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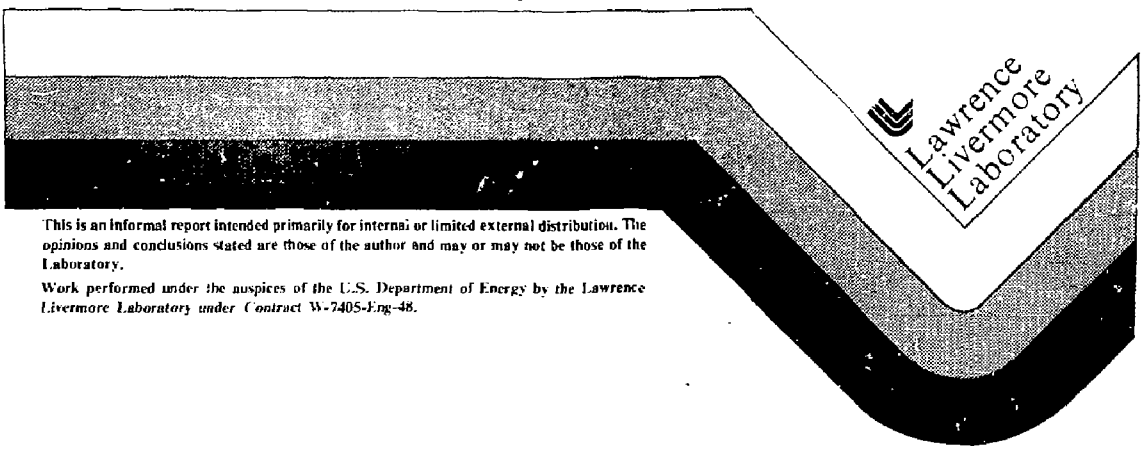
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The Underground Nuclear Explosions
at Astrakhan, USSR

by I. Y. Bora



August 13, 1982



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at Astrakhan, USSR

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by I. Y. Borg

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Abstract

The three underground nuclear explosions recorded in 1980 and 1981 by Hagfors Observatory in Sweden are in the vicinity of Astrakhan on the Caspian Sea. They are believed to be associated with the development of a gas condensate field discovered in 1973. The gas producing horizons are in limestones at 4000 m depth. They are overlain by bedded, Kungurian salts. Salt domes are recognized in the area. Plans to develop the field are contained in the 11th Five Year Plan (1981-87). The U.S.S.R. has solicited bids from western contractors to build gas separation and gas processing plant with an annual capacity of 6 billion m^3 . Ultimate expansion plans call for three plants with the total capacity of 18 billion m^3 . By analogy with similar peaceful nuclear explosions described in 1975 by the Soviets at another gas condensate field, the underground cavities are probably designed for storage of unstable, sour condensate after initial separation from the gaseous phases in the field. Assuming that the medium surrounding the explosions is salt, the volume of each cavity is on the order of 50,000 m^3 .

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Introduction

The Iranian revolution in the fall of 1978 resulted in severe curtailment in the amount of gas the U.S.S.R. received from Iran via the IGAT I pipeline. Before the revolution Iran supplied nearly 1 BCF/day of gas. The same amount of gas was supplied by the Soviet Union to West Germany, France and Austria by displacement from Orenburg. The result was severe energy shortages in Georgia, Armenia and Azerbaijan during the Winter of 1978-9^(1,2). By summer 1979 the IGAT II project, which was to deliver an additional 1.25 BCF/day to the Russian border for industrial development, was cancelled because of price disputes.

