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USSR: Reduction in Estimated Gold Production

A Research Paper

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ER 78-10731J

December 1978

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USSR: Reduction in Estimated Gold Production

A Research Paper

The authors of this paper are [redacted] of the Office of Economic Research and [redacted] of the Office of Imagery Analysis. Comments and queries are welcome and should be directed to [redacted]

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USSR: Reduction in Estimated Gold Production

Central Intelligence Agency
National Foreign Assessment Center

December 1978

Key Judgments

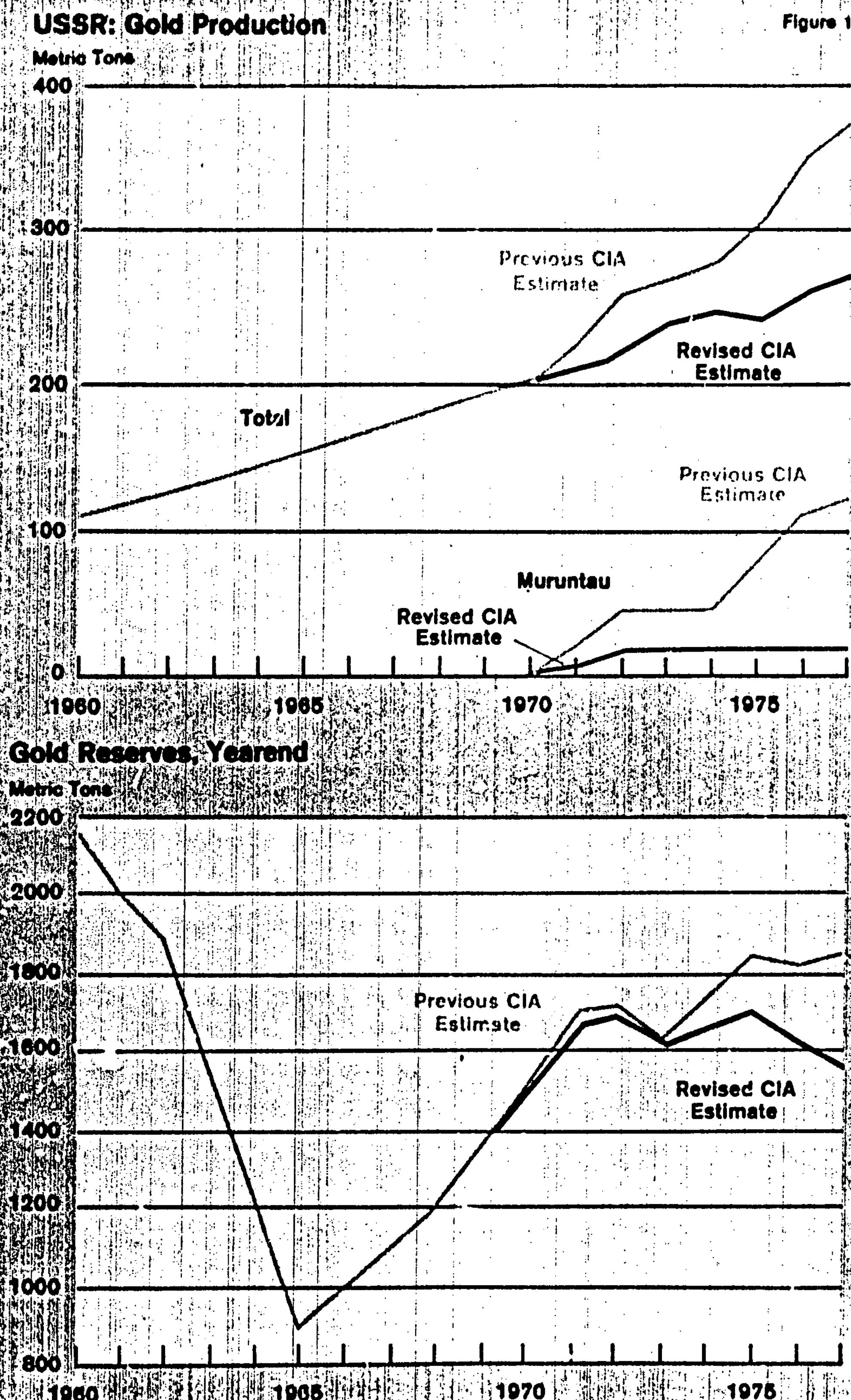
Identification of a major ore-unloading bottleneck at the Muruntau gold plant—the largest in the USSR—and revisions in our estimate of the gold content of the Muruntau ore deposit have resulted in a reassessment of the plant's output and a reduction in our estimates of total annual Soviet gold production since 1970. We now believe that Soviet gold production totaled about 270 metric tons in 1977, 100 tons less than our previous estimate. Soviet gold reserves at the end of 1977 are in turn calculated at about 1,530 tons instead of 1,865 tons, a difference of more than $2 billion at $200 per troy ounce (see figure 1). Our revised estimates suggest that the USSR has been selling substantially more gold than it has been producing since 1975.

The revisions reflect only the reassessment of production at Muruntau, which accounted for one-third of our previous estimate of total Soviet gold production but only 7 percent of production in the revised estimate. Estimates of production in Magadan Oblast and the Yakutsk ASSR, which account for about one-half of the revised estimate, [redacted] have not been changed. We are also reasonably certain of the accuracy of the estimate for the roughly one-fifth of total output produced as a byproduct of the copper industry. We are much less certain about production at 14 other gold mining locations scattered throughout the USSR, which account for most of the remaining 20 percent of production in the revised estimate. A detailed analysis [redacted] of these facilities, now under way, may lead to further revisions in our estimates of total Soviet gold production and reserves.

The estimates of the capacity and level of production at Muruntau were developed with the assistance of leading US experts in the fields of mining, metallurgy, geology, and transportation. These experts [redacted] developed estimating approaches [redacted] These experts also provided analysis on the nature of the ore deposit and the efficiency of the refining process.

[redacted]

Figure 1



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We estimate that Muruntau's present ore-processing capacity is 54,000 tons per day. Given an ore with an average gold content of 0.10 troy ounce per ton, a 90-percent recovery rate, and a 360-day work year, it is estimated that production would be 54 tons of gold per year. Processing capacity will increase to 75,000 tons of ore per day when construction currently under way is complete in 1979-80. This will be sufficient to support production of 75 tons of gold per year.

Since 1972, however, much of the processing capacity has been idle because of an ore-unloading bottleneck. Evidence [redacted] together with Soviet data and factors derived from [redacted] of US mining and railroad companies, indicates that, between the start of operations in July 1969 and mid-1978, the Soviets could deliver 20,000 tons of ore per day to the plant. This volume could support production of about 20 tons of gold per year, 100 tons less than the production figure we have been carrying for 1977. The estimate of ore deliveries [redacted] which points to a figure of about 16,000 tons for the ore processed per day since 1969.

Between the start of operations in 1969 and the end of 1972, Muruntau's unloading capability of 20,000 tons of ore per day was not significantly below the 25,000-ton capacity of the processing facilities. Between 1973 and mid-1978, however, processing capacity grew from 25,000 tons per day to about 54,000 tons, while ore-unloading capacity remained at 20,000 tons. A second ore-unloading facility was completed by mid-1978. With the second facility in place, maximum potential output from Muruntau has jumped to about 40 tons of gold per year, still well below the processing capacity. To operate the plant at or near design capacity in 1979-80 (75 tons per year), the Soviets will have to install at least two more unloading points, using the existing rail transport system, or move part of the ore by truck. To date we have no evidence they are doing either.

The revision of estimated gold production at Muruntau has caused us to reduce our estimate of Soviet gold reserves as of yearend 1977, from 1,865 tons ($12 billion at $200 an ounce) to about 1,530 tons ($10 billion). The reduction in our estimate of reserves is of little immediate importance for the Soviet hard currency position. With almost $10 billion in gold reserves and annual gold production valued at $1.7 billion, availability of gold for export is not likely to constrain imports substantially in the near term. In the next few years, however, falling Soviet oil production is expected to cut into Moscow's hard currency earnings; this will probably intensify pressure to expand gold sales in the West. At some point Moscow will have to tie its sales more closely to current production in order to maintain reserves at an acceptable level.

[redacted]

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[redacted]

USSR: Reduction in Estimated Gold Production

Introduction

In 1977, total world gold production amounted to about 1,160 tons, of which the USSR produced 270 tons or 23 percent and South Africa 700 tons or 60 percent. Since 1974, Soviet gold production has exceeded the combined output of all other world gold producers, except South Africa (see figure 2). Gold, along with arms, ranks after oil as the largest source of Soviet hard currency earnings. In 1977, for example, Soviet gold sales amounted to about $1.6 billion, roughly 10 percent of Soviet hard currency earnings in that year.

In 1965 the Soviets began to develop an open-pit gold mine near Muruntau, located in the Kyzylkum desert of the Uzbek SSR, roughly 400 kilometers west of Tashkent (see map). Construction of the processing plant began in May 1967, and production in July 1969. Since then, the entire Muruntau complex (processing plant, mine, support facilities, and housing) has been expanded dramatically. Although still under construction, Muruntau dwarfs in size any gold plant in the United States and is considerably larger than any South African plant (see appendix A for details). US experts estimate that it would cost about $500 million to duplicate the processing plant in the United States. Investment in infrastructure would amount to an additional $500 million.

