URANIUM MINING AND MILLING COMPLEX
PYATIGORSK, USSR

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PREFACE

This Joint Photographic Intelligence Report has been prepared by the Army, Navy, and Central Intelligence Agency, under CIA authorship. Its scope is intended to meet the combined requirements of the intelligence community as specified in the following requirements: JARIC Requirement HLA/R/01-79-79, Army Requirement 881-250-1-7B, and Navy Requirement OP22Y3 Project 22-28.

Geological data was supplied by the Geographic Division, Office of Research and Reports, CIA, and the U.S. Geological Survey.

This report is based on all available information as of 1 September 1958 derived from a large number of sources, including reports, open literature, and aerial and ground photography.

For further classification of several references cited in this report it should be noted that a conference on uranium mining and milling was held during the period 9-13 June 1958 for the members of Joint Project 19-57/D; the Nuclear Energy Division, OSO, CIA; and the Joint Atomic Energy Intelligence Committee (JARIC). Consultants to the conference were uranium mining engineers from the U.S. Geological Survey.
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INTRODUCTION

The Pyatigorsk uranium mining and milling complex is located northwest of the city of Pyatigorsk at 44°00'57"N, 42°35'37"E, in the northern foothills of the Caucasus Mountains. The complex is about 700 miles (1,126 km) southeast of Moscow, 380 miles (610 km) northeast of Stalingrad, and 350 miles northwest of Baku.

Little was known about the mining activity at Pyatigorsk until the aerial photography of the area was examined. Then it became apparent that a major new industrial complex had been established.

According to prisoner of war (POW) interrogations, the German POWs under the command of Colonel Steinhagen, who had been found on the site of the Pyatigorsk mining operation, stated that the plant was built in 1945 to produce uranium for the German U-boat fleet.

SUMMARY AND CONCLUSIONS

The Pyatigorsk uranium plant is one of the largest producers of uranium oxide in the USSR. It is a well-organized plant capable of producing an estimated 4,000 pounds of uranium oxide a day, or about 1,000 metric tons a year. The plant and the supporting facilities appear to be in full-scale operation at the time of photography.

The plant consists of a concentration facility that probably uses the ion exchange method of ore refining. Within the overall complex there are several support facilities, including a power plant that serves both the mine and the mill. The reservoirs in the area appear to be extensive, and the quality of the ore appears to be extremely high, as estimated by a factor of two or three.
GEOLOGY

Exploitation of the mineral wealth of the Pystigork region began with the creation of spas in the mineral springs area as early as 1737. The basic interest in the region remained the mineral springs until the early 1900's.

Russian geologists of the mid-1920's considered the Caucasus to be an area of little mineral wealth, but opinion has since changed. It is now known to be an area of considerable mineral wealth including a few areas containing uranium.

Volcanic activity in the Pystigork area of the Northern Caucasus has been expressed in the form of igneous masses or laccoliths forming isolated peaks, the highest of which is Gora Beshtau (Beshtau Mountain) at an elevation of 4935 feet. Other significant peaks include Gora Byk, Gora Verkhnaya, Gora Razvetkha, Gora Dehuga and Gora Golomya Kurgan.

The area from Pystigork southwest to the west and south west of Gora Beshtau, forms a small plateau which is the core of the creation complex. The terrain slopes northward from the plateau into the valley in which Mineral'nyy Vody is located. This otherwise gentle slope is interrupted by four main laccoliths, Gora Zheleznyy, Gora Razvetkha, Gora Zmejka and Gora Byk. The terrains to the northeast is similar, broken only by Gora Verkhnaya. South of this small plateau the terrain rises rapidly, it is broken with numerous drainage channels, and forms the threshold of the Caucasus.

Since radium and uranium exploration began seriously in the 1920's, prospecting has uncovered many deposits and the region is now believed to have significant amounts of radioactive ore. Uranium is reported to occur in a few small poly-metalliferous deposits, in placeres, inlinsations, in igneous rocks, and in deposits of unspecified type in the Beshtau hot springs area.

The Russian geologist, Pavlov, apparently did the most significant work in recent years. He analyzed the structures and made a detailed survey of the major structures of the Pystigork region.