By early 1980 gas exports to the USSR through IGAT I were completely stopped - again over price disputes* - and resumption of deliveries has not been rescheduled⁽³⁾. Energy shortages in southern USSR Republics could not be mitigated by additional gas from the old Azerbaijan fields. Thus it is likely that exploration and development for new sources of supply to these Republics were given emphasis in the final years of the 10th 5 year plan (1976-81) and the 11th 5 year plan. Alternatively gas could be diverted from Orenburg or the Krasnodor field, north of the Caucasus Mountains; however, in the latter instance pipeline reversals or construction would be required. In the long term the North Caucasus fields are said

*The Soviets were paying \$0.74/1000 cf and the Iranians were said to be asking \$3.00.⁽³⁾

to be inadequate to the task.⁽²⁾ The giant discoveries in 1975 and 1976 in the Astrakhan region at the mouth of the Volga River influenced the decision to move ahead with development in the region. The Astrakhan plan is the only one mentioned by name in the Eleventh (1981-5) Five year plan.⁽²⁾

Gas and condensate discoveries on the Astrakhan arch

The discovery well, known as Zavolzh well #3, was completed in 1973 to a depth of 4260 m.⁽⁵⁾ It flowed 20,000 m³ per day from Middle Carboniferous limestones beneath the Kungurian salts. This well was ultimately abandoned for undisclosed reasons. Subsequent discoveries were made at the Aksaray well, 25 km to the SW, in 1975 at 3985 m and the Shirayev well #5 (1976) which flowed 564,000 m³ per day with a 14.8 mm choke.⁽⁵⁾ A well on the Volozhkov structural high drilled about the same time on the arch yielded flows of 250,000 m³ per day (Figure 1). The targets that ultimately resulted in these impressive discoveries were delineated by seismic surveys on the arch starting in the early 70's which identified structural highs of 10-15 by 4-10 km on the 175-150 km arch. The area is described as consisting of two blocks separated by a fault along the Volga River.⁽⁷⁾ The two early strikes are on the left bank on what is called the Astrakhan field and the Volozhkov strike is on the right bank and comprises the Volozhkov field.⁽⁸⁾ Less than 20 wells on both banks were drilled by 1981; most were located on highs delineated by on-going seismic surveys.

Characteristics of the gas condensate field

The middle Carboniferous limestone (Bashkirian formation) at 3950-4100 m containing the gas has a 5.6 - 18.7% porosity and 0.4-9.9 md permeability. The formation is associated with high formation pressures

