

## **MEMORANDUM**

**TO:** John Stard - Mine Manager: Giant

**FROM:** Erik Madsen - Environmental Superintendent

**DATE:** November 15, 1995

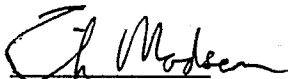
**RE: SUBMISSION TO ENVIRONMENT CANADA - ROASTER EMISSIONS**

Please find enclosed for your information and records a copy of the report submitted to Environment Canada.

I guess now we wait until the next step. This Regulatory Committee will digest this report and possibly request further information and potentially come up with "Draft" Regulations regarding arsenic levels from the roaster. Ed Collins with Environment Canada stated he would keep us informed of their progress.

In the mean time, we should seriously consider collecting more than one set of stack samples next year in order to obtain a statistically correct value of the levels exiting the roaster. Levels exiting the roaster change from day to day depending on the mill feed as well as a number of other parameters. One sample a year does not provide an accurate representation of the levels to ensure that we can comply with what ever regulation is decided upon.

Should you have any questions, or comments feel free to call me at ext. 136.



Erik Madsen

c.c. Phil McIntyre - Mill Superintendent: Giant  
Larry Connell - Kirkland

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### **APPENDIX**

- o October 16, 1995 Letter from Rosemount.
- o August 8, 1995 letter from AEM Systems Inc.
- o Baghouse Maintenance Record .
- o Map - S-92-1: Giant Mine Surface Plan

## **INFORMATION REQUEST REGARDING ARSENIC**

### **1) GENERAL DESCRIPTION OF ROYAL OAK GIANT MINE**

#### **Introduction:**

The Giant Mine is located just north of the city of Yellowknife in the Northwest Territories. The property was discovered in 1937 and commenced production in 1947. Previous owners include Falconbridge Nickel Mines Limited and Pamour Resources Limited. Royal Oak Mines has owned and operated the mine since 1990. The head office for Royal Oak Mines Inc is located in Kirkland, Washington.

The discovery and development of the Giant Mine has made the town of Yellowknife a familiar name the world over, and has contributed to the jobs and the resources which support and encourage the growth the city has encountered over the past 48 years.

The attached map appended to this report (S-92-1: Giant Mine Surface Plan - General Minesite Layout) displays the lease boundaries for the Giant Mine Property. The Giant Mine site is on Commissioner's Land, meaning that a Land Lease (#L-3668T) for the site has been issued by the GNWT's Department of Municipal and Community Affairs.

#### **Milling, Roasting, and Smelter Operations - Processing Description:**

Gold present in the Giant ore is associated with the arsenic bearing sulphide mineral, arsenopyrite. The ore is refractory, meaning that the arsenopyrite mineral structure must be broken down and oxidized to allow the effective recovery of the contained gold. The arsenopyrite and other sulphide minerals are first concentrated by flotation. The flotation concentrates are then roasted and leached in cyanide to achieve an overall gold recovery of 87.5%. The milling capacity of the ore processing plant at the Giant Mine is 1300 tons per day with a roasting capacity of 200 tons per day of flotation concentrate.

A simplified mill flowsheet is shown in Figure 1.0.

Run of mine ore is crushed underground in a primary jaw crusher and then hoisted to surface through "C" shaft to a surface coarse ore storage bin. Additional ore is truck hauled to surface through several underground ramp systems. The combined ore is then crushed and screened at a three stage surface crushing plant with minus 3/8 inch material being conveyed into the mill fine ore storage bins. Ore is drawn off the mill storage bins into two parallel primary grinding lines each consisting of an 8' diameter x 10' long ball mill working in closed circuit with a spiral classifier. Water is added to the ore at the feed end of the two ball mills. The spiral classifier is a particle sizing device using the size and specific gravity of the ground ore particles to separate fine particles from coarse particles. The coarse particles are returned to the primary ball mill to be ground again while the fine particles overflow the spiral classifier. The combined overflows from both spiral classifiers is then screened to remove wood chips and other debris that may interfere with later process equipment.

The screened classifier overflow is then subjected to a processing step called flotation where under controlled conditions the sulphide minerals are separated from the ground ore slurry. The sulphide minerals contained in the Giant ore are primarily arsenopyrite and pyrite. The surface of these sulphide minerals is coated with copper sulphate which is added at the feed end of the ball mill. The copper ions selectively coat the sulphide minerals surfaces. A chemical flotation collector called xanthate is added at the classifier overflows and attaches itself to the coated sulphide mineral. The xanthate has a high affinity for air which is bubbled through the flotation cells. A commercial frothing agent called Dowfroth is added to the slurry at the chip screen and provides a strong stable froth when air is bubbled through the slurry. The xanthate and the attached sulphide minerals attach themselves to these air bubbles and float to the surface of the flotation cell. At the surface of the flotation cell, this sulphide mineral rich froth is skimmed into a concentrate launder and collected for further processing.

The flotation circuit is broken into two sections set in series. The first section is called the rougher circuit. Material that did not float off in the rougher circuit is reground in two parallel regrinding circuits each consisting of a ball mill working in closed circuit with a set of cyclone sizing devices. The fine particles contained in the cyclone overflow from these two regrind circuits are combined and subjected to a second flotation circuit called the scavenger circuit. Additional copper sulphate, xanthate, and Dowfroth are added to the regrind circuits.

The flotation circuit is essentially a pre-concentrating step enabling Royal Oak to recover 95 % of the gold contained in the 1300 tons per day of ore milled into a sulphide mineral concentrate that weighs 200 tons per day. The remaining 1100 tons per day containing 5 % of the gold are rejected to the tailings impoundment area as what are called flotation tailings.