Gerselmov, another Soviet geologist, noted his belief in 1937 that all of the intrusive rocks came from a common magma. Also, it is reported that all of the intrusive rocks are abnormally radioactive.

The area included in the creation field is approximately 15 km in diameter and contains about 11 small plutonic bodies expressed as peaks throughout the area. These plutonic bodies are variously reported to be andesitic, basaltic or dolerite, but all of them apparently contain quartz as well as some minerals of the pyroxene-amphibole series.

The location of laccoliths are easily recognized on the photographs by their prominent out-crops, which are the only impediments to otherwise undulating terrain. Structures of interest consist of about sixteen laccoliths including the Creatacous, Tertiary, and Quaternary Layers. The third peak is Gora Beshtau. The laccoliths are typical, pegmatite-like, amygdaloidal masses, which are complicated by repeated intrusions of magma under hypabyssal conditions. All the igneous rocks are partly crystalline to massive.

There are two primary areas of mining, Beshtau and Byk. Anomalous is reported to be in contact with the igneous rock at Byk, but at Beshtau the igneous rock is believed to be in contact with andesites and andesites of Tertiary and Cretaceous age. Some of the sediments are reported to be relatively carbonaceous, which the carbonaceous material concentrated near the contact and the structures. The literature also states that black veins occur on the slope of Gora Topya. This would be in the igneous body, and the veinlets were said to contain about twenty percent manganese oxide with some hematite.

FIG. 4 PROFILES OF LACCOLITHS IN THE PYSTIGORK AREA. See Fig. 3 for location and legend for the above profiles.
MINING ACTIVITIES

There are several intelligence reports on uranium ore mining in the Pyatigorsk district. The ore, said to be dark-gray to brown rock resembling coal, has been estimated by one source to be low grade, perhaps averaging less than 0.1 percent uranium oxide. In the same source stated that there was a reserve of only a few hundred tons. 17

The size and scope of the operation, as evidenced on the photography, indicates a reserve much greater than several hundred tons, and one of quality near 0.2 percent uranium oxide. These mines are probably small, and could run to pitchblende, which would assay much higher than 0.2 percent.

PROSPECTING

Scars from test borings are visible at scattered points on Gora Sheludovaya on the slopes of Gora Dzhubga, particularly on the east slope; on Gora Verkhovaja on Gora Medovaya on Gora Osenaya on Gora Raukhalia on Gora Kisheh; on Gora Lyalya on Gora Zolotoy Kurgan; and on Gora Dubga. 18 These scars appear primarily in the form of trenching.

It is quite evident that prospecting in the area has been very extensive. There are probably many drill holes which are not visible, and certainly there is an unusual amount of trenching. It seems that, unless the Soviets has found significant amounts of good quality ore, an expensive modern installation such as this would not have been programmed. 18

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PHOTOELOGICAL ANALYSIS

According to an analysis during the mining and milling consultants' conference, there appear to be two general types of mineral exploitation in the Pyatigorsk area:

1. Exploitation of deposits of uranium and manganese present along fissures or veins. Most of the deposit of this type are in igneous rocks, and most of the mines in the Pyatigorsk region are exploiting deposits of this type.

2. Exploitation of deposits within the sedimentary rock surrounding the igneous areas. These mines are large and, although few in number, they may be the major source of supply of ore for the concentrating plants.

The Pyatigorsk deposits are rather unusual in that the uranium may be chemically associated with manganese in the vein-type deposits. **

** In a geologic report of the USGS, the same author, E. A. Kunk, reported that in the Pyatigorsk region there is an unusual amount of manganese in veins and fissures. However, this report does not provide specific data on the chemical association between manganese and uranium.

** In data provided by the USGS, manganese was found in veins and fissures in the Pyatigorsk region, but it was not specified to what extent it is chemically associated with uranium.**
All mining activity in the Fyshtgork complex lies within a 13-ha area called Gora Bezkas, the most important mining location. The four mines here do not appear to be remoteness (Figure 4), including Gora Kishal, Gora Lysava, Gora Doljava, and Gora Zeleny. Kurgan, were probably not producing any ore at the time of photography.