In 1973 OER estimated that the Muruntau plant would produce 90 tons of gold per year at capacity. During 1974-76, as the Soviets expanded key sections of the plant, we increased our estimate of the plant's annual production capacity to 135 tons—an amount at least 50 percent greater than the largest gold plant in South Africa. We estimated that production was close to the level of installed capacity during 1969-77, and by 1977 accounted for about one-third of total Soviet gold production.

New evidence about the pace of operations at Muruntau, however, led us to question whether the gold plant was actually producing up to capacity. Therefore we conducted, with the help of US experts, a thorough reassessment of both capacity and production at Muruntau. The results of this reassessment are reported in this paper. Because our estimates of capacity and production are directly related to the flow of materials through the refinery process, the following three sections of this report will (1) briefly trace the key elements in the refining process, (2) define the specific techniques used to estimate the *processing capacity* of the plant, and (3) describe the ore-unloading bottleneck and its effect on *actual production* at Muruntau. Finally, we offer some possible explanations for the unbalanced expansion of Muruntau's facilities, and briefly outline the prospects for future Soviet gold production and sales. A detailed description of all facilities at Muruntau and the basis for our estimates of gold production at other locations in the USSR are included in appendixes A and B respectively.

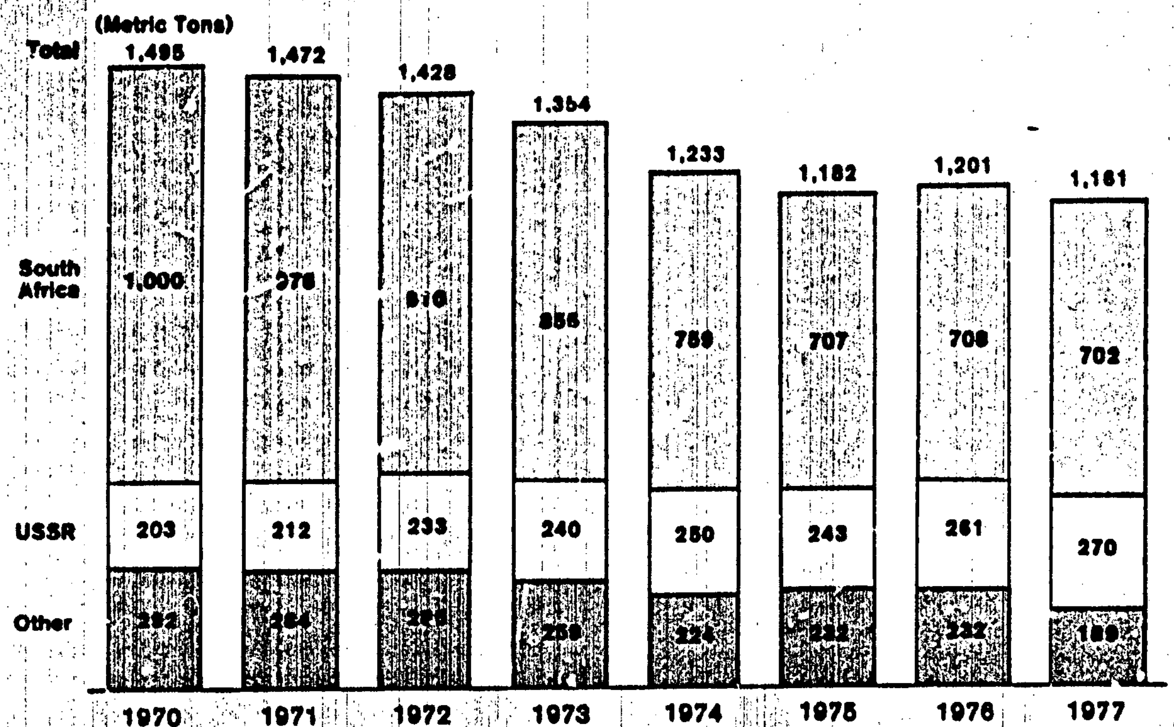
The Refining Process at Muruntau

The refining process at Muruntau is defined in metallurgical terms as a resin-in-the-pulp (RIP) process. Although not used in the United States to recover gold, the RIP process is employed in the US uranium industry and in South Africa for the joint recovery of gold and uranium.

The refining process at Muruntau consists of nine basic steps: (a) crushing the ore, (b) grinding the ore, (c) recovering the heavy gold nuggets

Figure 2

World Gold Production



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by mercury amalgamation, (d) thickening the slurry, (e) dissolving the pulp in sodium cyanide, (f) extracting the gold out of solution with ion exchange resins, (g) recycling the resin, (h) refining electrolytically, and (i) final refining. The process is described below and shown in the simplified flow sheet (see figure 3).

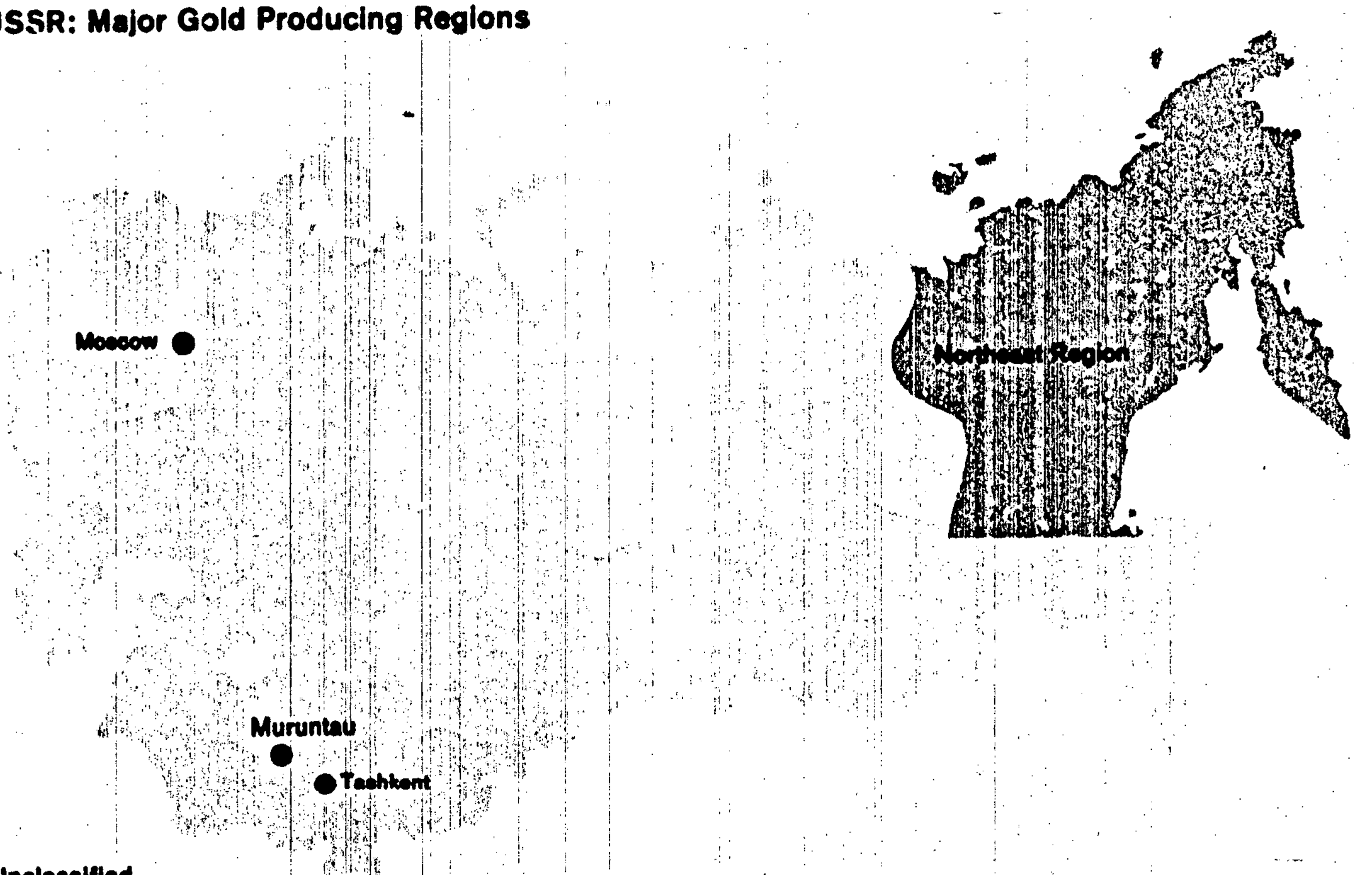
The ore is brought to the plant by rail from an open-pit mine eight kilometers to the east. Primary crushing of the ore is performed underground at the unloading points (1)[1] where the ore is probably crushed to a maximum size of 15 to 20 centimeters. The crushed ore is transported by conveyor belts (2) to the top of the mill building (3) and deposited into holding bins (4) located along the north wall of the building. The Soviets probably maintain an eight- to 16-hour inventory of ore at all times to ensure continuous operations when the crushers are undergoing maintenance.

The crushed ore is moved by conveyor belts from the holding bins to semiautogenous grinding mills where it is ground to a powder.[2] Water is added to the grinding mills to speed the grinding process and reduce power consumption.

[1] Figures shown in parentheses refer to the processing facilities shown in figure 4.

[2] An autogenous grinding mill is one in which the ore grinds itself by turning in a revolving cylinder. In a semiautogenous grinding mill a few steel balls are added to the mill to increase the efficiency of the grinding process.