The flotation concentrates from both the rougher and scavenger circuits are combined and dewatered in a circuit using a dewatering cyclone and a thickener. The water is returned to the grinding circuit as a recycle stream. The principal gold bearing mineral contained in this flotation concentrate is arsenopyrite, which is an arsenic - iron sulphide. The gold is interstitially locked inside the arsenopyrite mineral matrix making it resistant to recovery without first destroying the arsenopyrite structure, hence the term refractory gold. The breakdown of the arsenopyrite mineral matrix is accomplished in a two stage fluid bed roaster at high temperature (925° F). The flotation concentrate is thickened to a density of 75 % solids and then sprayed into the first stage of the roaster. The sulphur contained both in the pyrite and arsenopyrite is oxidized through contact with air blown through the tuyeres at the bottom of the roaster generating the heat which fuels the process. The atmosphere inside the first stage roaster is kept as close as possible to a reducing atmosphere (no residual oxygen). The arsenic contained in the arsenopyrite is oxidized and fumed off as gaseous arsenic trioxide. The remaining sulphide mineral is transferred into the second stage of the roaster and again oxidized at elevated temperature (925 ° F) driving off the sulphur contained in the arsenopyrite and pyrite as gaseous sulphur dioxide.

The off gasses from the two stages of roasting are combined, cycloned to remove coarse entrained dust particulate and then passed through an electrostatic precipitator. This electrostatic precipitator

uses electrical energy to charge the fine particles of entrained dust contained in the roaster off gas and then to remove these particles from the gas stream by collecting them on oppositely charged rods. The dust collected in these precipitators is slurried with water and processed to recover the contained gold.

The tail gas from the precipitator is cooled by mixing the off gas with large volumes of outside air. As the gas cools arsenic trioxide condenses from the gaseous state to the solid state. This arsenic trioxide dust is then filtered from the gas stream in a baghouse style dust collector. The remaining gas stream which is a dilute mixture of sulphur dioxide and air passes through the baghouse fabric dust collection bags and is exhausted to the atmosphere through a 150 foot high stack. The arsenic trioxide dusts collected in the baghouses are pneumatically conveyed into specially prepared vaults located underground. These vaults are isolated from the mine workings and are built in permafrost so that the arsenic trioxide dust will freeze. These storage vaults are excavated in competent waste rock, sealed with concrete bulkheads and then frozen using cold winter air.

The material left after roasting the flotation concentrates is called calcine. Roaster calcines are the gold bearing remains of the pyrite and arsenopyrite after the majority of the sulphur and arsenic have been driven off as a gas. These calcines consists of iron oxides, principally hematite and magnetite. The roaster calcines are water quenched and then ground in the two ball mills which work in closed circuit with cyclones. The ground calcines are water washed in a thickener to remove excess acidic water and to increase the slurry density for subsequent gold leaching. The wash thickener overflows are rejected to the tailings impoundment area. The regrind breaks down the size of the iron oxides contained in the roaster calcine exposing the contained gold for later recovery using lime and sodium cyanide.

The alkalinity of the washed calcine is then pH adjusted to 11.0 using lime. Sodium cyanide solution is added to the calcine. The contained gold is then leached from the calcine by the cyanide in a two stage agitated leach circuit. The gold is dissolved into solution as a gold cyanide complex. After the first stage of leaching, the calcine is partially dewatered in a thickener. The dewatering solution contains dissolved gold and is thus recovered for subsequent recovery. Fresh cyanide solution is added to the thickened calcine which in turn is leached in a second stage of agitated leaching. Again the slurry from the second stage leach is dewatered in a thickener with the solution recovered for subsequent processing. Thickened slurry is then filtered to remove all gold bearing solutions which are again recovered for subsequent processing. The filtered solids are called the calcine residue and are rejected to the tailings impoundment area.

All of the gold bearing solutions (pregnant solutions) recovered from the calcine leach circuit are combined and then filtered in a leaf clarifier using canvas bags coated with diatomaceous earth. The clean pregnant solution is then deoxygenated in a Merrill Crowe Tower. Zinc dust is added to the deoxygenated solution allowing the gold cyanide complex contained in solution to "precipitate" onto the zinc dust (actually a plating reaction). The zinc dust is then filtered from

the solution using a filter press. Lead nitrate is added to the pregnant solution at the clarifier to enhance the precipitation of gold onto the zinc dust by complexing competing ionic species.

The gold bearing filtered zinc dust is periodically removed from the press and melted to form a gold dore bullion. The solution that passes through the presses is returned to the circuit as barren solution. The barren solution is recycled to the leach circuit to make effective use of the contained unreacted cyanide. A portion of the barren solution is bled to the tailings impoundment area to control the buildup of impurities that inhibit the cyanide dissolution of gold.

A more detailed mill process flowsheet is presented in Figure 2.0. The location of all reagent addition points are included on this drawing. As well, mill process flowsheets are included for the following circuits:

- I) Grinding - Flotation Circuit;
- ii) Roaster Calcine Leach Circuit;
- iii) Roaster Dust Treatment Circuit; and
- iv) Roaster Gas Cleaning Circuit.

