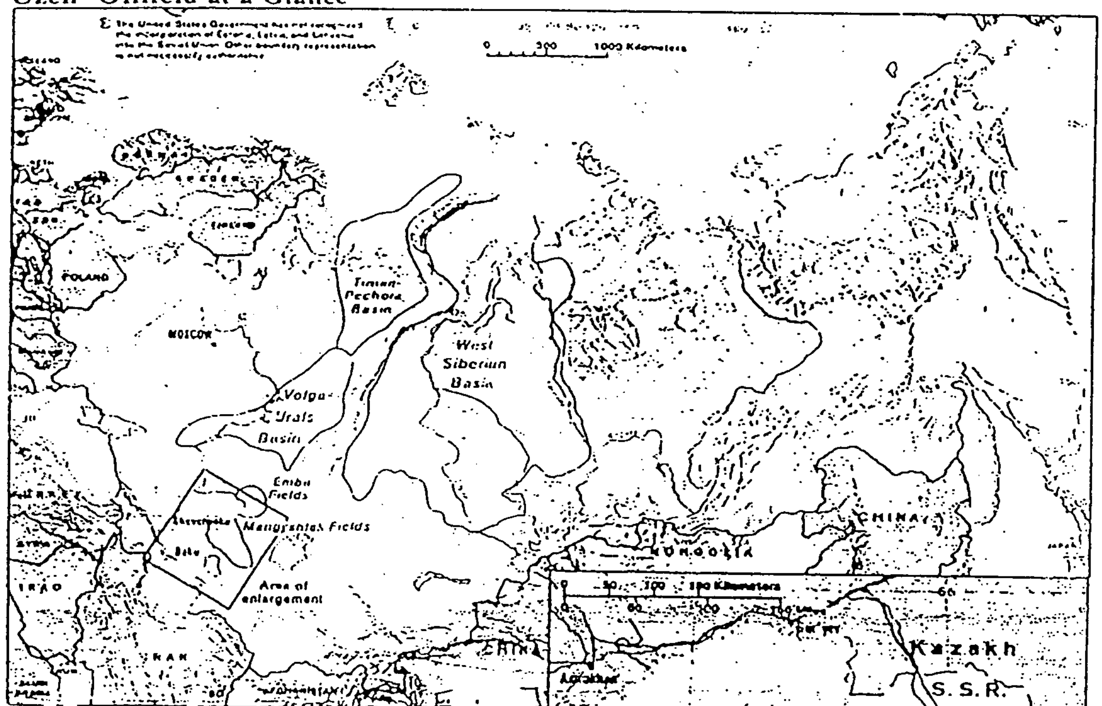
Figure 2
Uzen' Oilfield at a Glance



Year discovered..1961
Year production began................................1965
Peak production year.................................1975
Daily...339,600 b/d
Annual average...........................328,000 b/d
Projected production
1985................................121–149,000 b/d
1990..................................71–88,000 b/d
2000..................................25–31,000 b/d
Major recovery methods used.... Reservoir drive, gas lift, hotwater injection
Original oil in place (OOIP)..............7.0 billion bbl
Estimated ultimate recovery rate...24.8–26.6 percent (reserves) of OOIP