USSR: Major Gold Producing Regions



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The ground ore is passed through amalgamators adjacent to the grinding mills. Free gold (heavy gold nuggets) released from the ore during the grinding process adheres to the mercury-coated inner wall of the amalgamator. Periodically the sludge or amalgam formed on the inner wall of the amalgamator is removed and sent directly to the refinery for final purification. The Soviets probably recover about 55 percent of the total gold output at Muruntau by the mercury amalgamation process.

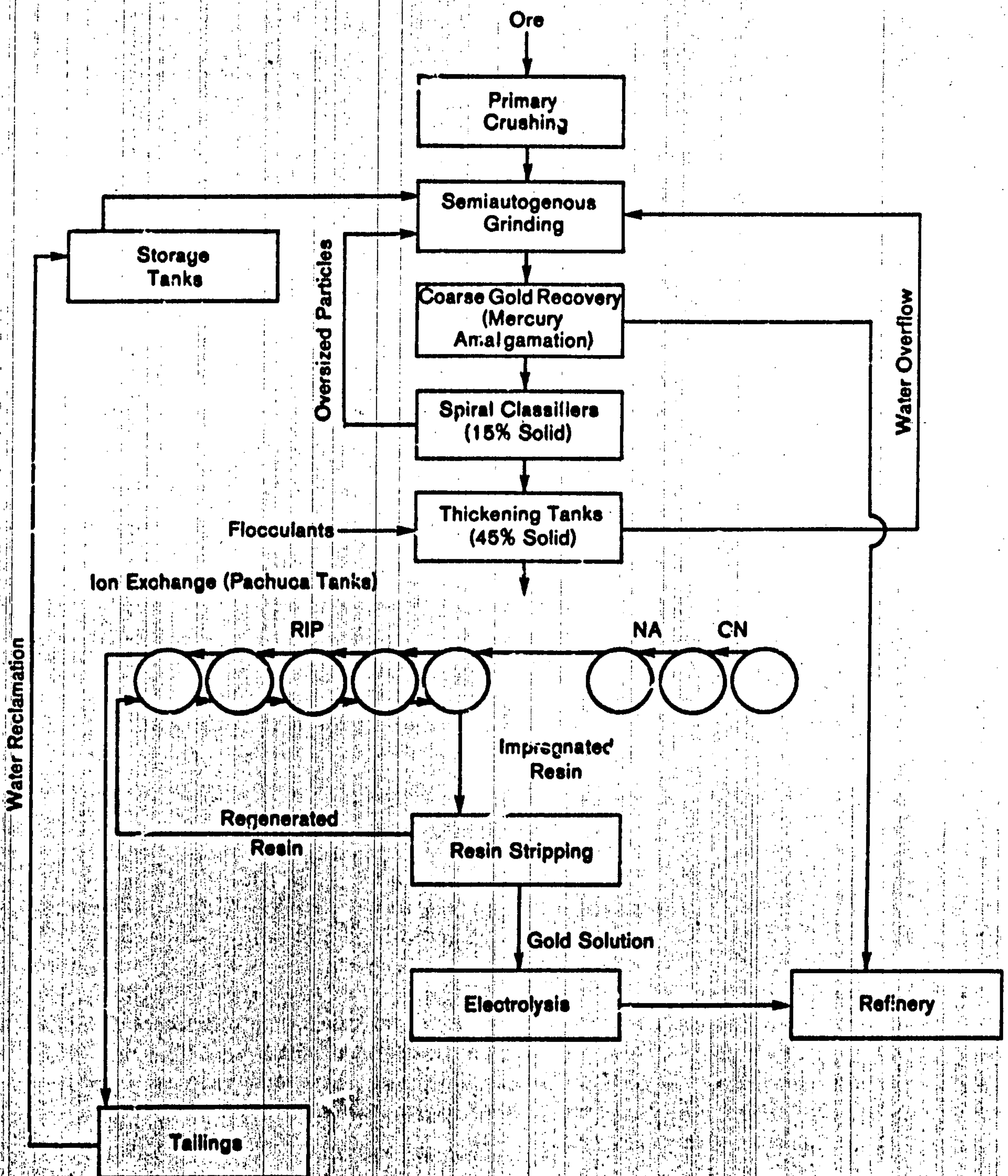
Ore containing the fine gold particles passes through the amalgamators into spiral classifiers which ensure a uniform size grinding prior to the thickening process. Oversize particles of ore are returned by the spiral classifiers to the semiautogenous mills for additional grinding. Upon leaving the classifier, the powdered ore is in a water mixture (slurry) with a solid content of about 15 percent.

The slurry is piped out of the mill building into large circular tanks called thickeners (5) to reduce the proportion of water. This is achieved by allowing the solids to settle to the bottom of the tank. Because the Muruntau ore settles slowly, chemicals called flocculants are added to the thickening tanks to speed the process.

When the desired liquid:solid ratio has been achieved, the viscous residue at the bottom of the thickening tank, called pulp, is piped through pump houses (6) into the ion-exchange building (7). The water in the thickening tanks, called overflow, is returned to the mill for reuse in the grinding circuit.

Ore-Refining Process at Muruntau

Figure 3



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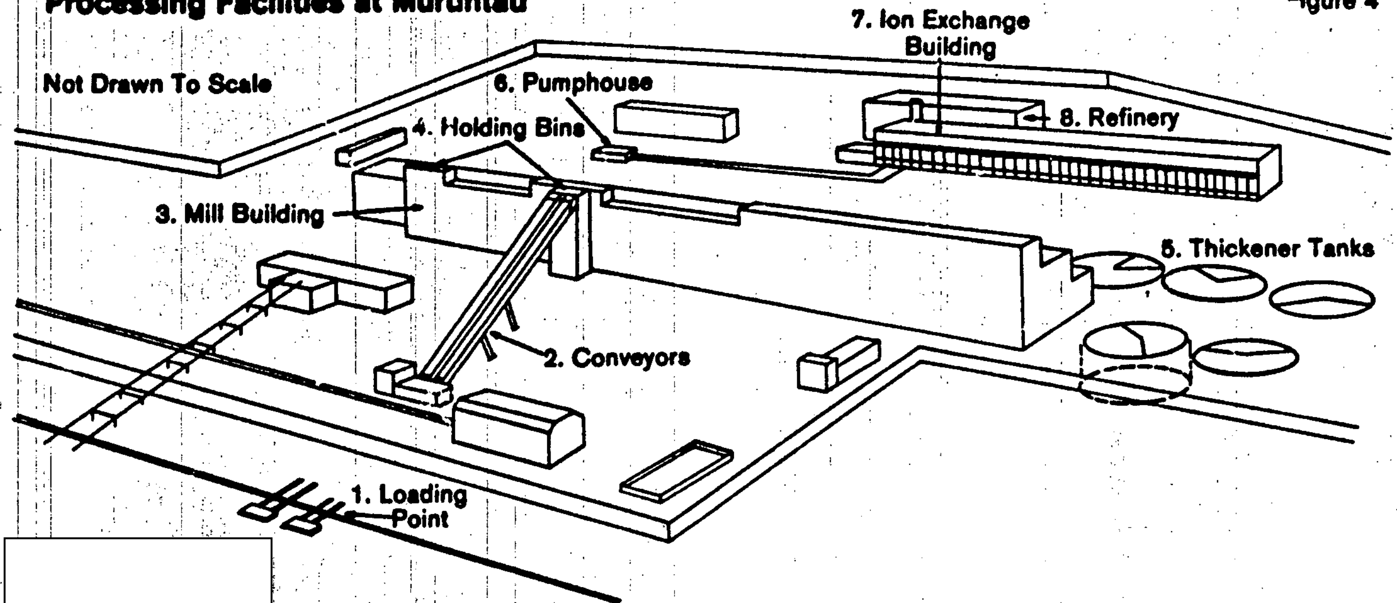
[redacted]

Processing Facilities at Muruntau Figure 4



[redacted]

The ion-exchange building houses columnar tanks, called Pachuca mixers. The pulp, which contains about 45 percent solids, enters a series of mixers and its gold content is dissolved in sodium cyanide, a process taking 10 to 14 hours. The dissolved pulp then enters other mixers, where it is exposed to ion-exchange resins (plastic polymers with an affinity for gold) that adsorb the gold out of the cyanide solution. A Soviet manual indicates that 52 Pachuca tanks are used to dissolve the gold pulp.[3] The remaining 86 tanks are used to expose the solution to ion-exchange resins. The resin is recovered for reuse in a process called resin stripping.

The gold is then refined by a standard electrolytic process in which the gold is deposited on titanium sheets (cathodes) set in electrolytic cells and then manually peeled from the cathode. Final purification of the gold recovered by the mercury amalgamation process and the RIP process is performed in the refinery (8) behind the ion-exchange building, using a standard refining process to produce gold that is 99.99-percent pure.

Estimating the Design Capacity of the Gold Plant

Our new estimate of the *ore processsing capacity* at Muruntau is based on analysis of [redacted] stages in the ore-processing sequence [redacted] An estimated range of maximum capacity has been established for each stage, depending variously on measurements [redacted] analysis by US engineers familiar with gold mining and processing techniques, factors derived from Soviet technical journals, and comparisons with processes used in gold plants in non-Communist countries.