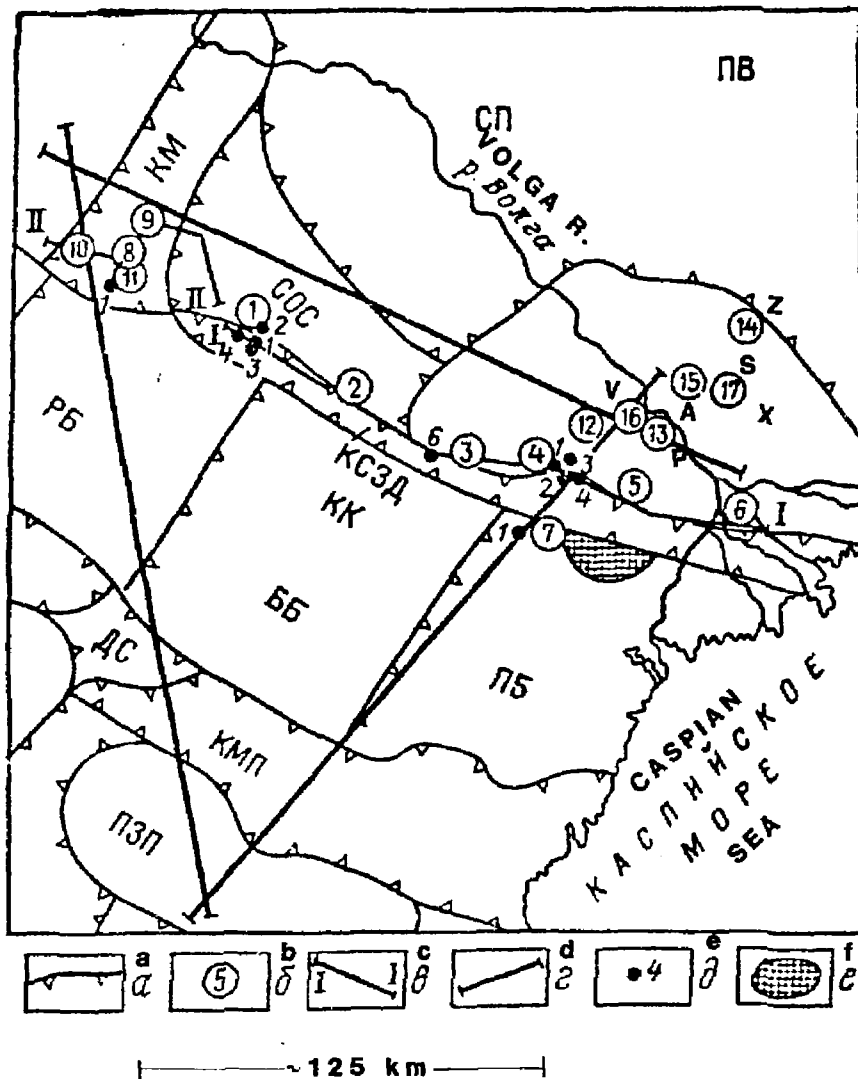


Figure 1 - Tectonic map of Kalmyk and Astrakhan regions. (6)

- a. boundaries of tectonic elements
- b. Areas of deep drilling (numbers in circles correspond to Astrakhan (6), Pioneer (13), Zavulzh (14), Aksaray (15), Volozhkov (16), and Shiryayev (17)).
- c. Profiles
- d. Planneu regional geophysical profiles
- e. Deep wells
- f. Area of erosion of Paleozoic carbonate sediments

The approximate location of the nuclear explosions is indicated by an "x".

(672 kg/cm²) which exceed the hydrostatic by 50%.⁽⁹⁾ It is overlain by the layered salt (Figure 2). Salt domes in the area have been identified by seismic techniques (Figure 3).⁽¹⁰⁾ The gas fields are sour gas condensate fields with approximately 25% H₂S and 12% CO₂. The ratio between gas and condensate at the well head is usually less than 450g per cubic meter (less than 1 barrel per 10 MCF). Analyses of the gas are given in Table 1. By contrast the Orenburg gas condensate field contains gas with 2.7% H₂S and 1.4% CO₂.⁽¹²⁾ No oil has been found in the Astrakhan field. Reserves are said to be 6 trillion cubic meters (212 TCF); however, in view of the limited exploration to date the extent of the resource must be uncertain. The corrosion problems associated with the development of the Astrakhan deposits have led the U.S.S.R. to seek Western technical help. To date their development has moved very slowly despite its clear high priority⁽²⁾ in national plans.