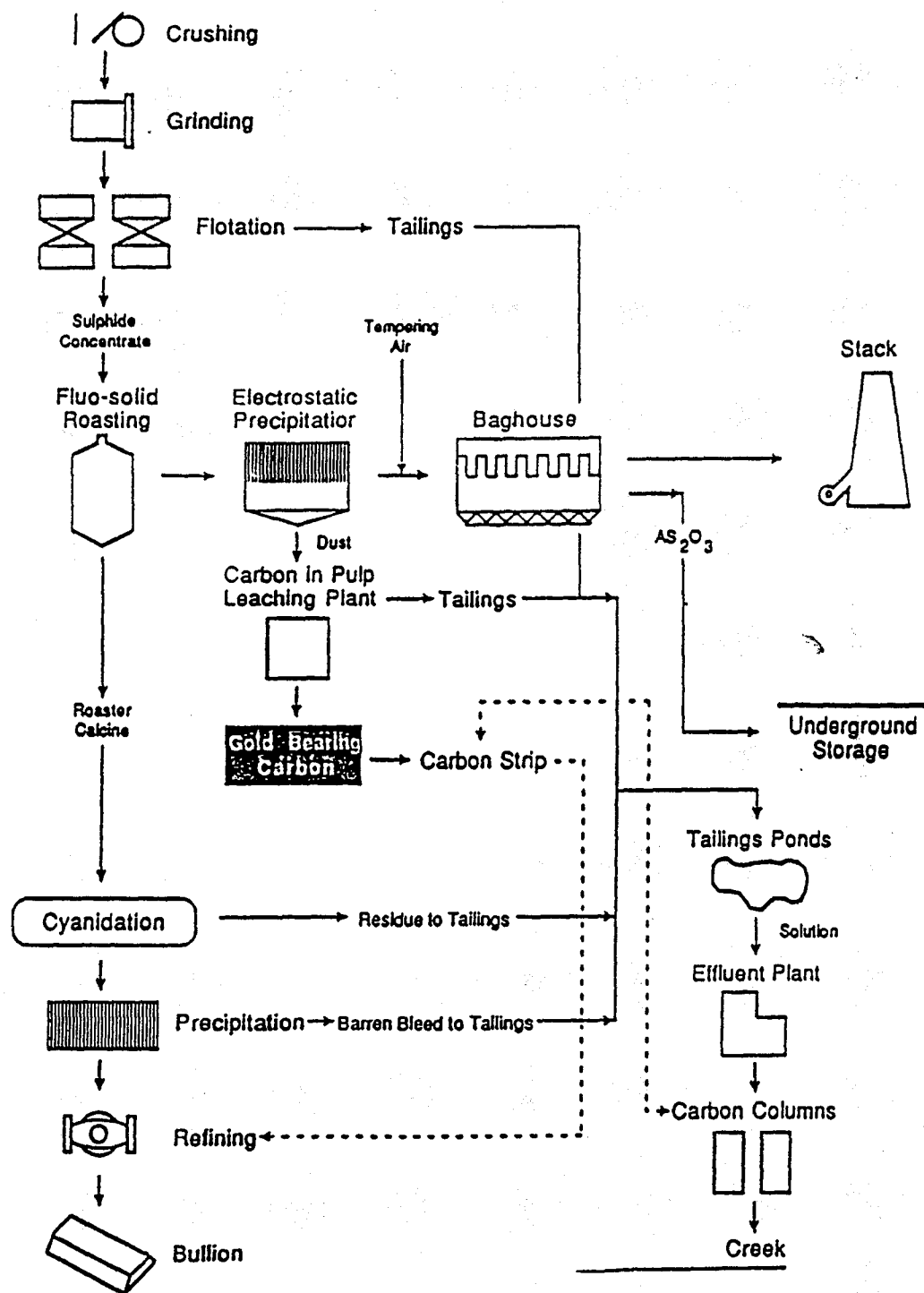
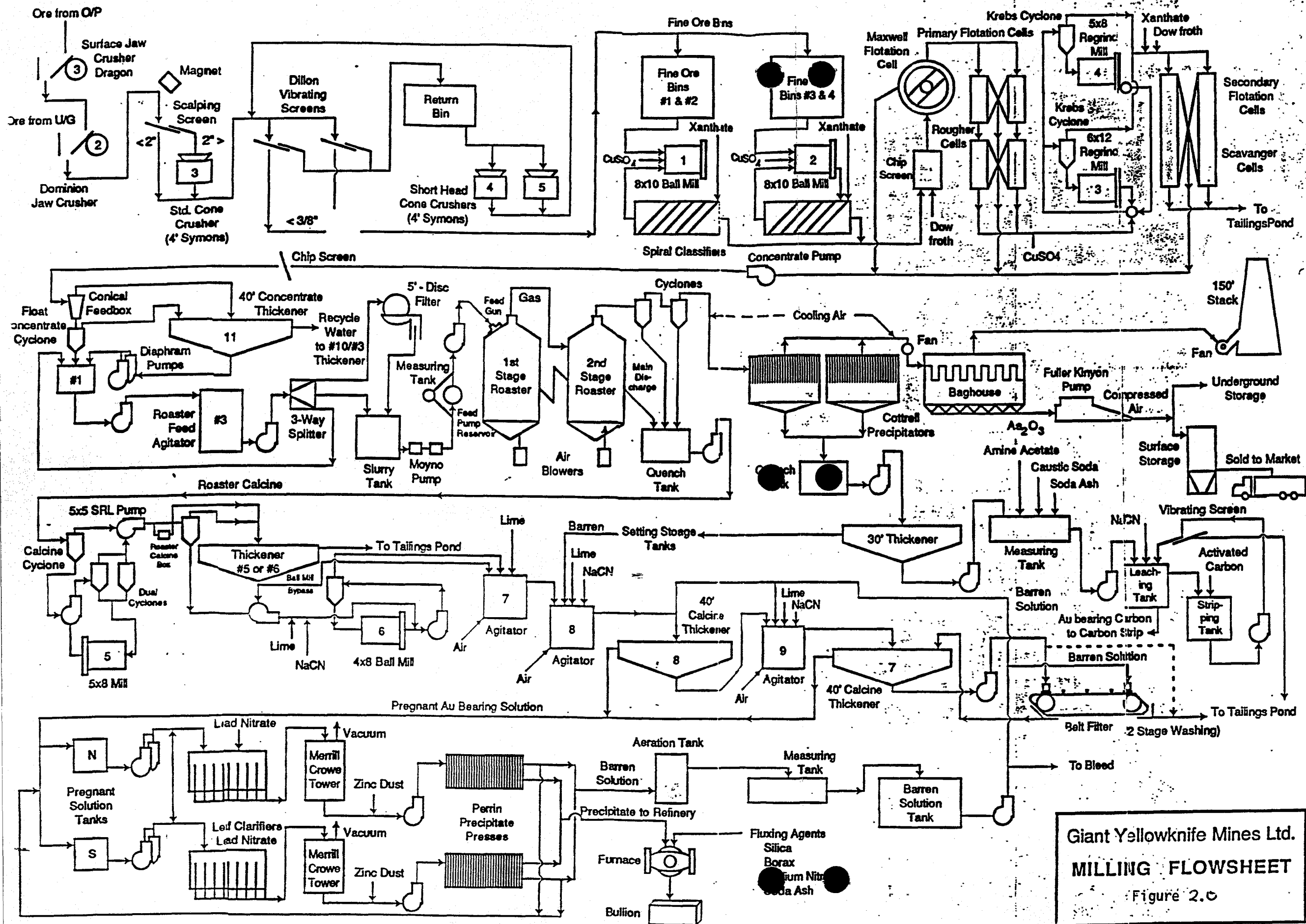


