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The Soviet Program for Peaceful Uses of Nuclear Explosions

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The Soviet Program for Peaceful Uses of Nuclear Explosions

Overview

Since 1965 the Soviets have conducted at least 77 underground nuclear explosions in their peaceful nuclear explosion program. The Soviets consider this program to be important to the development of their economy, but available evidence does not indicate that it has had a major impact

In general, Soviet experiments on peaceful uses for nuclear explosions do not appear to have produced all of the expected results. Examples of specific experiments and their results include:

- Control of runaway gas wells: three successes, one failure.
- Construction of storage cavities in salt domes: moderately successful.
- Deep seismic sounding: no evidence that practical results were achieved.
- Stimulation of oil and gas production: unsatisfactory, with the possible exception of recent experiments to overcome the effects of gas hydration when drilling in the permafrost zone.
- Fracture of phosphate ore to speed mining operations: unsuccessful

The most ambitious Soviet project involving the use of nuclear explosions is the proposed Pechora-Kama Canal. The Soviets plan to divert the north-flowing Pechora River through a 112-kilometer canal into the south-flowing Kama River in an effort to replenish the dwindling water supply of the Caspian Sea. If the initial project design is reaffirmed after ecological studies are completed, a 65-kilometer section of the canal would be excavated using nuclear row charges

The importance of the program for peaceful uses of nuclear explosions, and specifically of the Pechora-Kama Canal project, to the Soviets was evident during negotiations for the Threshold Test Ban and Peaceful Nuclear Explosion Treaties and during the early negotiations for a comprehensive test ban treaty. The Soviets initially insisted on the right to conduct nuclear explosions for peaceful purposes but eventually agreed to eliminate their use in a comprehensive test ban environment. When the Soviets gave up the right to conduct peaceful nuclear explosions during negotiations for a comprehensive test ban, they believed they had made a major concession and considered that bilateral negotiations on this issue would be resumed in the future

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Introduction

The Soviet program for peaceful nuclear explosions (PNEs) began in 1965 and is the most extensive in the world.[1] PNEs have been used in at least seven types of experiments conducted throughout the USSR [redacted]. This activity has been concentrated in Siberia in the past seven years, whereas in the nine years previous to that it was centered in the European USSR and Central Asia. The Soviets have conducted at least 77 experiments to date—at least one a year since 1965 and as many as eight in each 1972, 1978, and 1979 for almost five events per year [redacted]

Soviet Experiments With Peaceful Nuclear Explosions

Control of Runaway Gas Wells. The Soviets used nuclear explosions to control runaway gas wells on four separate occasions before mid-July 1972. They achieved closure of three of the wells. Although the Soviets have had runaway gas wells since then, improvements in their capability to control high-pressure gas wells and to use conventional methods to control runaway wells apparently have eliminated the need for this type of PNE.

Oil and Gas Stimulation. The Soviets conducted their first oil stimulation experiment using PNEs in 1965, when they detonated three nuclear devices in the Grachevka Oilfield. A second experiment in which two nuclear devices were detonated in the Osa Oilfield was conducted in 1969. No further oil stimulation took place until 1979, when a PNE was used in the Salym Oilfield in western Siberia (Suliny). In June 1980 the Soviets conducted another experiment that included PNEs in the Grachevka Oilfield (Lipovka) and one on the Krasnoleninskiy arch in western Siberia (Palyanovo). A recent experiment, probably for gas stimulation, occurred in May 1981 in a gasfield near the town of Afonikha at the mouth of the Pechora River. Three oil and gas stimulation experiments have been conducted since early September 1981. The first event, an oil stimulation experiment, occurred on 2 September near the town of Parma at the Pechora River Delta. The second and third events, probably for gas stimulation, occurred four minutes apart on 26 September. These two events were conducted in an gasfield near Astrakhan', north of the Caspian Sea

The 10-year hiatus in oil stimulation experiments and comments by the Soviet Minister of Oil Production after the tests in 1965 and 1969 indicate that those experiments did not produce the desired results. We do not know whether the tests conducted in 1979, 1980, and 1981 were more successful than the tests conducted in the 1960s. Analysis suggests that these tests were efforts to increase oil production because total Soviet oil production is leveling off and probably will begin to decline in the near future