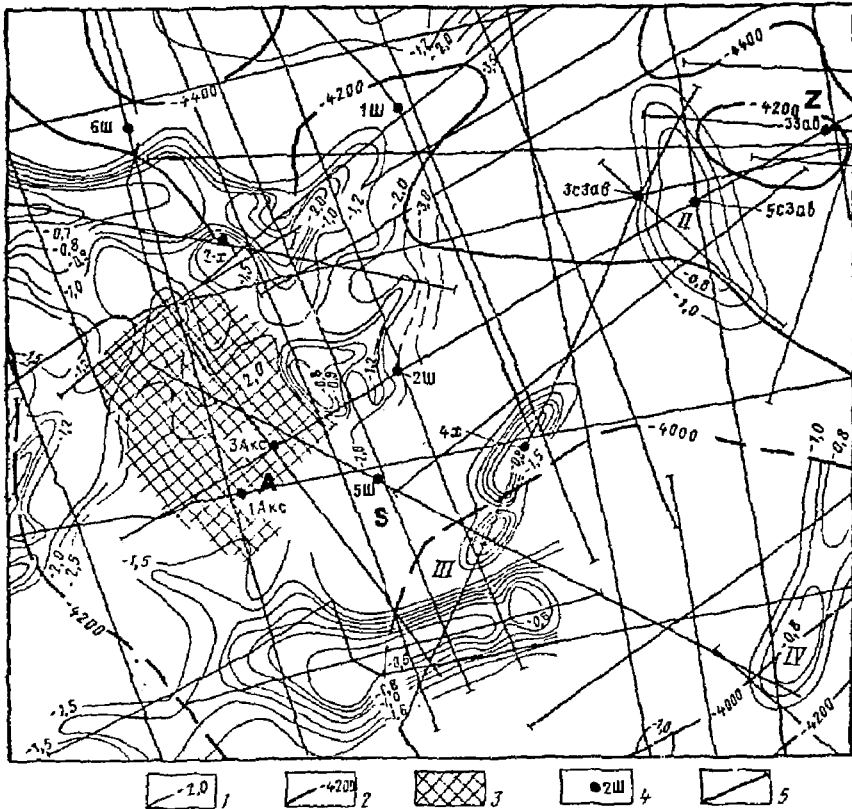


Figure 2 - Structure map of the Shiryayevsko-Aksary area based on geophysical surveys and drilling (10).

- Legenda:
1. isopach of top of the salt-bearing sediments according to telluric and magnetotelluric sounding (in km).
 2. for reflecting horizon $l \pi$ (in m)
 3. sectors of high occurrence of reflecting horizon $l \pi$.
 4. wildcat and structure wells
 5. lines of seismic profiles.

Salt domes: I. Verblyuzh
 II. Dosang
 III. Akhtubin
 IV. Sary-Sor

Wells: AKC Aksaray (A)
 3aB Zavolzin (Z)
 W Shiryayev (S)
 X Khasheutov

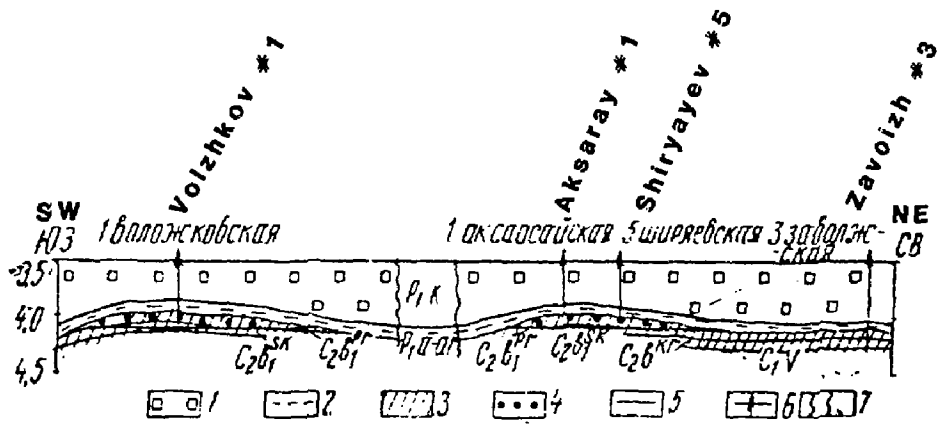


Figure 3 - Geologic profile through the Astrakhan and Volozhov fields (22)

1. Salt unit of Kungur stage
2. Cherty clay unit of Lower Permian
3. Carbonate rocks of Middle-Lower Carboniferous
4. Gas & gas condensate pools
5. Probable position of gas-water contact
6. Deep wells
7. Faults

For location of wells refer to Figure 1.