Figure 1.0 Giant Mine - Simplified Mill Flow Sheet



**Giant Yellowknife Mines Ltd.**  
**MILLING FLOWSHEET**  
Figure 2.c





**Royal Oak Mines**

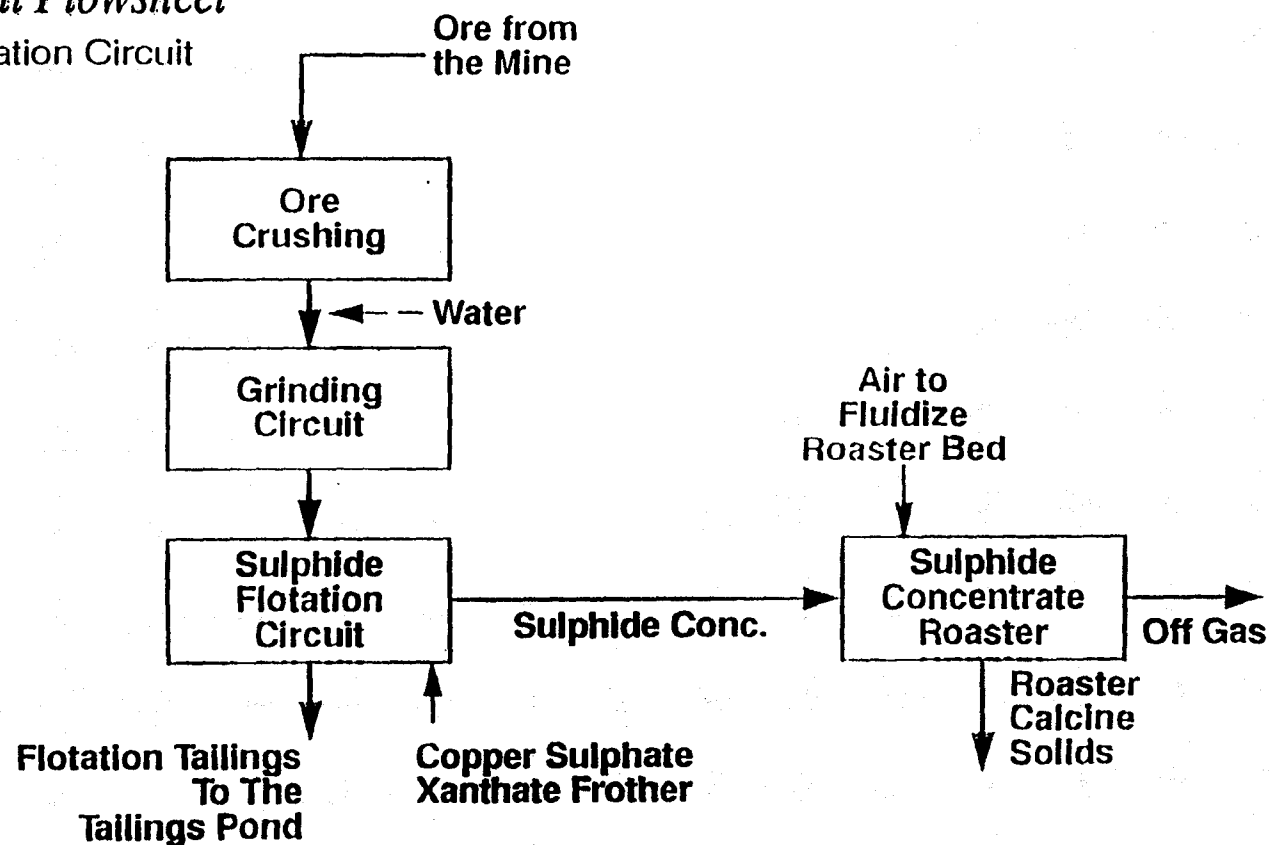
***Mill Process Flowsheet***

# ROYAL OAK MINES INC.

## The Giant Mine

### *Simplified Mill Flowsheet*

Grinding - Flotation Circuit

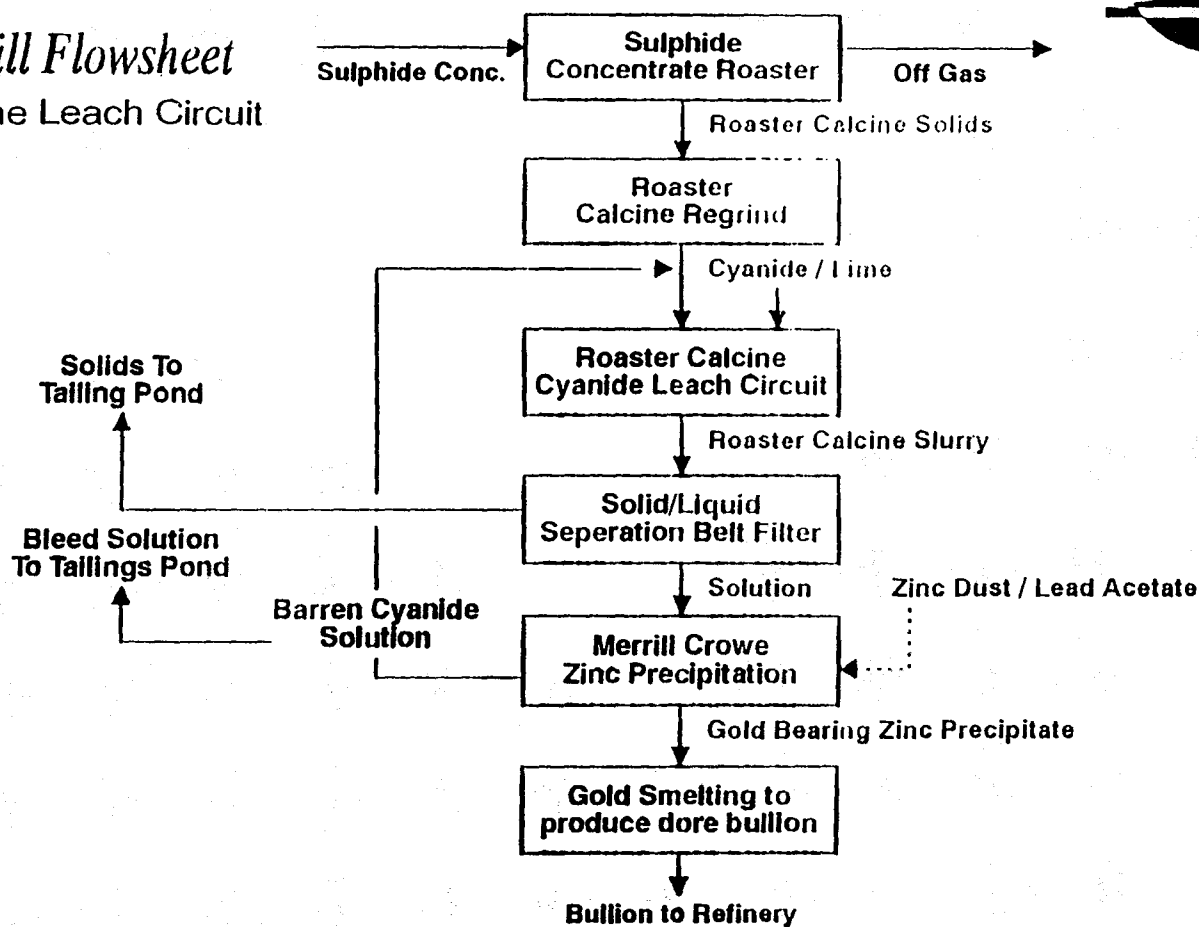


# ROYAL OAK MINES INC.

## The Giant Mine

### *Simplified Mill Flowsheet*

Roaster Calcine Leach Circuit

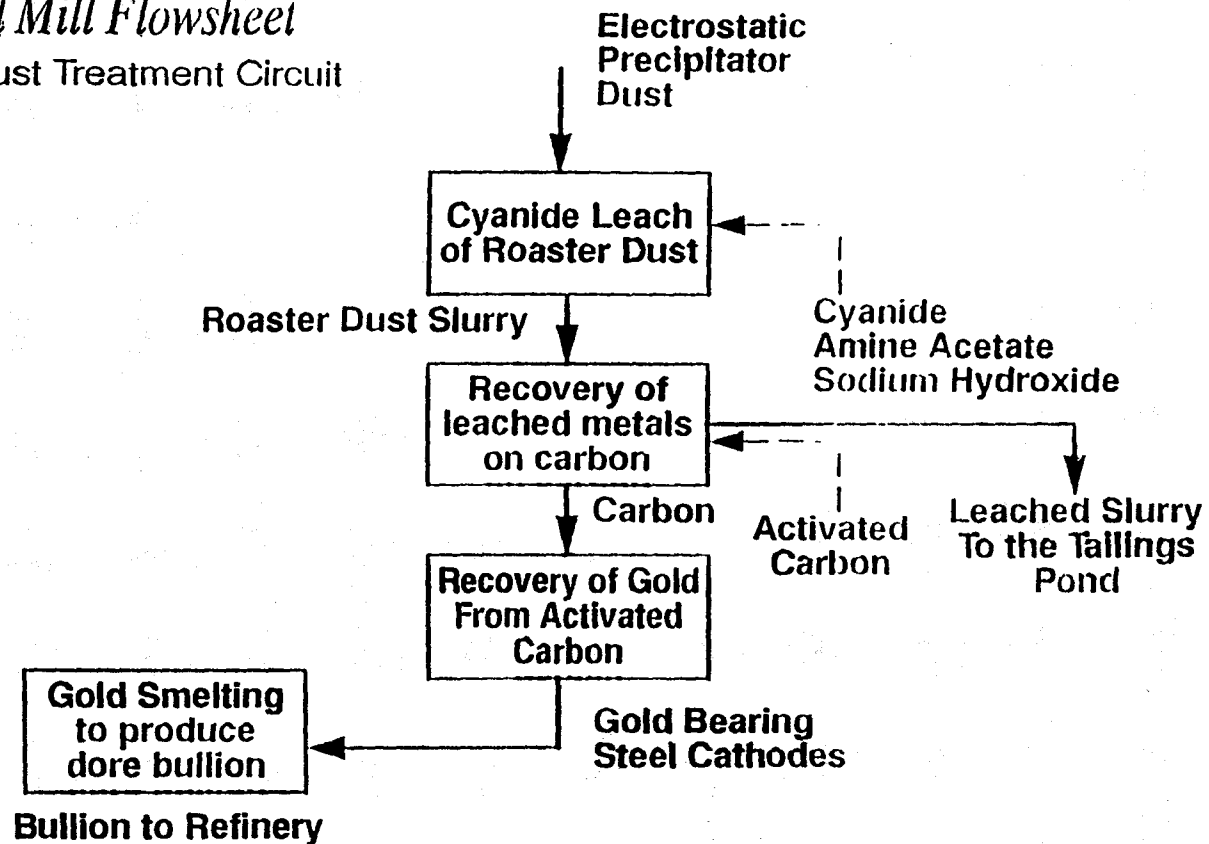