Crushing Capacity

The size and type of crusher used at Muruntau is based on reports from [redacted] who visited other Soviet mineral processing plants. These [redacted] reported that 60-inch crushers are com-

[3] I. N. Maslenitskiy and L. V. Chugaev, *Metallurgiya blagorodnikh metallov*, Moscow: "Metallurgiya," 1972, p. 210.

monly used. ~~Moreover, the size and configuration of the unloading facility at Muruntau is consistent with that required to support a 60-inch crusher.~~ US technical manuals indicate that one 60-inch crusher can crush 4,500 tons of ore per hour into 20-centimeter pieces suitable for feeding the grinding mills. According to a Soviet technical manual, a 60-inch cone crusher is capable of crushing more than 5,000 tons of ore per hour.[4] Gold ore processing plants operate 24 hours a day; crushers, however, frequently operate for only two shifts, or 16 hours each day. Maintenance is conducted during the third shift. Until this year, Muruntau operated with only one crusher. Assuming that the crusher can handle 4,500 tons per hour and operates for 16 hours each day, the plant would have had a crushing capacity of 72,000 tons of ore per day.[5]

In early 1974 construction began on a second unloading facility and crusher at Muruntau. [redacted] the new [redacted] 60-inch crushers operating 16 hours a day, the plant would have a crushing capacity of 144,000 tons of ore per day. [redacted] simultaneously. If the second crusher were constructed to ensure that one or the other would operate 24 hours a day, the plant has a crushing capacity of 108,000 tons of ore per day.

Grinding Capacity

[redacted] two semiautogenous grinding mills approximately 10 meters in diameter and 2.5 meters long (see figure 5). According to [redacted], each mill of this size could process approximately 13,000 tons of ore per day. [redacted] suggests that the building is divided into seven or eight bays, each large enough to accommodate one mill and the associated catwalk, pipes, and access space. Thus, if all of the grinding mills were operating, the total capacity of the mill building would be at least 91,000 tons per day, and possibly 104,000 tons per day.[6] These mills require constant maintenance, however, so at least one or two may be out of operation in any given time, thus reducing the overall milling capacity to 65,000-91,000 tons per day.

Thickening Capacity

Eighteen thickener tanks will be used in parallel at Muruntau to reduce the proportion of water in the slurry that emerges from the milling process. Each of the tanks measures 50 meters in diameter and has a surface area of 1,986 square meters (see figure 6). Thickener tanks [redacted] in Nevada—the best US analog to Muruntau—have a diameter of 38 meters and a surface area of 1,139 square meters. Their capacity is 2,250 tons per day. By applying the ratio of square feet to capacity of the tanks at the US plant to the tanks at Muruntau, we estimate thickener capacity at Muruntau to be 70,432 tons per day.[7] Applying the ratio of square feet to capacity of the thickener tanks at five other non-Communist gold plants to the tanks at Muruntau yields an estimated processing capacity in the range of 59,000 to 85,000 tons of ore per day.

According to a Soviet technical manual, thickening tanks require 1.5 to 2 square meters of surface area to process 1 ton of clay-base ore each 24 hours.[8] The manual adds that the amount of ore processed can be increased two to four times with the use of flocculants, which promote agglomeration and settling. Soviet geological studies indicate that the ore processed at Muruntau has a clay base. In addition, three

[4] A. I. Basov, *Mekhanicheskoye oborudovaniye obogatitelnikh-fabrik i zavodov tyazhelykh tsvetnikh metallov*, Moscow: "Metallurgiya," 1974, p. 99.

[5] [redacted] believe that 4,500 tons per hour is a more realistic estimate of the capacity of a 60-inch cone crusher.

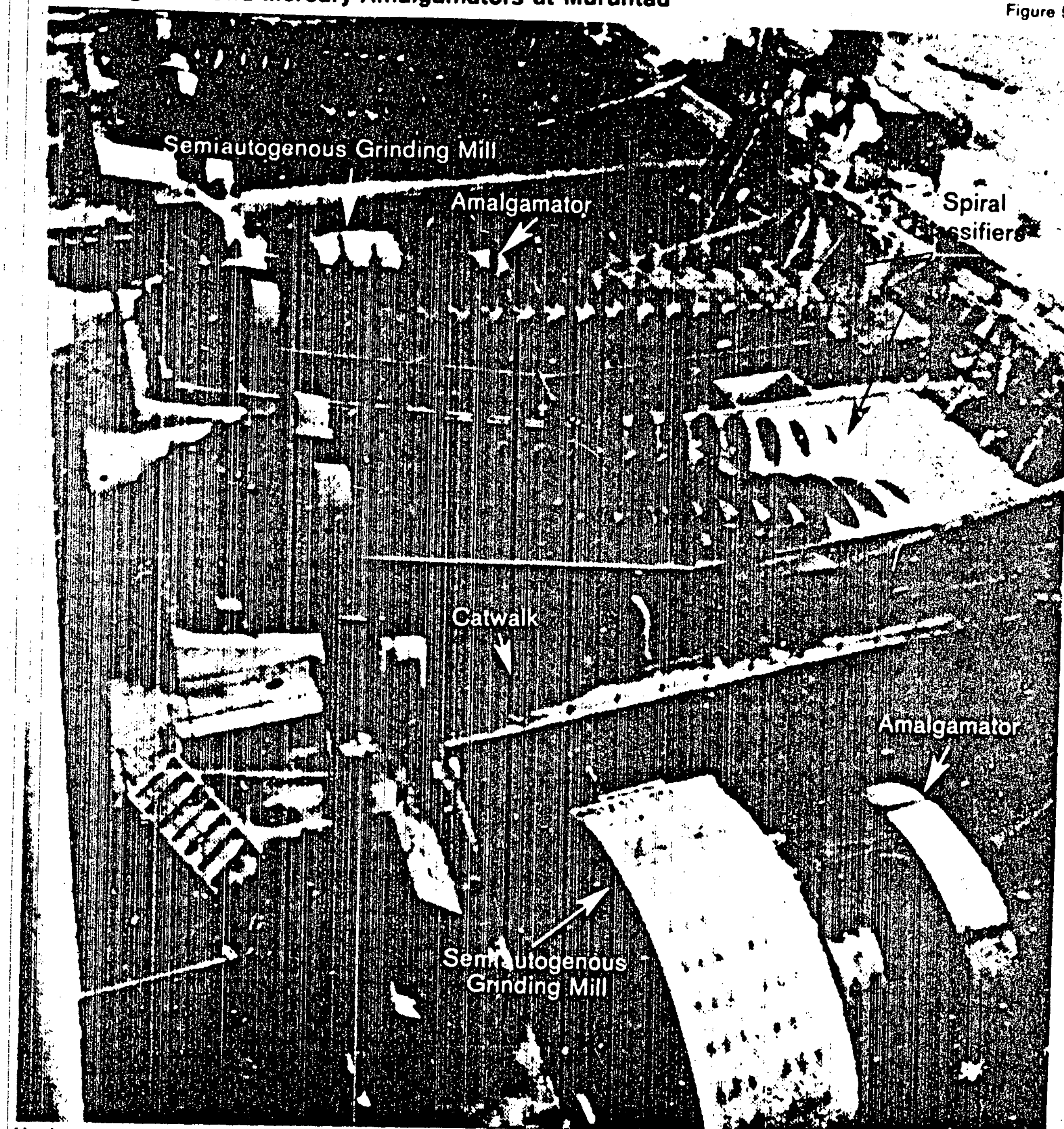
[6] 13,000 t/day per mill x 7 mills = 91,000 t/day.
13,000 t/day per mill x 8 mills = 104,000 t/day.

[7] 2,250 t/day ÷ 12,265 sq ft = 0.183 t/sq ft
0.183 t/sq ft × 21,382 sq ft × 18 thickener tanks = 70,432 t/day.

[8] I. N. Maslenitskiy and L. V. Chugaev, *op. cit.*, p. 137.

Grinding Mills and Mercury Amalgamators at Muruntau

Figure 5



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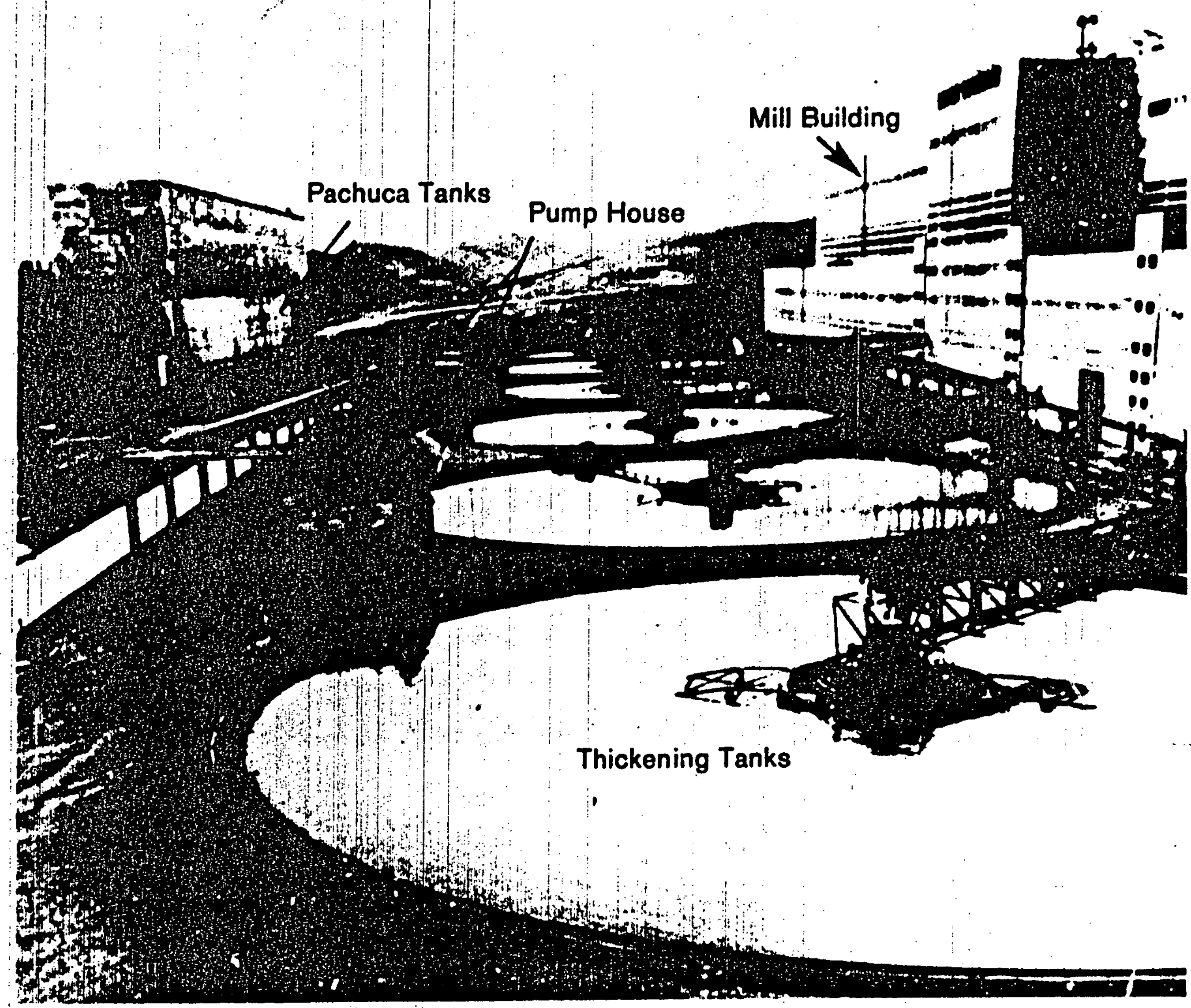
Thickening Tanks at Muruntau Figure 6