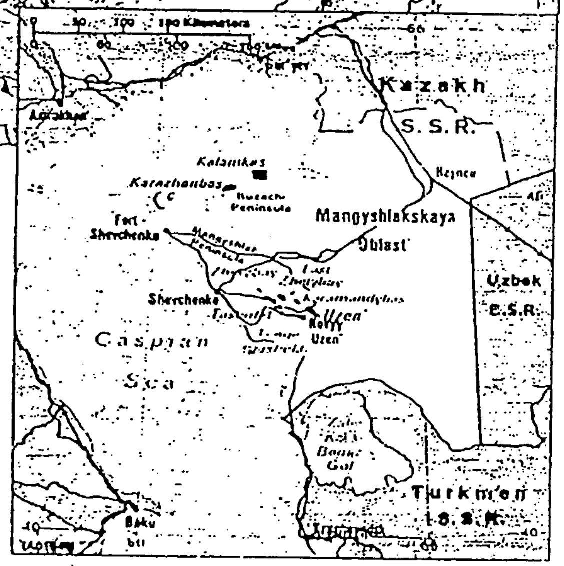


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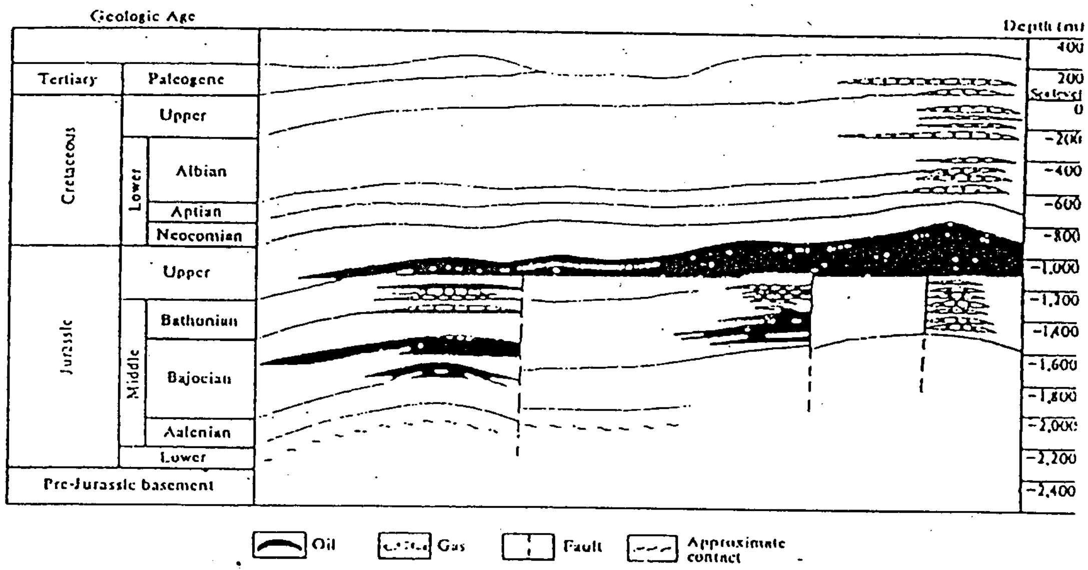
Figure 3
Uzen Oilfield: Generalized Cross Section



crystallize and collect in reservoir rock void space and on pipe surfaces when the temperature of the oil drops. At Uzen a drop in crude oil temperature of only 5° C to 10° C causes paraffin formation. Such narrow temperature tolerance complicates both the operation of the field and the surface treatment and transportation of the oil.

Because of Soviet inability to devise an effective field development plan and to handle the paraffin problem, we believe, based on our engineering analysis, that no more than one-fourth of Uzen's original oil in place will be produced during the life of the field. A 25-percent recovery factor would place Uzen's recoverable reserves at some 1.75 billion barrels—or in the medium-giant category. Under normal Western practices, we believe a 30- to 35-percent recovery factor could have been achieved.

Field Development

Production at Uzen began in 1965, and the Soviets worked to develop the field rapidly to offset expected declines elsewhere in the USSR. By the end of the first year, production was averaging slightly over 13,000 barrels per day (b/d)—or nearly 5 million barrels for the first 12 months. Although production increased in the next few years, the Soviets were not able to achieve the production goals they had set. The Soviets have admitted the field never reached the 1970 production goal of 400,000 b/d and prematurely peaked in 1975 at about 340,000 b/d. Production has since steadily declined at approximately 10 percent each year, and now probably stands at about 165,000 b/d, according to our engineering analysis of the production trend.

The original development plan for Uzen—as published by the Soviets—called for parallel rows of hot water injection wells perpendicular to the long axis of the field, dividing the field into blocks of production wells. [redacted]

Soviet literature suggests—and our engineering analysis confirms—that Uzen's troubled production history owes its origins to reservoir damage that occurred in 1967 when the Soviets, in their rush to boost production, initiated a field-wide injection program using cold, untreated Caspian Sea water. The cooling effect of the injected seawater caused the paraffin to solidify and clog the reservoir pore spaces, especially in the areas surrounding the injection wells. The paraffin plugging reduced the ability of the injected water to sweep the oil toward production wells. The injected water also tended to take the course of least resistance through the more permeable zones of the reservoir rock, thus bypassing oil in some areas and causing rapid rises in the water cut—the proportion of water produced with the oil.