Table 1
 Gas Composition at discovery wells at
 Astrakhan compared to Orenburg^(5,12)
 (%)

	Orenburg	Zavolzh #3	Aksaray #1	Shiryayev #5
CH ₄	82.3	76.1	58.2	58.9
C ₂ H ₆	5.2	5.4	7.3	1.9
C ₃ H ₈	1.9	2.6	1.1	0.6
C ₄ H ₁₀	1.2	2.0	0.5	0.1
C ₅ H ₁₂	0.6	0.6	0.1	0.1
C ₆ H ₁₄	0.2	0.1	--	0.0
CO ₂	1.4	12	13.2	11.0
N ₂	4.0	0.3	4.1	0.8
H ₂ S	2.6	5.7	15.5	26.5

Underground nuclear explosions in the Astrakhan area

Three underground explosions in the Lower Volga area near Astrakhan were recently detected and announced by Hagfors Observatory in Sweden. Dates, magnitudes and locations (Figure 4) as described by Hagfors, the National Information Service or International Seismic Center are as follows:

		Lat	Long
		$^{\circ}N$	$^{\circ}E$
8 October '80	5.2	46.75	48.29
26 September '81	5.2	46.78	48.24
26 September '81	5.4	46.71	48.24

The latter two were set off 4 minutes apart possibly to minimize disturbance at the nearby city of Astrakhan, some 30-40 km distant. The concept of sequential firing to minimize seismic damage was a topic of discussion at the Second International Atomic Energy Agency PNE panel in 1971. The approximate location of the three explosions, presumed to be nuclear, relative to the Astrakhan gas condensate field is indicated in Figure 1 by an X.

The underground geology at the site of these three explosions consists of thin Quaternary sediments lying upon 3900-4000 m of Kungurian bedded salt.⁽¹³⁾ In 1971 and 1973 the Soviets carried out two nuclear explosions in a bedded salt formation above the Orenburg gas condensate deposit. They were described as for storage of condensate. They were in the same salt formation, but at another area of the Pre-Caspian basin. The seismic magnitudes were similar (5.2 and 5.3). Information provided by the U.S.S.R. on nuclear explosions in the gas condensate field at Orenburg indicates the yields of the nuclear explosions were both 15 kt.⁽¹⁴⁾ Based on the similarity of the

seismic magnitudes it seems reasonable to estimate the Astrakhan explosions to be of about the same yield, i.e. 15 kt. As at Orenburg the nuclear explosions preceded both commercial development of the field and construction of requisite gas processing plants. At Orenburg the first processing plant went on stream in 1974.