# ROYAL OAK MINES INC.

## The Giant Mine

### *Simplified Mill Flowsheet*

Roaster Dust Treatment Circuit

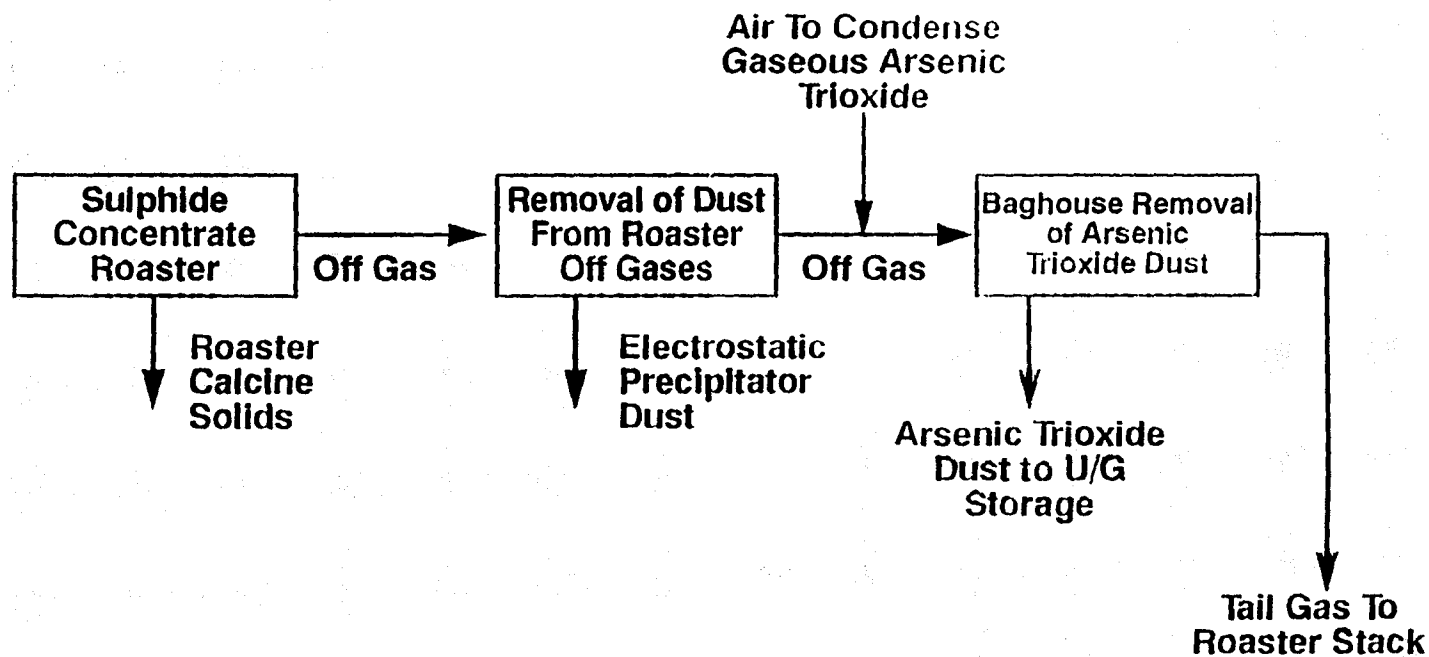


# ROYAL OAK MINES INC.

## The Giant Mine

### *Simplified Mill Flowsheet*

Roaster Gas Cleaning Circuit



### **2/3) DETAILED DESCRIPTION OF ENTIRE EMISSION CONTROL SYSTEM AND YEAR OF PERTINENT EQUIPMENT INSTALLATIONS**

#### **Roaster Off Gas Cleaning Operations - Brief History:**

Gas cleaning was initiated at Giant in October of 1951 with the installation of a low temperature Cottrell electrostatic precipitator designed to collect the combined calcine dust and condensed arsenic trioxide from the exit gases of the Edwards type hearth roaster. With the installation of the first fluosolid roaster in 1952, a new 9 foot diameter, 150 foot high brick stack was added, together with a booster fan and an enlarged flue system. It was hoped that the new system would improve the electrostatic precipitator performance, through better control of draft and air tempering. However, with the expanded roaster production, the precipitator collection efficiency actually dropped 10%.