Soviet field managers were well aware that rapid development of the field could cause grave difficulties for future recovery, but they proceeded anyway. According to one open source, as early as 1967 scientists at the Moscow All-Union Petroleum Scientific Research Institute recognized the seriousness of the paraffin problem and recommended heating all injection water. However, the Kazakh Institute for Design and Planning of Establishments of the Petroleum Industry, primarily concerned with meeting short-term production goals, ignored the recommendations. We have seen this pattern repeated frequently in the Soviet oil industry, most recently at several major oilfields in West Siberia. Had the West Siberian fields not been less complex and their oil of lower paraffin content, production would have been more significantly diminished there also.

By 1969 the large-scale injection of cold saltwater had caused other negative side effects. Salts dissolved in the untreated injection water interacted with the reservoir fluids to produce corrosive and noncorrosive deposits on the insides of well tubing, surface equipment, and pipelines. This further decreased lifting capabilities and complicated maintenance of surface facilities. The corrosion problem was compounded by the presence of highly toxic hydrogen sulfide in the crude oil gas. According to Soviet literature, the improper treatment of this gas resulted in extensive damage to field production equipment and pipelines.

Correcting the Damage

[redacted] the Soviets have [redacted] acknowledged that the emphasis on meeting large, early production goals led to the ill-conceived development plan and actually shortened the lifespan of the Uzen reservoirs. Thus, most of the activity at the field during the past 10 years has been to remedy previous errors in order to recover as much oil as possible. Desulfurizing facilities were completed at the main gas processing plant in 1980 to limit corrosion buildup in the pipelines and equipment, and injection water is now desalinized at Shevchenko before it is piped to Uzen and injected. The Soviets have also been attempting a variety of specialized recovery techniques for the field.

Hot Water Injection. The Soviets are now concentrating their efforts on hot water injection, both to limit corrosion and paraffin damage and to improve the ability of the injection water to sweep the oil to the production wells. We know [redacted] that, to date, this experimentation has been successful neither in checking the paraffin accumulation nor in reversing the buildup. Slow implementation is part of the problem. According to Soviet literature, six years after work with hot water injection began, only 10 to 15 percent of the injection water was heated. By the time hot water injection received the needed development priority, the buildup of paraffin had become too profuse to counter the ill effects of the cold water injection

We do not believe that the hot water injection would have significantly increased the movement of oil to production wells. At reservoir temperature and pressure, Uzen's oil is already in the normal range for density (35° API) and viscosity (3 to 4 centipoise). A thermal method, such as hot water injection, has little effect on the viscosity and, thus, the mobility of this type of oil. Our analysis indicates that the only real benefit from the hot water injection would probably be a reduction in the paraffin plugging in areas adjacent to the injection wells that had earlier received most of the cold injection water. Alleviation of the plugging problem around these wells would increase water injection rates but would not significantly change production rate.

There are other significant disadvantages to a hot water injection program at Uzen. The equipment is relatively costly and the heaters each consume fuel at the rate of 50 to 100 b/d [redacted] Based on Soviet reports and our analysis, water-scaling problems with the heaters have also added to the operational difficulties. Altogether then, our analysis suggests that the Soviets' lack of success with hot water injection will continue. Once paraffin is deposited, a much higher temperature than the deposition temperature is required to melt the paraffin and return it to solution. We do not believe the Soviets will be able to generate enough thermal energy by any currently available economic method to reverse the deposition process and clean up the damaged Uzen reservoirs.

Steam Injection. [redacted] report that the Soviets recently attempted to purchase US-designed and Japanese-built steam generators and pipeline equipment for a steam-injection project at Uzen. According to these sources, the Soviets hoped to use steam to boost production up to 80 percent over the present rate

Engineering analysis which we have undertaken indicates that a steam-injection program would decrease the amount of paraffin around injection wells but would offer only negligible improvement in the overall mobility of oil through the reservoir to production wells. Moreover, a steam-injection program requires closely and evenly spaced wells to achieve good results. The Soviets would find it extremely expensive to change Uzen's irregular well pattern and established water-injection rows to an efficient steam pattern. Such a project would involve conversion of some producing wells to injection wells and a massive drilling program to even out the well spacing. The longer the Soviets delay in beginning the conversion—and they have yet to start—the less its benefits will be relative to the remaining productive lifespan of the field.