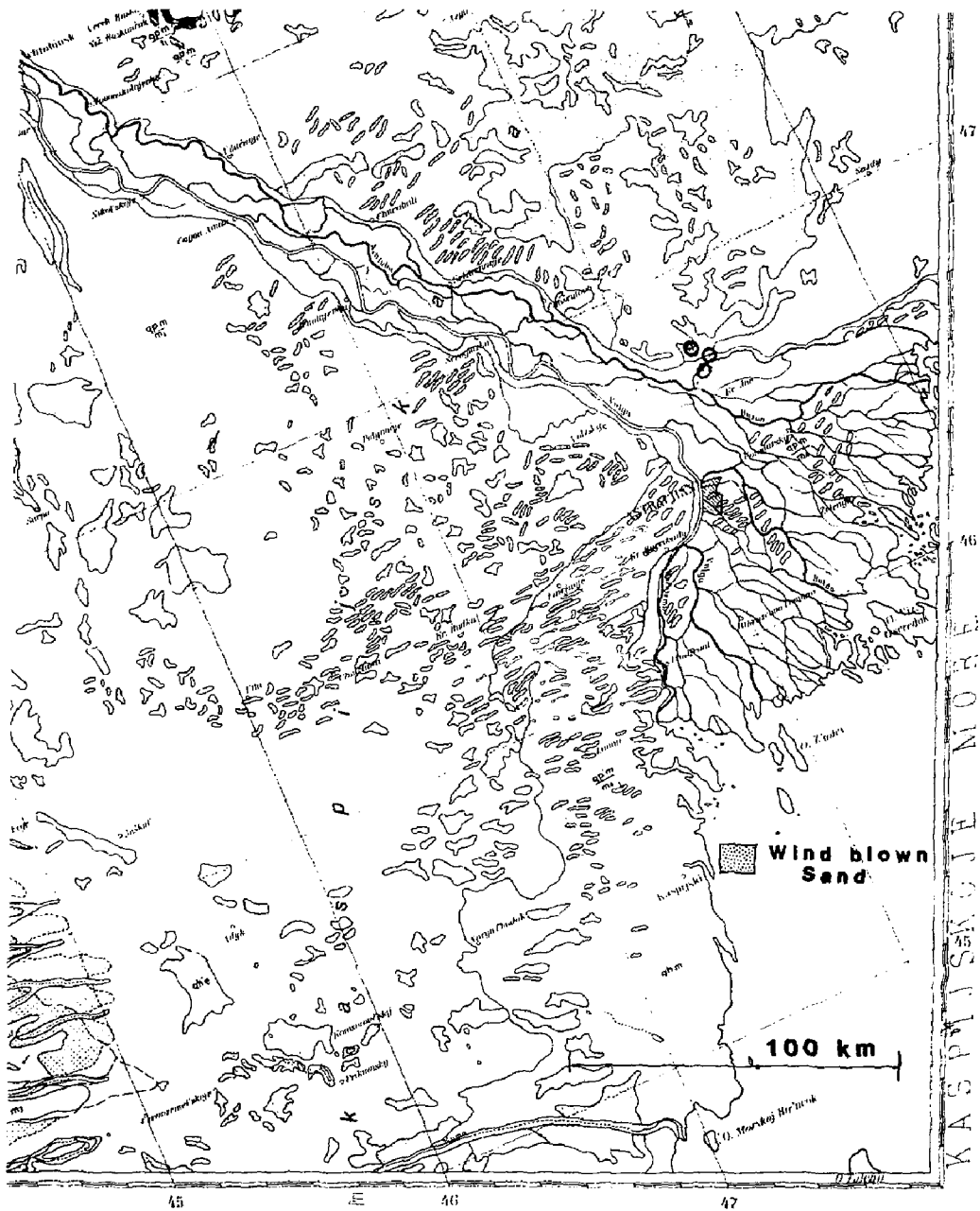


Figure 4 - Site of underground nuclear explosions at Astrakhan, U.S.S.R. (Circles indicate approximate locations.)

Development plans at the Astrakhan gas condensate field

In February of 1979 the Soviet Union's Machinimport solicited bids for construction of a large sour gas processing plant near Astrakhan. Initially companies* from six countries were approached (U.S. Canada, U.K., France, Germany and Japan).⁽¹¹⁾ The 1980 U.S. trade sanctions following the Afghanistan invasion greatly limited the ability of U.S. companies to respond. Most observers anticipate the French groups to win the contract.^(15,16)

The Soviet plan is to treat 6 billion m^3 /year (212 BCF/year) of gas which contains somewhat less than 50% combined $H_2S + CO_2$.⁽¹¹⁾ 6500 tons/day of elemental sulfur would be recovered for the fertilizer industry as a by-product.. Extraction of CO_2 is expected to be 1.5-2 million tons/year for use in tertiary oil recovery. Ultimately capacity is to be expanded to the treatment of 18 billion m^3 /y (635 BCF/y) of gas from the field.⁽¹⁷⁾ By contrast, the combined capacity of the three Orenburg gas processing plants is 45 billion m^3 /y (1600 BCF/y).⁽¹²⁾

*A consortium consisting of Occidental Petroleum Co., Fluor and Japan steel works; another made up of Ralph M. Parsons (U.S.) and Mitsubishi. Other partners were the French Technip/SNEA, Creusot-Loire/Partec-Lavalin; Davy McKee Power Gas (U.K.), Lurgi, Mannesmann (W. Germany), & Alberta Gas of Canada were initially undecided whether to team up.