Gora Bysty: The most important mining activity at Gora Bysty is on the east slope of the mountain. (See Figure 5.) The largest mine is in the settlement area, located along an alignment of features that can be seen clearly on the photograph. Associated with this large mine there is what appears to be a crushing mill.

Ore is removed from the mine by ore cars and taken directly to the crusher. It appears that the ore is classified after crushing, because there is a pile of discarded ore beside the crusher building.

The up-graded ore is loaded on trucks which back onto the crushing plant from the loading areas. There is a good road from the crushing plant to the processing plant nine km by road to the south.

The installation probably serves as a general service and administration center for all of the mines in the Gora Bysty area. A small complex of buildings near the mine adits includes a probable administration building, a compression building, and a transformer yard. The complex is served by a transmission line leading from the power plant in the main mill area to the transformer yard. Water is apparently supplied to the area by pipeline, as evidenced by earth mounds that enter the area from the south and north.

Gora Bezkas: The largest mine in the Fyshtgork area is located on the southwest slope of Gora Bezkas, about three km east of the uranium plant. Ore from
This mine is probably the major source of supply for the plant.

The photographs show that the mine at Gora Radinova is in the sediments near the margin of the igneous intrusion. The sediments exposed at the surface are of two types, 1) a bedded sequence reported to be part of the Picaunica Series of Tertiary age, and 2) an overlying series, probably continental and probably composed of poorly-consolidated, permeable material. These latter deposits are approximately 100 feet thick and may be locally derived. 137

Primary Processing at Mines: The large mine on the west slope of Gora Radinova is situated within a double-fenced complex that includes a grizzly in the crusher building, and a modern screening plant, including a hopper. The complex is well-served by a spur line from the main processing plant down to the west.

Ore cars deliver the ore from the mine to the grizzly in the southwest corner of the crusher building. After crushing, the ore is given a coarse screening and then transported by conveyor to a multidecked screening plant.

The screening plant appears to be new, and from the size of the waste dumps it can be estimated that the plant had not been in operation more than a year at the time of photography.

At the screening plant, the fine material drops directly into rail cars through a hopper, and the sand is dumped onto the side. The ore is then transported by rail to the processing plant.

It appears from the size of this primary processing plant that the input could be as high as 3000-1500 tons a day, yielding perhaps 100 tons of upgraded ore. 157

Other Mining Activity: All of the other mines in the area are apparently located along alignments of features mentioned above, or along steep-sided valleys that may represent features or dikes. It appears probable that the mines at Gora Beshkent and Gora Blyk were the only ones producing ore for the plants at the time of photography, and that the other mines are being held in reserve or are used for quarrying rock for road surfacing.

Mine Power Supply: A well-developed power grid radiates from the power plant at the main processing mill and serves most of the major mining operations of the Bystrinka complex. The facility on the west slope of Gora Beshkent appears to have its own boilerhouse, but may also be served by a line from the main plant.

The mines on the east slope of Gora Beshkent are connected with the regional power grid in addition to its local supply from the processing plant. Other transmission lines from the central power plant serve the Gora Blyk transalation and the mine operations at Gora Shokodarya, Gora Zmeei, and Gora Verblina.

It is probable that Gora Radinova, Gora Dzhuga, and Gora Zolonts Kurgans are tied into the grid for their power supply, but transmission lines cannot be identified. Gora Chaya, Gora Medevaya, and Gora Kinsbhal do not appear to have a power supply.

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PROCESSING

The most significant installation of the Pystygorak mining and milling complex is the processing plant, which is estimated to be capable of producing 4600 pounds of uranium a day or about 700 metric tons a year.19

PROCESSING PLANT

The processing plant is located on a narrow plateau about three km WSW of Gora Beshent, seven km northwest of Pystygorak.

Plant Layout: The processing plant is -- The analysis in this section is based on the referenced transcript of the consultants' conference.

The four principal buildings of the processing plant are Building 6, where ore is received and bailed; Building 5, where it is crushed and screened; Building 4, where it is purified and leached with acid; and Building 7, where the uranium oxide is separated from the slurry, probably by the ion exchange process.