The results from the first gas stimulation test, which was conducted in the Takhta-Kugul'ta Gasfield near Stavropol' in 1969, were not released by the Soviets as were the results of their early oil stimulation experiments. The fact that no additional tests were conducted in this gasfield suggests that the improvement in production was not satisfactory. This experiment probably was conducted to overcome the lack of porosity in the producing rocks by fracturing them with the explosion

From 1974 through mid-1981, the Soviets conducted nine PNEs to stimulate production at seven gasfields in Siberia. They discussed several of the earlier nuclear events in open source literature. According to the Soviets, these tests were designed to solve the

problem caused by gas hydration when drilling in the permafrost zone. When the small amounts of water produced with the gas freeze, the resulting accumulation of ice in the borehole eventually chokes off the flow of gas. The heat from the nuclear explosion probably melts the accumulated ice. After the heat dissipates, the cavity or chimney formed by the explosion provides room for ice to accumulate without plugging the borehole. The fact that the Soviets have conducted several of these experiments suggests they may have achieved some success.

Mining. In 1972 the Soviets used a PNE to fracture phosphate ore (apatite) underground to speed mining operations [redacted] the site, near Kirovs[redacted] has remained inactive since the experiment, indicating that this use of a PNE did not produce the desired results. The Soviets have not conducted any other experiments of this type.

In 1974 the Soviets used a PNE to produce a mound of broken rock (retarc) in the vicinity of the Udachnaya diamond mine near the Arctic Circle in central Siberi[redacted]. The diamonds are mined by use of open-cast methods, separated from the matrix rock by crushing the ore, and recovered by using flotation methods. The remaining slurry is pumped into holding ponds where the crushed stone settles

The nuclear explosion conducted near the mine in 1974 was probably the first in a series of explosions planned to create a rock dam across a small streambed, thus providing an additional holding pond. Dam construction is the only use for retarcs suggested in Soviet literature

Excavating. PNEs were first used for excavation purposes in the USSR on 15 January 1965. The Soviets used a 150-kiloton (kt) explosion to create a large throwout crater, the lip of which dammed the Shagan River, a tributary of the Irtysh River. A large lake formed behind the earthen dam, which held until the spring of 1969 when the lake overflowed and washed out the dam. The Soviets repaired the dam with an impervious core and paved spillway so that it would not be damaged by future overflows.

No use of the water in the lake has ever been observed. It is possible that the water in the Shagan River, which normally flows only during the spring thaw, is contaminated with salts and minerals from the soil in the river's watershed. The Soviets may have repaired the dam to prevent the flow of contaminated water into the Irtysh River, the source of drinking water for the main support complex of the Semipalatinsk nuclear weapons proving ground.

The Soviets detonated a device [redacted] at the Konystan area of the Semipalatinsk proving ground in October 1965. The explosion [redacted] created a throwout crater. [redacted]

Two excavations were made [redacted] at the Taylan area of the Semipalatinsk proving ground in 1968 [redacted]

[redacted] the data collected probably were used in planning for the proposed Pechora-Kama Canal project

The Pechora-Kama Canal is the most ambitious project involving the use of PNEs that the Soviets have proposed. This 112-kilometer (km) canal is planned to divert water from the north-flowing Pechora River to the south-flowing Kama River, a tributary of the Volga. The canal has a planned cross section of 3,000 square meters and, if completed, would be one of the largest manmade excavation projects in the world.

The Soviets propose to excavate the northern 65 km of the canal with nuclear explosions. In March 1971 they conducted a row charge experiment on the route of the proposed canal. According to the Soviets, the row charge comprised three 15-kt nuclear devices emplaced about 150 meters apart and buried at depths of 218 to 254 mete

The canal project is intended to help alleviate the water shortage in the European USSR, particularly in the lower Volga River Basin and near the Caspian Sea. During the past 35 years, the consumption of water has increased in this area due to urban and industrial expansion and the irrigation of farmland along the Volga and its tributaries. These factors, together with changes in climatic conditions, have caused the level of the Caspian Sea to drop 2.5 meters. These conditions are expected to continue, and it is estimated that by the year 2000 the level of the Caspian Sea will have dropped another 1.7 meters.