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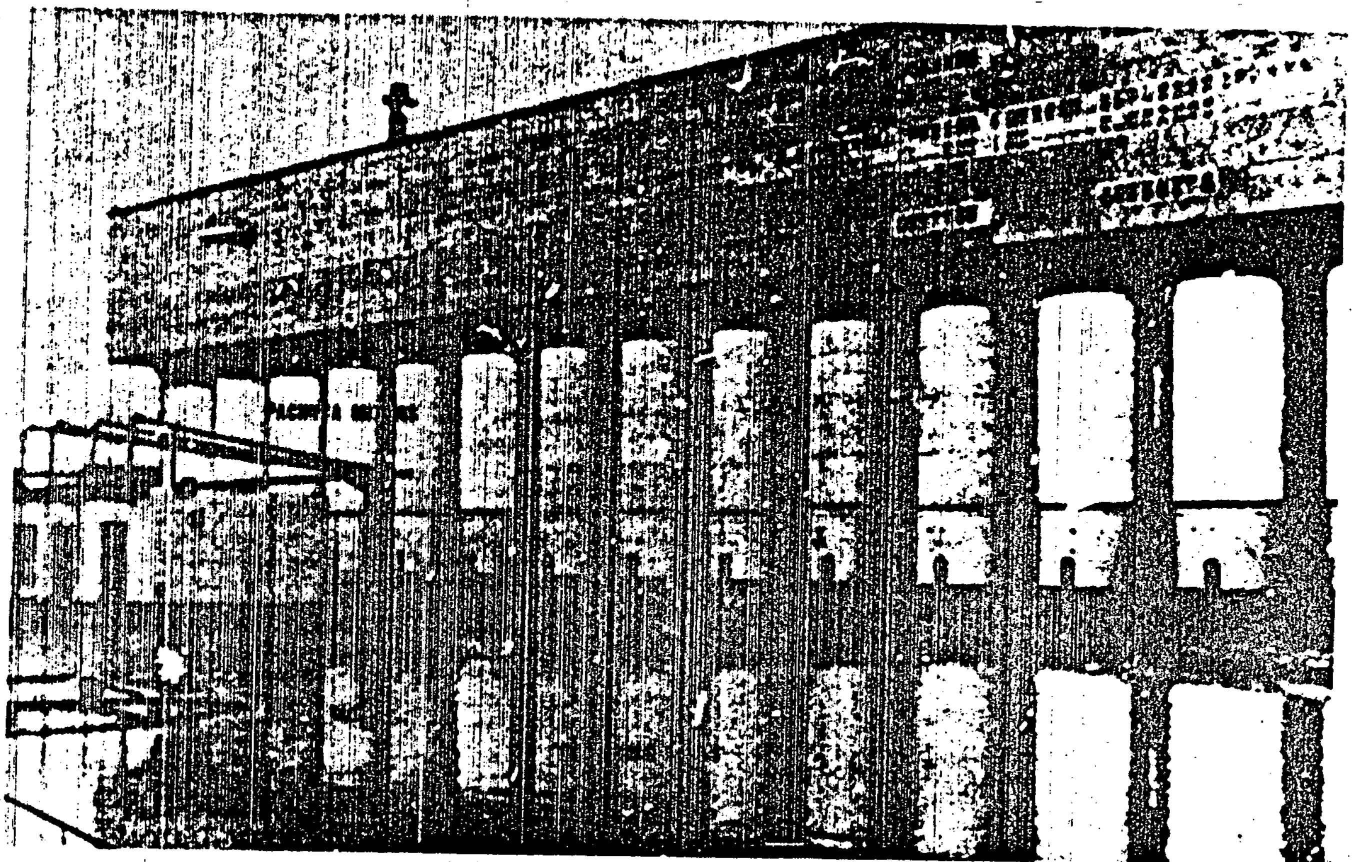
cylindrical tanks 9 meters in diameter were [redacted] colocated with the thickener tanks. [redacted] believe these tanks contain flocculants. Thus, taking the measured surface area of the thickener tanks at Muruntau and applying the variables contained in the Soviet manual, the daily capacity of the thickeners would fall within a range of about 35,000 to 96,000 tons.[9]

[9] 21,382 sq ft ÷ 22 sq ft/t/24 hrs = 972 t/tank/24 hrs × 18 thickener tanks = 17,496 t/24 hrs × 2 (effect of flocculants) = 34,992 t/24 hrs.
21,382 sq ft ÷ 16 sq ft/t/24 hrs = 1,336 t/tank/24 hrs × 18 thickener tanks = 24,048 t/24 hrs × 4 (effect of flocculants) = 96,192 t/24 hrs.

Pachuca Tanks at Muruntau

Figure 7



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It is estimated that the capacity is more likely to be in the upper half of the range of 35,000 to 96,000 tons, given the calculations of thickener capacity at non-Communist gold plants and our calculations of Muruntau's capacities at the other stages in the processing sequence.

Pachuca Tank Capacity

A total of 138 Pachuca tanks will be operational at Muruntau when construction is complete. The tanks are located in the ion-exchange building and are used for leaching and ion-exchange adsorption of the gold. Each tank measures 17 meters high and 5.5 meters in diameter with a volume of 410 cubic meters (see figure 7). [redacted] calculate that each tank could process 255 tons of ore in a 24-hour period; 138 tanks could process 35,190 tons. However, [redacted] believe that the pulp can be fully dissolved in the Pachuca tanks in a period of 10 to 14 hours (contact time). Experts reason that because the heavy gold particles have already been removed by the mercury amalgamation process, the fine gold particles remaining in the pulp would be comparatively easy to dissolve. Assuming a contact time of 10 to 14 hours, the processing capacity of the Pachuca tanks during a 24-hour period would range from 60,000 to 84,000 tons.[10]

[10] 24 hrs ÷ 14 hr contact time × 35,190 t = 60,326 t.
24 hrs ÷ 10 hr contact time × 35,190 t = 84,456 t.

At present only 102 Pachuca tanks have been constructed, thus constraining processing capacity to a range of 44,000 to 62,000 tons/day.

Power Capacity

Two electrical substations supply power to the Muruntau plant. One substation contains three transformers designed to step-down 220-volt alternating current. [redacted] two of the transformers are the Soviet TDTNG type, rated at a power capacity of 40,000 kilowatts each. The third transformer appears to be a modified TDTNG with fewer cooling radiators and a smaller oil-coolant tank. This suggests that its power capacity is somewhat less than 40,000 kilowatts. Current from the substation is carried on transmission lines to a nearby rectifier building for conversion to direct current, which is needed in the electrolytic recovery of the gold.

The second substation contains two probable Soviet TRDTsNG transformers with a Soviet-rated power capacity of 63,000 kilowatts each. This substation does not appear to be linked to the rectifier building. Instead, it probably provides alternating current for operation of plant equipment. Soviet technical manuals indicate that industrial plants involved in processes that would be severely disrupted by power interruptions are provided with a 100-percent redundant transformer capacity. Individual transformers are routinely operated at 50 percent of their rated capacity so that they will be ready to assume the additional load needed to operate the plant in the event one transformer or the other fails. Thus, the actual power used to operate equipment at Muruntau may be only 50 percent of the substation capacity of 126 megawatts, or 63 megawatts (63,000 kilowatts).