There are other engineering reasons why steam injection is inappropriate for Uzen. Injecting steam into reservoirs deeper than 900 meters has questionable engineering advantages. The heat of the steam naturally dissipates as it travels through the well bore; by the time the steam would reach a deep reservoir, much of it would have condensed. Because Uzen's main pay zones, at depths of 800 to 1,200 meters, are at the low end of the heat effectiveness range, the net effect would probably be no better than for normal hot water injection, which has already proved ineffective at Uzen. In addition, because of the greater difference in density between the oil and the steam, the steam would also tend to bypass the oil, moving less of it than even hot water would move. Finally, although hot water heaters require a great deal of fuel oil to run, steam generators require even more.

In March 1982 the Soviets suspended efforts to obtain Western steam generators and insulated pipe for Uzen, reportedly because of hard currency problems.

In our judgment, it is more likely that they have reevaluated the potential for steam injection and discarded it as an option

Polymer Injection. Despite promising experimental results, [redacted] indicate that the Soviets have also abandoned polymer injection as a realistic recovery option at Uzen. The problem is that sufficient amounts of the essential equipment and chemicals are expensive and are available primarily in the West. Adding polymers to injection water would thicken the water, enabling it to push more oil toward the production wells. This could increase recovery efficiency and reduce the amount of injection water required. The Soviets limitedly tested various chemicals at Uzen from 1975 to 1977, reportedly with good results. But even if enough equipment were procured, the Soviets could not use full-scale polymer injection to produce the field until a source of supply had been established for the large volumes of polymers needed. This they have yet to do.[1] Moreover, polymer injection is a sophisticated, costly, and risky technique; in the past, the Ministry of Petroleum Industry has generally avoided the widespread use of such an uncertain procedure.

Gas Lift. Gas lift has given better results than any other recovery technique tried at Uzen. The Soviets used an indigenously designed system for most of the oil produced in 1981 at the field. A gas-lift system injects compressed gas into the well bore, lightening the fluid column and increasing the rate of fluid production. Though it will not significantly increase total oil recovery, it can sharply increase daily production rates

Experimentation with the gas-lift system began at Uzen in 1969 and recovery efficiency increased immediately. The system was rapidly expanded, and by 1975, gas-lift wells were producing approximately 60 percent of Uzen's oil (averaging more than 500 b/d per well with 25 percent water cut). At that time the Soviets claimed to be converting approximately 170 wells to gas lift each year. [redacted] about 30 percent of all production wells are on gas lift. [redacted] The Soviets plan to expand the existing system and have recently contracted with a French firm for the equipment.

[redacted]

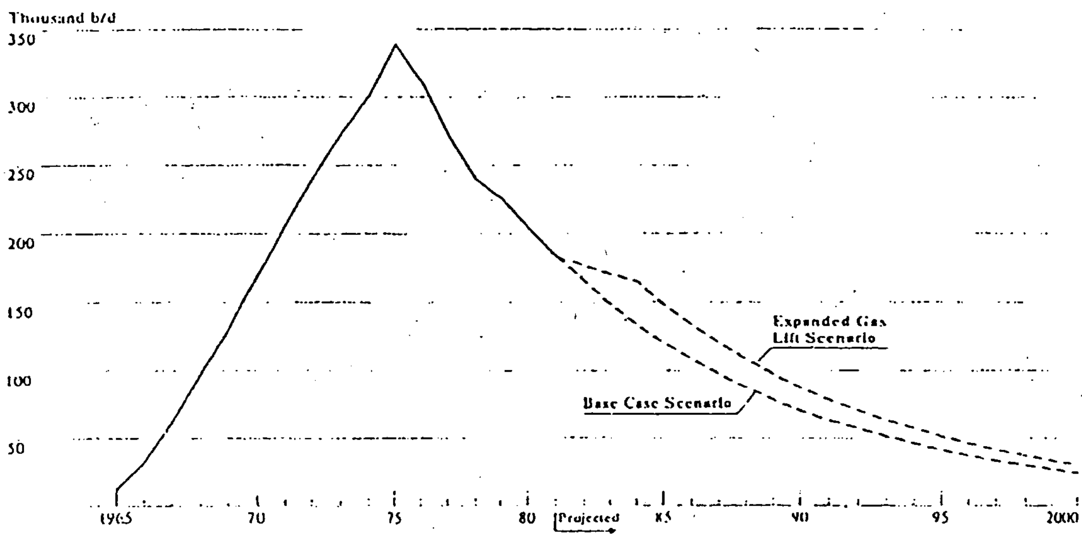
The operation of the gas-lift network at Uzen has been continually plagued by paraffin deposition in the well bores and corrosion in the gas lines and equipment. In 1974 a change in gas source from the Tenge field to the Kazakh Gas Refinery caused further complications in the gas-lift process. The refined gas contained a much higher concentration of impurities and water than the system could tolerate, and the lower gas temperature also caused noncorrosive deposits to restrict flow in the gas lines. We know from Soviet literature that, of the various measures taken to improve the conditions, the use of chemicals as corrosion inhibitors has proved most effective.