It appeared that the roasting of arsenopyrite under ideal conditions for gold extraction did not result in ideal conditions for precipitator operation. The first stage fluosolids reactor was operated under very close air control to maintain moderate reducing conditions. As a result the roaster exit gases contained a high concentration of  $\text{SO}_2$  and essentially no sulphur trioxide. At this reduced precipitator temperature, the dust particles including non conductive arsenic absorbed the  $\text{SO}_3$  as a surface layer. This was sufficient to render the suspended solid dust conductive and thus recoverable. The  $\text{SO}_3$  deficiency in the roaster exit gas allowed non conductive particles of condensed arsenic to pass through the electrostatic precipitator and out the stack.

In 1955, a second Cottrell unit was installed to operate as a high temperature electrostatic precipitator for the selective recovery of the gold bearing calcine dust prior to the collection of condensed arsenic in the original low temperature Cottrell unit. The tandem operation of the hot and cold precipitators resulted in improved dust collection efficiency, however the condensed arsenic particles were not sufficiently conductive to allow recovery in the cold unit. Efforts were made to increase the  $\text{SO}_3$  content in the roaster off gas with limited success. Eventually the combined recovery of arsenic trioxide and calcine dust dropped to 60% making it necessary to operate both precipitators at a low temperature.

In 1957, a small fabric baghouse collector was piloted on a fraction of the roaster off gas. The unit indicated that arsenic collection efficiencies exceeding 99% were attainable with satisfactory bag life.

In 1958, an enlarged two stage fluosolids reactor was installed. At the same time, an eight compartment model 30 Dracco type baghouse was introduced to the operation. For a short period, the baghouse was used to collect both calcine dust and condensed arsenic trioxide from the tempered roaster off gas. Once the new fluosolid reactor was operating satisfactorily, one of the

Cottrell units was put on stream as a high temperature electrostatic precipitator. From that time, the selective collection of gold bearing calcine dust and condensed arsenic trioxide has been practised. In the spring of 1962, the original low temperature Cottrell unit was converted to operate as it still does today, in parallel with the high temperature precipitator.

#### **Gas Cleaning - Recovery of Calcine Dust:**

The combined roaster off gases leave the second stage reactor and pass through two Ducon dust cyclones positioned in series. Each cyclone discharges calcine dust into separated quench tanks. All of the quenched roaster products are pumped to the calcine washing circuit. The remaining calcine dust and gas exit the cyclones and are tempered before entering the electrostatic precipitators.

The two precipitators are identical Type K rod curtain Cottrell units. Each precipitator consist of two units arranged in parallel with each unit split into two sections arranged in series. Each section is comprised of 882, 1/8 inch diameter (Schedule 40) collecting electrodes and 272, 3/16 inch square twisted discharge electrodes. The collecting electrodes are arranged to form 18 curtains, 8 feet long by 12 feet high with an 8 inch duct between curtains. The discharge electrodes form 17 curtains and sit in the 8 inch duct. The precipitator housing is constructed of mild steel and is fully insulated.

Time controlled rapping hammers strike the collecting and discharge electrode frames to dislodge dust from electrodes. The calcine dust falls into V-shaped hoppers and is then conveyed to quench tanks.

The distribution and gas flow through the precipitator units is controlled by multivane dampers located in the inlet and outlet of each unit. At present, only two of the four units are active while the remaining two are held in reserve. When severe electrical shorts or other difficulties arise in an onstream unit, one of the reserve units is put in service until the required repairs are completed.

High voltage direct current is produced by a transformer stepping up low voltage 550 primary to a high voltage 50,000 secondary. The high potential AC current is converted to high voltage DC current through the use of mechanical rectifiers. Negatively charged discharge electrodes ionize the surrounding gas and impart a charge to the conductive calcine dust. The charged dust particles are attracted to and deposit on the electrically grounded collecting electrodes. The dust remains on the collecting electrodes until discharged by the action of the rapping hammers.

Maximum voltage without arcing produces the highest precipitator collection efficiency. Operating voltage is affected by gas composition, temperature, and dust concentration, all of which are a function of the roaster operating parameters.

The voltage and amperage on the primary side of the transformer are monitored to indicated the presence of a broken discharge or collection electrode, an electrical short caused by a build-up of dust between the curtains or a dirty insulator. Seemingly unimportant items such as damaged flue and shell insulation give rise to cold spots which promote the formation of aggregates of antimony and calcine dust. These aggregates damage the hopper screw conveyors or cause electrical shorts. Air leakage around the access doors is sufficient to condense arsenic trioxide out of the gas and contaminate the collected calcine dust.

Collection efficiency of the electrostatic precipitator averages 94.5 % of the gold contained in the cyclone tail gas.

**Table 1: Electrostatic Precipitator Operating Parameters**

Inlet Temperature	600 ° F
Outlet Temperature	500 ° F
Primary Voltage	550 Volt
Secondary Voltage	50,000 Volt
Type K Rod Curtain Cottrell	E.S.P.