In the early 1970s the Soviets initiated studies to evaluate the environmental impact of the canal project on the northern region of the European USSR. Concerns were expressed about the effect that the annual diversion of as much as 30 cubic kilometers of water from the Pechora River would have on the climate of this region. An investigation to determine the amount of water that can be safely diverted to the south is scheduled to be completed in 1981. The results of this investigation probably will influence the final determination of the size (cross section) of the canal and thus the method of its excavation.

Creating Underground Cavities. As a part of their PNE program, the Soviets have extensively investigated the potential uses for explosion-produced cavities in salt. Salt domes are the only geological

medium in which a nuclear explosion is known to produce a standing cavity. Other types of rock collapse into a rubble chimney following an underground nuclear detonation.

Five cavities produced in salt by PNEs apparently have been or are in use for storage. Two of these cavities are at the Orenburg Gasfield, one at the Sovkhoz Gasfield, and two near Sterlitamak. The cavities at the gasfields were used to store gas condensate, a volatile liquid produced with methane that must be stored under pressure. The cavities near Sterlitamak apparently are used to store toxic wastes from chemical and other industries in the area.

Other cavity shots in salt were conducted by the Soviets about 80 km east of Noril'sk.

Other cavities have been created at numerous sites. Many are near planned industrial projects and probably will be used for storage of toxic industrial wastes.

The salt dome near the village of Azgir, north of the Caspian Sea, has been the site of at least 15 PNEs in both salt and salt cavities. The first two explosions at this site were described by the Soviets at international meetings on the peaceful uses of nuclear energy in 1970. Although the Soviets did not specify where or when the tests occurred,

The Soviets reported the yields of the two explosions as 1.1 and 25 kt, respectively.

In 1972 the Soviets conducted an experiment at Azgir using high-explosive (HE) charges. This suggests that they were surprised by the relatively large seismic signals generated by the two earlier nuclear explosions. In the experiment, two groups of HE shots were used in an effort to determine if the ground motion from the 1.1-kt nuclear explosion could have been predicted

Altogether, the Soviets created at least seven cavities in salt at Azgir. They conducted four separate shots in one cavity (location H) and one shot in another (location L). The tests at Azgir most likely were part of an ambitious program to examine potential uses of cavities formed by nuclear explosions in salt, including use for storage, use in perfecting the capability to reenter cavities and reuse the original emplacement hole, and use in developing methods of conducting repeated shots in a cavity, possibly toward the eventual use of the heat from the explosions to generate electricity. provided it

No testing has taken place at Azgir since these walls were poured (beginning between June and November 1979), possibly because ground movement could damage them. The Soviets have indicated that they plan to use salt cavities to store high-level radioactive wastes, and the large cylinder may be part of a nuclear waste processing plant.

Seismic Profiling. The Soviets have used nuclear explosions as a source of seismic energy to investigate the deep crust and upper mantle of the earth. Most of these shots were spaced at 400- to 500-km intervals and bisected several major tectonic regions in the USSR. For some shots, seismographs were spaced in profiles at 20-km intervals around the emplacement point in a plus-shaped patter

The Soviets have published the results from some of the seismic profiles but allude to the energy source as "industrial explosions." The published results only include seismic data on the deep crust and upper mantle, such as velocity and attitude or dip of the interfaces in these zones. The authors do not comment on the significance or potential applications of these results.