Ore Receiving: The ore is received and building building, Building 6, is a large cable-roofed structure served by a cell spur. It appears probable that all ore arriving directly from the mines is received at Building 6, while ore from the primary processing plant associated with the large mine at Gora Beshent is probably received at Building 1.

Crushing and Grinding: Ore is conveyed by conveyor from Building 6 to Building 5, where it is crushed, screened, and conveyed on to Building 3. Ore received at Building 1 is processed through Building 2 on its way to Building 1. Building 2 is probably a sorting and sampling facility.

Acid Leaching: After grinding, the ore is moved into the main section of Building 3, for acid leaching. Heat is probably used to aid the agitation of the slurry. Small flues on top of Building 3 could be used to disperse heat as well as acid fumes.

The discharge from the leach tanks is probably fed directly to settling tanks, from which a solution would be recovered. There would probably be two or three filtration stages, with repulping between each stage.

The solutions and tailings would then be pumped to Building 7. The products taken

FIG. 7 PERSPECTIVE VIEW OF PYSTYGORAK URANIUM PRODUCTION PLANT. This view shows the thermal electric power plant at the left and the uranium concentration plant at the right.

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at the northwest end of Building 7 could be used for neutralizing the solutions and tailings or for uranium oxide recovery.

Uranium Oxide Recovery: The final stage in the recovery of uranium oxide from the ore occurs in Building 7, which is almost identical in size and configuration to an ore-exchange building designed by Porter for construction in South Africa.

The possible exogenous combination used in the plant would be sulphuric acid for leaching, lime for neutralization of the solutions and tailings, and either salt, or sulphuric or nitric acid, for stripping of the low-exchange oxides. 27

Production Laboratory: The estimate of production of uranium oxide is based on 1) the grade of ore entering the plant and 2) the size of the tailings pond.

The grade of the ore entering the plant is difficult to estimate, but from the amount of radioactive ore that is taking place in the mining areas it could be estimated that the grade would be similar to other Soviet uranium enterprises, where the grade is believed to be in the neighbourhood of 3 to 3.5 percent uranium oxide.

Since it has been estimated that the upgraded crushed ore might also be of that grade, it is feasible that the current average of the feed to the plant. 27

It appears that there are between 800,000 and 1,000,000 tons of tailings at the plant, which would mean that during the 3.5- to 5-year period about 400,000 tons of ore a year or 1000 metric tons a day had been processed. Estimating the grade at 3 percent uranium oxide, or four pounds in a ton of ore, the yield would be 3000-4000 pounds of uranium a day. This rate of production agrees with the known production of the South African mill.

* The reasons oxide may also be used as a reagent at the Pyatigorsk plant. It is readily available from mines in the region.

After which the Pyatigorsk mill was probably modeled. Recovery should be extremely high, probably 90 to 92 percent, so that it appears safe to estimate that the production would be close to 4,000 pounds of uranium oxide a day, or approximately 1,000 metric tons a year. The output from this plant would be a very high concentrate ranging from 25 to 30 percent uranium oxide. 27

Dispatching: The concentrate is sent from Building 7 to Building 8 for packaging and shipping. Packaged concentrates may leave the plant five times a week, if transportation is not a problem. Shipping approaches have been reported to include trucks, but this method of shipment is probably used only to by-pass heavy rail-traffic between the mill and the main rail line at Airstrip. At other times shipments would be entirely by rail.

Waste: Liquid waste is deposited in two probable steel-lined uranium recovery tanks 450 feet south of the plant and in a tailings pond 2000 feet west of the plant. Pipelines carry liquid waste to the tanks for probable settling out of concentrates lost in the leaching process. Other pipes convey the recovered material back to the plant. Water recirculated at the refinery is not likely to be used by the power plant. Remaining waste is carried by air.
other pipes lead to an evaporator 1500 feet farther NNE. Material separated in neutral filtration is piped from the plant to the tailings pond. An earth dam approximately 20 feet high retains the tailing material. The pipelines from the processing plant run along the top of the south wall of the pit and then out along the length of the crest of the dam. The stilings here are indicative of 2.5 to 3 years of operation.