Production Forecast

To estimate the future contribution of Uzen to Soviet national oil supplies, we evaluated both a base case and a best case scenario (figure 4). The base case assumes a continuation of the current field development strategy with no major changes in operating practices. That is, conventional pump-lifting methods would predominate, the network of gas-lift wells would not exceed approximately 30 percent of the total number of wells in use, and limited experimentation with hot water injection would continue. Under this scenario, a decline curve analysis reveals that Uzen's production will continue to drop by some 10 percent annually, to approximately 120,000 b/d by 1985 and to 25,000 b/d by the year 2000. Expected ultimate oil recovery would be about 25 percent of original oil in place.

The best case, which postulates an expanded gas-lift program, represents the maximum the Soviets can reasonably expect to accomplish at Uzen. This scenario assumes the refurbishment of the existing gas-lift well network and the conversion of some 50 conventional wells annually to gas lift through 1984, with no

Figure 4
Uzen Oilfield: Oil Production History and Forecast



change in the total count of working wells. This scenario, which appears to be what the Soviets are now trying to do, does not include additional thermal operations because we believe they would not be effective. Our decline curve analysis in this scenario indicates that production at Uzen would drop to about 150,000 b/d in 1985, decrease to some 90,000 b/d by 1990 and to 30,000 b/d by the year 2000. Expected ultimate oil recovery would be approximately 27 percent of original oil in place.

[ ] have told us that during 1981 the Soviets planned to install new compressor facilities and add more gas-lift wells to the present system. Uzen's producing wells are already at optimum density, however, making it unlikely that a large number of new wells would be drilled to expand the gas-lift system, but rather that the existing wells would be converted.

As indicated in the oil production forecast, we believe that an expansion of the gas-lift system at Uzen would result in a temporary production increase. Production would be slightly higher than the base case but still decline at approximately the same rate; and ultimate oil recovery would be only 2 percentage points higher. Thus, in light of the ineffectiveness of steam and the polymer supply problem, there is little the Soviets can do to alter the fate of Uzen.

Lessons Learned—And Not Learned

The Soviets have learned a painful but useful lesson from their development errors at Uzen oilfield. The current costly and largely unsuccessful attempt to maintain production at this once-promising giant has driven home the importance of instituting an effective field development program in the early stages. That the Soviets have learned at least this much is evident in their attempt to implement systematic thermal recovery programs at Kalamkas and Karazhanbas, the neighboring fields on Mangyshlak Oblast's Buzachi Peninsula

At the same time, however, the institutional and technical shortcomings of the Soviet oil industry appear to be limiting the full application of this experience. The Soviets, for example, are currently attempting to purchase a variety of expensive Western recovery processes for Uzen, much of which is inappropriate for use at the field. And despite somewhat better initial planning, even Kalamkas and Karazhanbas were put on line in a hasty manner in order to start production as soon as possible and at any cost

Outside of Kazakhstan, the lessons of Uzen appear to have had even less impact. Our continuing analysis of key Soviet oilfields reveals that, most notably in oil-rich West Siberia, Soviet field managers continue to apply hasty and sometimes ill-conceived field development practices—often against the advice of their own scientific experts. The end result of this is that the Soviets are trading larger, stable oil recovery in favor of high but shorter lived production rates. With growth in Soviet oil production at a near standstill, however, the true cost of this trade-off may now be becoming even more apparent