Analysis of Western gold plants processing ores similar to those at Muruntau indicates that between 15 and 24 kilowatt hours (kWh) of electricity are required to process 0.9 ton of ore. Average power consumption per ton of ore at these plants is 20 kWh. Assuming that (a) power consumption at Muruntau is comparable to average power consumption at Western plants, and (b) the transformers at Muruntau are operated at 50 to 75 percent of capacity, about 69,000 to 103,00 tons of ore could be processed each day.[11]

While the estimated range of capacity differed somewhat from process to process, all five estimates consistently covered a range of 72,000 to 84,000 tons (see figure 8). As a result, we judge that this range represents the most likely interval within which the design capacity of the Muruntau plant falls, with a best estimate of about 75,000 tons of ore per day. Given (a) an average gold content of 0.10 troy ounce, (b) a 90-percent recovery rate,[12] and (c) a 360-day work year, this equates to an output of 75 tons of gold per year.[13]

The Production Bottleneck

Despite our finding that the design capacity of the Muruntau plant seems to be roughly 72,000 to 84,000 tons of ore a day, [redacted] a significant difference between the processing capacity of the plant and the capacity of the transport system that supports it (see figure 9). Specifically, the loading and unloading areas as presently configured are major bottlenecks, having the capacity to supply only around 18,000 to 26,000 tons of ore per 16-hour day—far less than the ore-processing capacity of the plant.[14] For the rail system to meet the design capacity of the plant to process ore would require that one 80-ton rail car be unloaded every 90 seconds during a 24-hour day—a physical impossibility, given the present configuration and use of the loading and unloading facilities.

---

[11] 63,000 kW ÷ 20 kWh/ton × 24 hrs/day =
75,600 (short tons) × 0.907185 =
68,583 (metric tons) or
94,500 kW ÷ 20 kWh/ton × 24 hrs/day =
113,400 (short tons)
× 0.907185 = 102,875 metric tons.

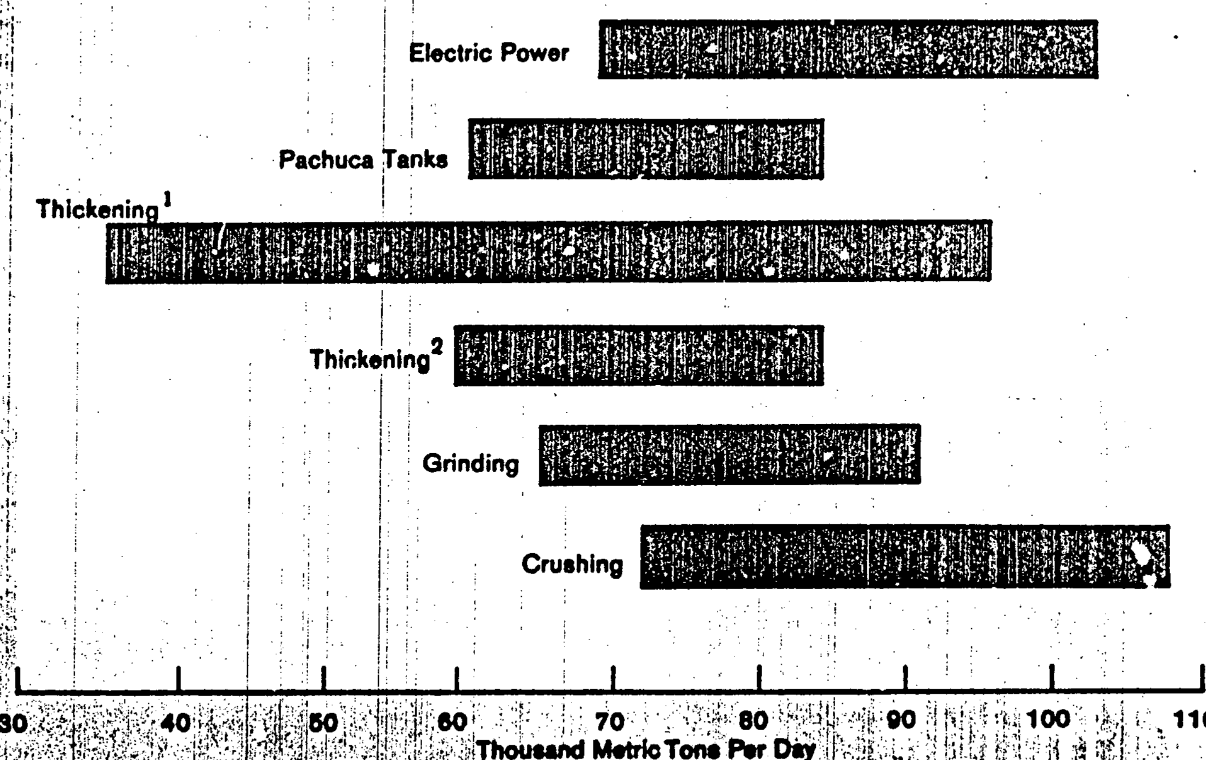
[12] The recovery rate is the amount of gold actually obtained as a percent of the amount that could be obtained if the refining process were perfect.

[13] Since construction of all facilities is not yet completed, the present processing capacity is estimated to be only 54 tons of gold per year.

[14] The transport system probably operates on a two-shift day, as do the crushers. Downstream facilities operate around the clock.

Figure 8

Estimates of Ore-Processing Capacity at Muruntau



1. Based on Soviet technical specifications.
2. Based on performance characteristics of noncommunist gold plants.

[redacted]

Ore-Loading Facilities

The ore-loading facilities at Muruntau are located 1.5 km west of the open-pit mine and consist of two broad-gauge rail spurs that connect with the main rail line to the plant, some 8 km to the west. Ore moved from this mine is transported to this area by Bel AZ-540 (27-ton capacity) or Bel AZ-548 (40 ton-capacity) trucks. Ore is then loaded onto rail cars[15] using either EKG-4.6 (10-ton capacity) or EKG-8.E (20-ton capacity) power shovels (see figure 10).

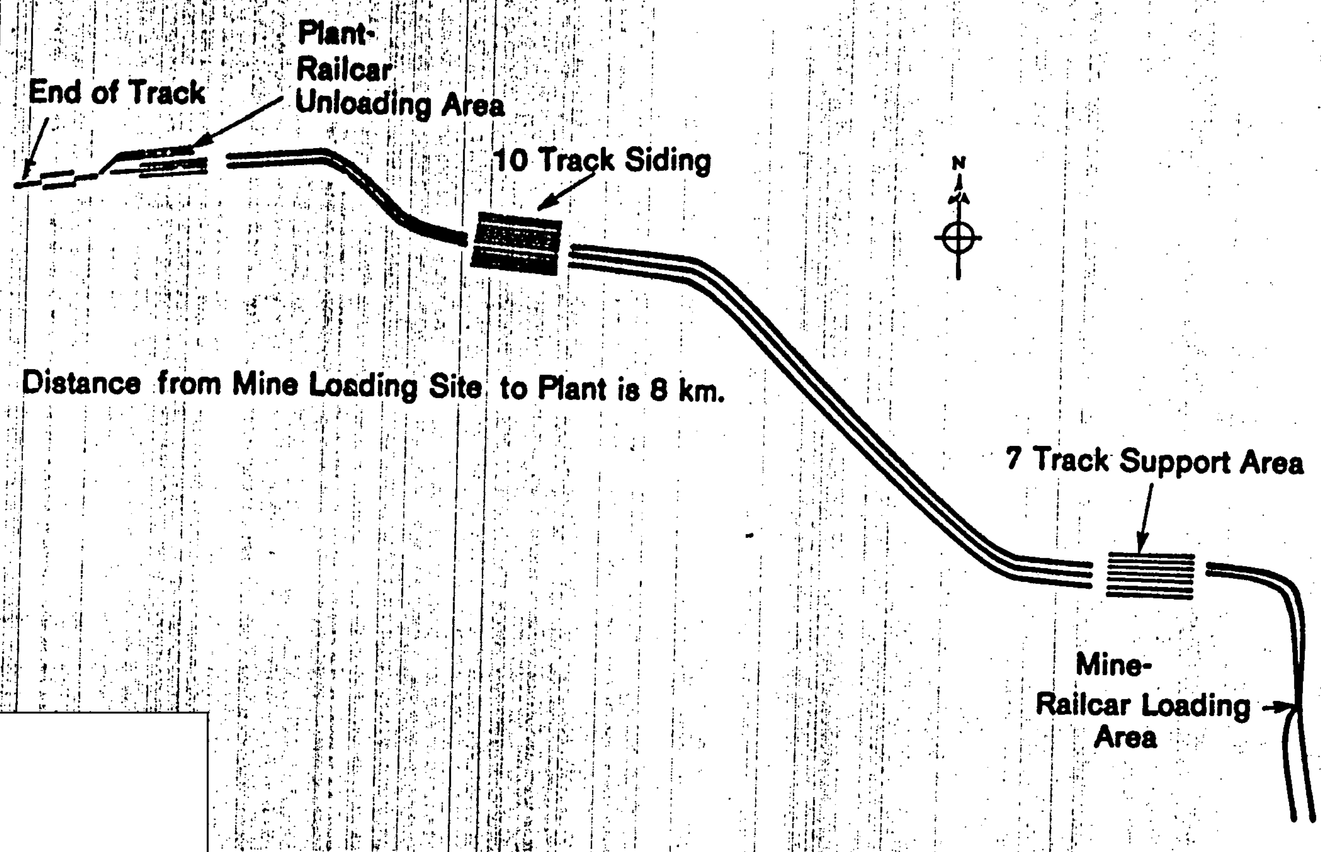
[redacted] usually only one of the rail spurs and one power shovel have been [redacted] loading rail cars at this site at any gi[redacted] time.[16] This information combined with equipment operation factors obtained from Soviet technical manuals made possible estimates of rail car loading rates.