About \$1 billion of corrosion-resistant well head equipment is also required of foreign participants since the Ministry of Non-Ferrous Metallurgy does not produce drilling pipe with that specification.⁽¹⁸⁾

Soviet planners are quoted in Pravda as giving the drilling of commercial wells immediate priority. Although there are on the order 20 wells in the Astrakhan arch only one is ready for production.⁽¹⁷⁾

U.S.S.R. plans at Astrakhan include the development of 56 gas wells, construction of pipelines between field and gas processing plants as well as product pipelines from the plant. Glavneftegazstroy, the organization that built all facilities apart from the main gas processing plants at Orenburg, has been designated as the lead contractor for site development at Astrakhan. The product pipelines include a 580 km stable condensate pipeline, a main gas line (Astrakhan - Kamysh-Burun), and a CO₂ pipeline to oil fields 630 km distant in Gur'yevskaya Oblast.⁽²¹⁾ This work described in the current (1981-5) Five Year Plan is underway.

Discussions with potential contractors have continued but have taken a back seat to negotiations on the West Siberia - West Europe gas pipeline, which were not concluded in all details until early 1982.

Possible use of underground nuclear cavities at Astrakhan

It is premature to know precisely the purpose the U.S.S.R. intends to put the three underground cavities produced by nuclear explosions. However, the experience at the Orenburg gas condensate field may be instructive. The underground storage facilities in the field in the opinion of a U.S. process engineer who worked at the site are designed to handle condensate during peak periods.⁽¹⁹⁾ Initial separation of gas and condensate is made at field or satellite plants before transmission of both to the gas processing plants some 16 km distant.

During periods of peak demand for sweet natural gas, the plants capacity to process liquid hydrocarbons (condensate) to products is less than the capacity to process sour gas⁽¹²⁾ hence condensate storage facilities are desirable. Thus processing peak winter condensate output can be delayed to the summer months when gas loads are minimal at the plants. Another consideration is that condensate storage facilities can allow gas cleaning capacity to remain high even if there are shut-downs or problems with the condensate processing portions of the plants. The problem of degasification of the troublesome unstable condensate prior to transfer to the main gas processing plants is also a consideration by Soviet accounts⁽¹⁴⁾ for storing it underground.

The cavity developed for condensate storage and presumed to be at Orenburg was described as having a volume of 50,000 m³ at the 1975 Peaceful Nuclear Energy discussions.⁽¹⁴⁾ The volume is consistent with the Soviet reported yield (15 kt), depth of burial (1140 m) and a salt medium using Butkovich & Lewis approximations.⁽²⁰⁾ Assuming a liquid of 0.8 g/ml and a useful capacity of three quarters of the total volume this corresponds to about 30,000 tonnes of condensate.

From all indications in the minds of the planners a similar need for condensate storage exists at Astrakhan. If it follows the pattern at Orenburg, the storage capacity will be located in the gas field rather than at the site of the main gas processing plants.

Judging from the similar seismic magnitudes recorded at Orenburg and Astrakhan (5.2-5.4) the individual cavities are similar in size and on the order of 50,000 m³ each. There were three explosions at Astrakhan and two at Orenburg. Thus despite Astrakhan's smaller, ultimate planned gas capacity (18 billion m³/y versus 45 billion m³/y) it has 50% more storage capacity.