In a bilateral PNE meeting the Soviets stated that profiles from deep seismic sounding would be used for oil exploration. Data on the lower crust and upper mantle would only be applicable to the investigation of the theory of the inorganic origin of oil. Many Soviet earth scientists are advocates of this theory, whereas most Western earth scientists believe in the organic theory of the origin of oil. The Soviets may be investigating the deep crust and upper mantle to locate areas where methane forms before migrating upward to porous zones

Modification of Tectonic Environment. In December 1974 the Soviets conducted a nuclear explosion near the Konystan area of the Semipalatinsk nuclear weapons proving ground. This explosion was located on a large and extensive fault zone

Other explosions at Konystan have been located off of the fault on relatively flat terrain. The location of this test in the rough terrain just on the upthrown side of the fault indicates it most likely was designed to modify or affect the tectonic character of the area.

The Soviets may have detected low-magnitude (3.0 o. lower) tremors or significant strain along this fault. One conjecture of the PNE experiment conducted here could have been an attempt to release tectonic stress to preclude a larger earthquake. On 20 March 1976 an earthquake with a magnitude of 5.1

Its epicenter was about 22 km northwest of the site of the test in December 1974. This is the only earthquake ever detected within the Semipalatinsk proving ground. It is unlikely that this earthquake occurred as a result of the earlier nuclear explosion because the two events occurred 15 months apart at locations separated by a distance of 22 km. The Soviets have not published any results from this experiment, which suggests that it was not successful.

Relationship of the Soviet Peaceful Nuclear Explosion Program to Nuclear Test Ban Treaties

The Limited Test Ban Treaty. The LTBT, entered into force in October 1963, prohibits nuclear explosions in the atmosphere, space, and underwater, and in any other environment that causes nuclear radioactive debris to be present beyond the borders of the country exploding the nuclear device. There is no evidence that the Soviets have conducted any nuclear explosions in prohibited environments, but a number of their underground tests have vented radioactivity into the atmosphere. The extent to which such ventings are a violation of the LTBT is in dispute between the United States and USSR. The Soviets frequently quote the Russian text which prohibits "radioactive fallout outside national territory," the English language text refers to radioactive debris.

The most severe ventings since the LTBT were the excavation experiments on the Shagan River dam and the row charge explosion on the route of the Pechora-Kama Canal. In the latter case, the Soviets made an effort to contain the radioactive debris within their borders by conducting the test when weather conditions were such that the winds carried the radioactive debris over the Ural Mountains, where rain and snow clouds washed out most of the debris over the largely uninhabited area

The future use of PNEs by the Soviets should not pose any threat to this treaty, with the exception of the planned Pechora-Kama Canal. If the Soviets use nuclear explosions to excavate a portion of this canal, some radioactive debris almost certainly will escape the borders of the USSR.

The Threshold Test Ban and the PNE Treaties. These treaties have been signed by both the United States and the USSR but have not been ratified by either country. Many of the provisions of these treaties, however, have been voluntarily adhered to by both parties pending ratification. The Threshold Test Ban Treaty prohibits the detonation of a nuclear device with a yield in excess of 150 kt. The PNE Treaty governs nuclear detonations conducted outside weapons test areas.

The PNE Treaty stipulates that no nuclear detonation shall have a yield in excess of 150 kt; that no single device, when detonated as part of a group explosion, shall have a yield in excess of 150 kt; and that no group explosion shall have an aggregate yield in excess of 1,500 kt. Further, the PNE Treaty provides for advance notification of group PNEs by the country conducting the experiment and for on-site inspections of some group PNEs. Since the PNE Treaty was signed in 1976, none of the Soviet PNE shots have been large enough to invoke provisions of the treaty, such as inspection or advance notice before testing.

Comprehensive Test Ban Negotiations. The future of PNEs was a contentious topic in the early stages of negotiations for a comprehensive test ban (CTB) in 1977. The Soviets initially insisted that any CTB treaty should provide for the continued used of PNEs, even if all nuclear weapons tests were prohibited. Finally, they agreed to a moratorium on PNEs for at least the initial duration of any CTB, but continued to insist on the eventual necessity to use PNEs in the industrial development of the USSR. Igor Morokhov, who was the chief Soviet advocate for PNEs, was replaced as chairman of the Soviet CTB delegation at the time this concession was made. Thus, despite the high value the Soviets have placed on the potential benefits of PNEs, they have shown a willingness to forgo them to achieve a CTB.