[15] T[redacted] We have used 80 tons per rail car in our estimates.

[16] The largest number of power shovels [redacted] at the mine was 22 in June 1978,[redacted]

Rail Transport System at Muruntau

Figure 9



The output of a power shovel was determined by using the size of the bucket in cubic meters, the amount of time required to dig and unload each bucket (cycle time), and the total operating time per day. In addition, other factors such as the bucket's actual load (it is not always full), interruptions in cycle time, and the type of soil being loaded were taken into consideration to refine the output estimate. [redacted] the largest shovel, the EKG-8.E cubic-meter bucket, is used for loading, and we assume that downtime for maintenance is covered by use of another EKG-8.E shovel.

The practical hourly output of a power shovel with these factors in mind can be obtained from the following formula contained in a Soviet manual.[17]

$$Q = \frac{360\ E\ k_1\ C}{k_2 t}$$

[17] B. Boky, *Gornoye delo*, Moscow: *MIR*, 1967, pp. 548-549. K_1 equals 0.95, the filling factor for well-fragmented rock. K_2 equals 1.5, the bulking factor for soil of medium density.

Where:

Q = output per hour in cubic meters

E = bucket capacity in cubic meters

t = duration of cycle in seconds

3,600 = seconds per hour

k_1 = filling factor of the bucket

k_2 = bulking factor of the soil

C = time-use factor of the excavation; for filling cars it is 0.55-0.90 to account for spillage. In this estimate, we use the midpoint of 0.725.

Thus:

$$Q = \frac{(3600) \quad (8) \ (0.95) \ (0.725)}{(1.5) \ (30)}$$

$$Q = \frac{19836}{45} = 441 \text{ cubic meters per hour}$$

At 2.5 tons of gold ore per cubic meter (a standard engineering conversion), this power shovel output suggests a capacity to load about 1,100 tons of ore per hour or about 17,600 tons of ore per 16-hour day. This could easily be increased, however, by using both tracks at once and adding more power shovels.

Unloading Facility

The unloading facility at Muruntau is the major bottleneck restricting ore deliveries to the quantities supplied by only one power shovel loading onto one rail car at a time. Until May 1978, the plant had only one unloading pit 15 meters long served by two tracks. Since the second ore unloading facility just came on stream in May 1978, we have not considered it in our estimates of past production

railroad engineers estimate that it would take each side-unloaded car three to four minutes to complete the unloading cycle at the plant. This includes getting the cars positioned, unloaded, repositioning the carriage, and moved to allow another car to unload. This is long by US standards but reflects the fact that the size of the ore-loading pit is almost the same as the length of the rail cars. This means that each car has to be positioned exactly before unloading to avoid spills that could increase downtime at the pit.

We estimate that in a 16-hour day, 320 cars could be unloaded with a three-minute turnaround, and 240 cars could be unloaded with a four-minute turnaround. Assuming each car carries 80 tons of ore, this equates to 25,600 tons per day and 19,200 tons per day, respectively.

As a cross-check on these figures, we examined the volume of waste in the waste ponds south of the plant. The four manmade waste ponds (see figure 12) contain an estimated 43 million tons of waste, all of which has accumulated over the last nine years. Dividing the figure by nine years or 3,285 days yields a throughput of around 13,000 tons a day—much more in line with the transport delivery capability than the plant's processing capacity. An additional waste pond exists in the desert 25 km to the southeast. This pond has been used for the past two years, but measurements [redacted] are not possible since the waste is being dumped free-form in the desert. Since each of the other four waste ponds took 18 to 24 months to fill, however, we estimate that the waste in this pond represents 25 percent of the total waste in the four manmade ponds. The total volume of waste equates to a throughput of 16,000 tons of ore a day.

Because the estimated throughput of ore ranges from a low of 16,000 tons per day (based on waste deposits) to a high of 25,600 tons per day (based on a three-minute unloading time), we judge that ore deliveries probably have averaged about 20,000 tons per day. This is equal to 20 tons of gold per year using the assumptions already specified regarding the gold content of the ore, the recovery rate, and the length of the workyear.

Between the start of operations in 1969 and the end of 1972, unloading capacity of 20,000 tons of ore per day was not significantly below the 25,000-ton capacity of processing facilities. Between 1973 and mid-1975, however, processing capacity grew from 25,000 tons per day to about 54,000 tons, but ore-unloading capacity remained at 20,000 tons until mid-1978. The second ore-unloading facility, installed this year and which doubled Muruntau's capacity to unload ore, gives the plant a maximum output of about 40 tons of gold per year, still well below its processing capacity. To operate Muruntau at or near its design capacity, the Soviets will have to install at least two more unloading points using the existing rail transport system or move part of the ore by trucks. We have no evidence that they have done either.

Possible Explanations of Unbalanced Muruntau Expanison

We do not know why the Soviets have not expanded ore-unloading facilities in tandem with the ore-processing facilities. We can think of a number of explanations but have no hard evidence to support any of them. One possibility is that the Soviets have encountered technical problems in the refining processes that limited production and delayed the need for expanded ore-unloading facilities.

- Moscow recently criticized the Ministry of Chemical Industry for not producing sufficient amounts of chemicals used in the refining process at Muruntau. The Soviets reported that shortages of chemicals (ion-exchange resins and flocculants) were hampering gold production at plants using Muruntau's technology.[11]
- [redacted] gold production at [redacted] (a plant which uses the same refining process as Muruntau) fell short of planned output in 1977, thereby suggesting a nationwide shortage of chemicals.

Moreover, we cannot overlook the possibility that the gap between unloading capacity and processing capacity has been the result of a different kind of bureaucratic bungling. Soviet ministries are notorious for their lack of coordination when given responsibility for different parts of the same construction project. As a result, large new facilities often stand idle for lack of raw materials or critical components.

A change in Soviet gold sales policy may also have slowed the growth of gold production at Muruntau; requisite chemicals could have been imported and/or additional unloading points constructed sooner had the USSR attached a higher priority to domestic gold production in the early 1970s. In all likelihood, the USSR—with

[11] *Khimicheskava promyshlennost*, 12, 1977, p.7.

its substantial gold reserves and cautious sales policy—had no pressing need for additional gold production.

Following heavy sales in the early 1960s, the USSR withdrew from the gold market during 1966-71. Annual sales to the West fell from an average of 450 tons in 1963-65 to an average of 23 tons in 1966-71. The Soviet decision to resume substantial gold sales apparently came late in 1971. By this time reserves had been substantially rebuilt, and gold prices had begun their upward movement following the Smithsonian accords.

The USSR followed a relatively cautious gold sales policy in 1972-75. Except for 1973, when heavy gold sales were required to meet grain import requirements, Soviet gold production outpaced sales (see table 1). Estimated gold reserves at the end of 1975 were slightly above their 1971 yearend level.

During this period the USSR probably was loath to increase gold sales markedly at the risk of adversely affecting gold prices. Moreover, the availability of Western credits in the early 1970s provided a relatively costless alternative means of raising needed foreign exchange. Under these circumstances Moscow appeared under little pressure to expand domestic production.

By the end of 1975, Moscow's attitude regarding sales strategy had apparently changed. The rise in Soviet indebtedness increased the cost of borrowing and raised questions in the West regarding Soviet ability to manage its balance of payments. Western recession demonstrated Soviet vulnerability to Western market conditions in marketing exports. Thus, it appears, in retrospect, that the USSR may have decided to increase its reliance on gold in managing its balance of payments. Annual sales targets in 1975-78 were raised well above previous levels. Soviet gold sales (660 tons in 1976-77) substantially exceeded production in the last two years and are expected to do so again in 1978.

Outlook for Production and Sales

With the recent expansion of the ore-unloading facilities, we estimate that annual gold production at Muruntau will climb to about 30 tons in 1978 and 40 tons in 1979 and 1980. Given likely increases in other parts of the country, total Soviet gold production probably will not

Table 1

USSR: Production and Allocation of Gold

Metric Tons

	1969	1970	1971	1972	1973	1974	1975	1976	1977
Previous CIA estimates									
Total production	191	203	222	258	265	275	303	351	370
Muruntau	1	5	20	45	45	45	80	110	120
Other	190	198	202	213	220	230	223	241	250
Domestic consumption	37	39	30	40	41	42	43	45	46
Sales	0	3	19	158	304	131	147	328	332
Yearend reserves	1,376	1,537	1,701	1,761	1,681	1,783	1,896	1,874	1,867
Revised CIA estimates									
Total production	191	203	212	233	240	250	243	261	270
Muruntau	1	5	10	20	20	20	20	20	20
Other	190	198	202	213	220	230	223	241	250
Domestic consumption	37	39	39	40	41	42	43	45	46
Sales	0	3	19	158	304	131	147	328	332
Yearend reserves	1,376	1,537	1,691	1,726	1,621	1,696	1,749	1,637	1,529

exceed 310 tons by 1980, about 20 percent lower than we previously believed. If the Soviets are able to operate the Muruntau plant at or near capacity, total Soviet gold production could increase to 350-375 tons per year by the mid-1980s. (See appendix B for the methodology used to estimate gold production in regions other than Muruntau).

The revised estimate of gold production at Muruntau has caused us to reduce our estimate of Soviet gold reserves as of yearend 1977 from 1,865 tons ($12 billion at $200 an ounce) to about 1,530 tons ($10 billion). We now estimate that since the resumption of large gold sales in 1976 the Soviets have drawn down their gold reserves by about 200 tons to meet hard currency requirements. In 1976-77 Moscow earned almost $3 billion from gold sales. Moscow sold about 334 tons of gold valued at nearly $2.1 billion during the first nine months of 1978. Sales this year could reach 400 tons, yielding more than $2.5 billion.