Bibliography

1. Iran on verge of killing big IGAT II gas line to USSR, Oil & Gas J., June 18, 1979, p. 75.
2. Platt's Oilgram News, Sept. 4, 1981, p. 1.
3. Intn'l. Gas Technology Highlights, April 14, 198, p. 6.
4. Platt's Oilgram News, Feb. 17, 1982, p. 1.
5. Kovnin, L. I., Misinov, N. V., and N. L. Voronin, Discovery of a gas field on the Astrakhan dome and goals of further exploration. Translated from Geologiya Nefti i Gaza. #10, p. 41-3, 1977 in Petroleum Geology 15 #10 p. 447.
6. Uvcharenko, A. V., Mizinov, N. V., Mordovin, A. Ya., Fedorov, U. L., and Brazhnikov, O. G., Directions of Oil and Gas exploration in the Kalmyk and Astrakhan regions. (In Russian) Geologiya Nefti i Gaza #12, 7-13, 1979.
7. Mizinov, N. V., Voronin, N. I., Reutova, A. A. and Chernetskaya, M. G., Sitnik, G. S. Tsvedel, Yu. L. and Shchuchkina, V. P. New ideas on structure of the Astrakhan arch. Translated from Geologiya Nefti i Gaza #7, p. 13-15, 1978 in Petroleum Geology 16, #7, p. 801.
8. Ivanov, Yu. A., and Kiryukhin, L. G., Petroleum occurrences in subsalt deposits of the Caspian depression and the Mid-European basin. Intn'l. Geology Review 23 #10, p. 1170, 1981.
9. Serebryakov, U., Characteristics and conditions of formation of condensates of the Astrakhan field. Translated from neftegazovaya Geologiya i Geofizika #1, p. 15-20, 1979 in Petroleum Geology 16 #7 p. 292.
10. Karalerov, K. V., Slavkin, V. S. and Besprozvanny, P.A., Deep subsurface of the Shiryayevsko-Aksaray area based on geological-geophysical data. Translated from Geologiya Nefti i Gaza #3 p. 19-24, 1978 in Petroleum Geology 16, #3 p. 122.
11. U.S.S.R. to build massive elemental sulphur plant, European Chemical News, Feb. 5, 1979, p. 32.
12. Scheirman, W. L., world's largest processing complex handles Orenburg gas, Oil & Gas J. May 2, 1977, p. 245.
13. Slavkin, U.S., Burakov, V. K., Besprozvanny, P. A., Linkovskiy, V. Ye., and Lein, I. S., Experience in the use of Ascint (automated system of complex interpretation for study of sub-salt sediments of the Astrakhan arch). Translated from Neft. Geologiya i Geofizika, #8, p. 30-32, 1981, Petroleum Geology 18 #2.

14. Kedrovskij, D. L., Myasnikov, K. V., Leonov, A. E., Romadin, N. M., Borodnev, F., and Nikiforov, G. A., The application of contained nuclear explosions for creating underground reservoirs and testing their operation for the storage of gas condensate. Translated from Peaceful Nuclear Explosions IV IAEA, Vienna, 1975 by M. E. Jones AWRE - Trans. 69, Aldermaston, Berks, May 1975.
15. Platt's Oilgram News, December 16, 1981, p. 1.
16. Rigassi, D. A., Oil & Gas in the USSR: There's alot of both, World Oil, October 1981, p. 221.
17. J. of Commerce, July 29, 1981, p. 3.
18. Platt's Oilgram News, September 4, 1981, p. 1.
19. Scheirman, W. L., The Pritchard Corp., 1 March, 1982 - personal communication.
20. Butkovich, T. R. and Lewis, A. E., Aids for estimating effects of underground Nuclear explosions, Lawrence Livermore Report UCRL--50929, 104 pp, 1973.
21. Plans for Astrakhan gas-chemical complex outlined Moscow SIROITEL'STVO TRUBOPROVOĐOV #2, Feb. 82 p. 4-5. (in English) USSR Report-Energy #101 JPKS 80856, FBIS, 20 May 1982.
22. Ivanov, Yu., Kapustin, I. N., Kiryukhin, L. G., and Nemchenko, N. N., Oil-gas productivity of the lower Volga region. Translated from Neftegazovaya Geologiya i Geofizika, #11, p. 26-29, 1978 in Petroleum Geology 16 #5 p. 202.

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