PLANT SUPPORT FACILITIES

The buildings in the northeast quadrant of the plant area have administrative and maintenance functions. Building 32 and buildings 11-14 are probably supply and commissary buildings. Building 31 has elaborate doors with a roof, suggesting its use as a laboratory. Building 16 is a shop-type building, probably the center of maintenance activities. Building 17 is probably the plant superintendent's quarters, and buildings 19 and 6 are probably dormitories for mill workers and for the plant security force. Building 24 is either an administrative building or a laboratory.

Power Supply: Within the uranium mill dump is a large coal-fired thermal power plant with an estimated capacity of 10-16 megawatts. In addition to supplying the uranium plant, it provides power for much of the entire complex. Lines cross the great cline hall to a large transformer yard which lies outside the south corner of the processing plant. From the transformer yard, transmission lines branch out to the mines, the housing areas, and to other supporting facilities.

Water Supply: A lake occurred by an earth dam adjacent to the millings pond is a partial source of water supply for the processing plant. It probably contains a minimum of 15 million gallons of water. This reservoir did not exist in 1965. 25

Another man-made lake at the base of Gora Srebrenica holds about 14 million gallons of water. In addition, there are two semi-buried probable water storage reservoirs each about 65 feet in diameter adjacent to the crushing mill on the west slope of Gora Blagovej. On the east side of Gora Blagovej is a small water treatment plant, associated with the Gora Blagovej crushing plant, which may be for water purification or for sewage treatment.

Storage: Within the plant area there are several cylindrical tanks approximately located between the processing buildings and the power plant. These tanks are used for the storage of acids, and are computed to have a total capacity of about 3.5 million gallons.

Several fenced storage facilities lie on the south side of the rail yard adjacent to the shop area. One of these is rail-served with a spur passing through a building into which appears to be a metal storage yard, which is served by a gantry crane. A row of warehouse-type buildings lie adjacent to the probable metal storage yard, and to the east there is a small storage area consisting of eight buildings of various sizes.

Another storage facility, to the west of the mining district headquarters, is both road and rail-served and is secured by a wall. Within this compound there are four major buildings, eight smaller buildings, and a considerable amount of unidentified open storage.

Transportation: The Duga Kokhov mine and milling complex is served by a broad-gauge rail line that terminates at the processing plant. A five-truck rail yard 1000 feet east of the plant provides car storage. At the time of photography there were at least 38 freight cars in the plant area. A spur line leads from the processing plant to the mine and extends until three miles to the east. Roads connect the processing area with Duga Kokhov and with all sections of the mining area. There is a large motor pool near the processing plant.

Subsidence Dam: There is a large construction material plant adjacent to the processing plant. It includes a sawmill and a lumber yard, as well as a cement plant. These facilities are all served by rail. A new, unidentified plant lies between the processing plant and the rail yard. The main building is a large structure with a concrete roof.

Housing: The main workers' housing area is about one mile S of the processing plant. Included in the area is a large group of apartments which were still under construction at the time of photography, and about 250 individual houses, of which about 75 were still under construction. These units will accommodate 6000-9000 people using a factor of 600-900 square feet for each family. In addition, some old tempora...
easy housing nearby could shelter about 2000 workers, and on a more permanent basis could accommodate about 700. A "KGB" or laboratory area on the west slope of the Krasnaya Gorka will probably house about 90-100 people. The area is isolated, but is served by a good road. The area is well laid out, with four apartment buildings that appear to be permanent structures, and eight other buildings that may house laboratories. On the southeast slope of Krasnaya Gorka there is a workers' camp that has eight barrack-type buildings with a total floor space of about 11,200 square feet, capable of housing up to 185 workers, and about 45 individual dwellings.

***

REFERENCES

SOURCE REFERENCES

2. WDOE 34-35-31, pp. 11, 15, 17.
3. Ibid.
12. Ibid.
13. Ibid.
14. Ibid.
15. Ibid.
16. Ibid.
17. This thesis was reviewed by the U.S. Geological Survey.
19. Ibid.
20. Ibid.
21. Ibid.
22. Ibid.
23. Ibid.
24. Ibid.
25. Ibid.
26. Ibid.

MAP REFERENCES


PHOTOGRAPHIC REFERENCES

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