The drawdown on reserves is of little immediate importance for the Soviet hard currency position. With $9.8 billion in gold reserves and annual gold production valued at about $1.7 billion, availability of gold for export is not likely to constrain imports much in the near term. In the next few years, however, falling Soviet oil production is expected to cut into Moscow's hard currency earnings; this will probably intensify pressure to expand gold sales to the West. At some point, Moscow will have to tie its sales more closely to current production in order to maintain reserves at an acceptable level.

APPENDIX A

DESCRIPTION OF FACILITIES

The Muruntau complex consists of mines, processing facilities, a refinery, a laboratory, a rail and road transport system, and a truck motor pool. In addition, there are maintenance facilities, power supply facilities, an administration building, two separate housing compounds for military and prison labor, a chemical storage area, a few ancillary buildings that have not yet been identified, and a waste disposal area.

The open-pit mine covers a surface area of about 230 hectares and has a maximum depth of about 140 meters. [redacted] 22 excavators were operating in the mine. Piles of displaced overburden cover an area of about 400 hectares [redacted]

An underground mine is under construction roughly 1 kilometer from the open-pit mine and will begin operations at a depth of 460 meters. This mine does not yet appear to be in operation. An article published in *Ogonyok* indicated that several underground mines eventually will be built at Muruntau, but there is no firm evidence that development of more than one underground mine is under way.

The Ore Deposit

Intensive geological prospecting of the Kyzylkum desert began in 1957 and continued through at least 1968. The decision to build the Muruntau plant apparently was based on estimates made during the early 1960s of gold in surface deposits. Exploration during 1966-68 revealed that vast reserves also existed at depths up to 2,100 meters below the surface. This ore reportedly has a higher gold content than the ore at the surface. Although data on the size of total reserves have not been published, the Soviets reported officially in 1969 that reserves were twice as large as originally believed.[19] Soviet publications have indicated that the Muruntau deposit is one of the world's largest, with proved reserves that will last at least several decades.[20]

The Muruntau formation is a low-grade deposit in which gold appears in quartz veins,[21] similar to the Australian gold deposits at Ballarat and Castlemine and to the Homestake deposit in South Dakota. Experts [redacted] estimate the average gold content of the Muruntau deposit at 0.10 ounce per ton, based on detailed Soviet studies of the geochemistry of the Muruntau deposit.[22] Their analysis is consistent with Soviet reports indicating that where favorable mining conditions exist, such as those at Muruntau, deposits with ore grades of 0.10 ounce per ton are being commercially exploited. An ore grade of 0.10 ounce per ton is about one-half the average grade of ores currently being mined in the United States and South Africa.

Processing Facilities

The processing plant is located about 8 kilometers west of the open-pit mining area and is connected to the mining area by a rail shuttle. The plant covers a surface area of about 60 hectares and consists of four major production facilities [redacted]

[19] *Pravda*, 4 August 1969, P. 3.

[20] N. A. Vykhover, *Ekonomika mineralnogo syrya*, Moscow: Nedra, 1969, p. 222.

[21] According to the US Geological Survey, the deposit is described technically as quartz-pyrite-arsenopyrite.

[22] We previously estimated the average gold content of the ore at 0.15 troy ounce per ton. Indeed, some [redacted] experts believe that the irregular shape of the mine indicates that the Soviets have selectively mined the ore deposit, a technique called "high grading"—extracting the richest ores first in order to achieve a higher level of output from smaller quantities of ore. Nevertheless, these experts are convinced that the total quantity of ore removed to date would yield an average gold content of 0.10 ounce per ton.

[redacted]

- *A mill*, 670 meters in length, grinds the ore; primary crushing is performed underground before entering the mill. The mill also sizes and sorts the ore to ensure a uniform feed mixture prior to final refining. The mill is equipped with amalgamators that recover the heavy gold nuggets. The mill building appears to be completed, although we do not know whether it has been completely outfitted with machinery and equipment.
- *A thickener area* of 18 tanks, each 50 meters in diameter, develops a viscous solution. Construction in this area was recently completed.
- *An ion-exchange building* housing cylindrical tanks—called Pachuca tanks—extracts the gold. At present, 102 Pachuca tanks are installed and work is under way on putting the final 36 tanks in place.
- *A refinery*, 120 meters in length, is used in the final stages of purification. The refinery was completed in the early 1970s.

The pace of construction suggests that the processing facilities should be completed in 1979-80.

Muruntau is the largest investment project ever carried out in the Soviet gold industry and probably the most expensive undertaking by any gold industry in the world. industry experts estimated that if this investment, including infrastructure, were undertaken in the United States, it would cost about $1 billion (in 1978 dollars). The most expensive part of the project, the processing facility, probably would cost about $500 million. This is roughly three to five times the capital valuation of the largest gold plants in South Africa and the United States. The remaining $500 million represents costs such as the water supply system, road and rail transport, the construction of the nearby city of Zarafshan, and related ancillary costs such as the geological survey and development of the open-pit and underground mine.

The capital investment at Muruntau can also be inferred roughly from published Soviet literature. In 1973 the Soviets reported that the total capital investment at the Zod plant (a new gold plant in Armenia) amounted to 160 million rubles.[23] According to ruble-dollar ratios calculated in a previous CIA study, the published ruble investment figure would equate to about $220 million in 1970 prices or about $400 million in 1978 prices. The Zod plant is considerably smaller than the one at Muruntau, in terms of both size and estimated capacity, and is located in a region of the USSR where construction costs are less.

[23] Summary of World Broadcasts, 20 April 1973.

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APPENDIX B

BASIS FOR CIA ESTIMATE OF SOVIET GOLD PRODUCTION AT LOCATIONS OTHER THAN MURUNTAU

Total Soviet gold production is the sum of (a) mined gold and (b) gold recovered as a byproduct in the refining of copper, lead, and zinc.

Mined Gold

The *Northeast Region*, consisting of the Magadan Oblast and the Yakutsk ASSR is the largest gold producing region in the USSR (see table 2). [redacted] Estimates of gold production in the Northeast Region are based [redacted]

The estimate of gold production in the *Lena Gold Trust* (Irkutsk Oblast) is based on the reporting [redacted]

Table 2

USSR: Revised Estimates of Gold Production, by Region

Metric Tons

	Total	Northeast Region [1]	Muruntau	Lena Gold Trust	Byproduct Recovery [2]	Other Mined Gold [3]
1957	94	48	0	7	14	25
1958	97	50	0	7	14	26
1959	105	55	0	8	15	27
1960	110	58	0	8	17	27
1961	118	62	0	8	18	30
1962	126	68	0	9	19	30
1963	134	71	0	10	21	32
1964	144	77	0	11	23	33
1965	154	86	0	11	24	33
1966	165	92	0	11	26	36
1967	172	96	0	11	28	37
1968	182	99	0	11	32	40
1969	191	105	1	11	33	41
1970	203	109	5	11	36	42
1971	212	108	10	11	38	45
1972	233	112	20	12	40	49
1973	240	115	20	12	42	51
1974	250	120	20	13	44	53
1975	243	113	20	13	46	51
1976	261	128	20	13	47	53
1977	270	133	20	13	49	55

[1] Consisting of the Magadan Oblast and the Yakutsk ASSR.
[2] Gold recovered as a byproduct of copper refining.
[3] Gold produced in Kazakhstan, Amur Region, the Transbaikal, and other scattered locations in the USSR.

[redacted] gold production in the Lena [redacted] to about 11 tons per annum during 1967-69 and that output was not expected to increase significantly in the foreseeable future.

The estimate of mined gold production in other parts of the USSR is based on two Soviet reports [redacted] that indicated that the Northeast Region accounted for about 60 percent of the USSR's production of mined gold at that time. Production in the Northeast Region amounted to 48 tons in 1957. Hence, total Soviet mined gold production probably was 80 tons in that year, of which other areas accounted for about 32 tons.[24]

Since the late 1950s, little information has been available on gold production in these other areas. In the absence of such intelligence we have simply increased our estimate of output in these areas at about the same rate that production has been increased in older mining areas in the Northeast Region. This estimate is, of course, tenuous at best. We are currently reassessing available data on the 14 gold processing plants other than Muruntau and those in the Northeast Region and the Lena Gold Trust. When this study is completed, we may revise our current estimate. Preliminary analysis of five of the largest of these 14 Soviet gold plants suggests that their combined output probably is 25 to 30 tons per year. Thus our overall estimate of gold production in other regions of the USSR—56 tons in 1977—may be of the right order of magnitude.

[24] Previously, reporting for the Lena Gold Trust was included under other areas. Since information on gold production in the Lena Region has become available, we have listed the Lena Region separately and have adjusted our estimates of gold production in other areas accordingly.

Gold Recovered as Byproduct

To estimate the amount of gold recovered in the processing of copper, lead, and zinc, an average factor was developed for the recovery of gold per ton of refined copper at each copper refinery in the USSR. The average recovery factor for each refinery was weighted according to its estimated share of total Soviet output of refined copper. The overall factor was then adjusted upward slightly to allow for the small amount of gold that is recovered in the processing of lead/zinc ores. We estimate that on the average the Soviets recover 35 grams of gold (slightly more than one troy ounce) per ton of refined copper. The USSR produced an estimated 1.4 million tons of refined copper in 1977, which would yield an estimated 49 tons of gold.

Top Secret

[redacted]

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