**Typical Analysis of Electrostatic Precipitator Dust**

<u>Au</u>	<u>Fe</u>	<u>S</u>	<u>As</u>	<u>Sb</u>
1.43	18.00	2.75	2.29	1.00
ozs/ton	wt%	wt%	wt%	wt%

Average Au collection efficiency is E.S.P. - 94.5 %

**Gas Cooling:**

Tail gas from the electrostatic precipitator is cooled to 220° F by the addition of tempering air drawn from outside the roaster building through the mixing fan. The arsenic trioxide contained in the vapour phase condenses into a fine grained dust expansion chamber located just downstream of the mixing fan. The temperature in the baghouse is maintained at 220° F through the use of a pneumatically controlled damper located in the tempering air inlet to the mixing fan. A thermocouple and temperature controller are used to automate the positioning of this damper.



The gas volume leaving the electrostatic precipitator is approximately 6500 s.c.f.m. (standard cubic feet per minute) at a temperature of 500° F. The gas is air tempered to a volume of approximately 35,000 s.c.f.m. at a temperature of 220° F.

The condensed arsenic trioxide dust is recovered from the cooled roaster gas in an eight compartment Dracco baghouse. Each compartment contains 300, five inch diameter by 10 foot long, Homopolymer Acrylic Dralon T bags. Rated capacity is 60,000 cfm at 230° F. The unit was designed for an air to cloth ratio of 1.9 cfm per square foot. Collection efficiency is at least 99.8%. The unit was originally supplied with a timed shaking device for dislodging the dust from the bags.

Each two compartments are equipped with a V-shaped hopper and screw conveyors for the removal of the arsenic trioxide. A cross conveyor transfers the arsenic trioxide dust into a Fuller Kinyon pneumatic conveying pump.

In 1978, the Federal Government announced its intention to establish an emission standard of 15 mg/scm total arsenic for gold roaster stack emissions. During this period the baghouse collection efficiency at Giant was improved by modifying the basic baghouse operating parameters.

#### **Baghouse Temperature:**

The operating temperature in the baghouse was reduced from 230° F to 220° F to increase the percentage of arsenic trioxide condensed from the vapour to the solid phase. Further temperature reduction is felt to be impractical due to the constraint of maintaining the gas temperature above the SO<sub>2</sub> acid dew point.

#### **Baghouse Shaking Cycle:**

The baghouse was originally supplied with a timed shaking device for dislodging the dust from the bags. At Giant, the shaking cycle was activated every 45 minutes for a total of 32 cycles per day. A study indicated that the poorest collection efficiency occurred during the bag shaking cycle. It is believed that the action of shaking the bags caused some of the fine grained arsenic trioxide to pass through the pores in the filter media thus increasing the emission of arsenic trioxide from the stack.

The baghouse design air to cloth ratio of 1.9 cfm per square foot was felt to be fairly low, so the shaking cycle was converted from a timed cycle to a pressure drop cycle. The bag shaking mechanism is now activated when the pressure drop across the baghouse reaches 2 inches of water. As a direct result the frequency of shaking was reduced from 32 to 4 cycles per day. The arsenic trioxide dust now builds up on the dirty side of the bags acting as an additional filter media. This filtering action of the dust combined with the reduced frequency of shaking have contributed to an overall improvement in the baghouse collection efficiency.

**Table 2: Baghouse Operating Parameters**

<u>Parameter</u>	<u>Prior to 1977</u>	<u>Present</u>
Temperature	230° F	220° F
Bag Shaking Cycle	Time Shaking Cycle Every 45 minutes	Pressure Drop Shaking Cycle When pressure drops across the Baghouse reaches 2" of water.
Shaking frequency	32 cycles/day	4 cycles/day
Filter media	Orlon	Homopolymer Acrylic Dralon T
Stack Emissions mg/scm	25-75	6-10
lbs/day of arsenic	273 - 760	16 - 20

**Average Baghouse Dust Grade**

<u>Au</u>	<u>Fe</u>	<u>S</u>	<u>As</u>	<u>Sb</u>
65 - 72	85 - 95	1.0 - 2.5	0.3 - 0.7	0.10 - 0.15
wt%	w%	w%	wt%	ozs/ton
Average Collection Efficiency - 99.85 %				

**Filter Media:**

The baghouse was originally supplied with Orlon filter media, however after an extensive period of testing various manufacturer's filter bags, a switch was made to Porritts and Spencer's Draylon 32 filter media. However, these bags became unavailable in 1992, and therefore a switch was made to Crosible Ltd's - Acrylic Dralon T Filter Media, which have proven to be very reliable for this application.

A variable speed, hydraulic drive stack fan draws the "cleaned" baghouse tail gas to a 9 foot diameter by 150 foot acid brick stack. The stack gas typically analyses: 1.25 % SO<sub>2</sub>, 78.50 % N<sub>2</sub>, and 0.10 % CO<sub>2</sub> with a dry molecular weight of 29.4 lb/lb mole.

**Disposal of Recovered Arsenic Trioxide:**

An average of 12 - 15 tons of material is recovered in the baghouse each operating day. The typical analysis of this baghouse dust is 85 to 95 wt%  $\text{As}_2\text{O}_3$  to wt% Fe, 0.3 to 0.7 wt% Sb and 0.10 to 0.15 oz/ton of gold.

Transportation of arsenic dust is achieved by means of a Fuller-Kinyon pump, delivering material through a 4 - inch diameter standard weight pipe. The delivery pipe passes through air-tight bulkheads at entries to the storage stope, or is directly connected to 3 - inch diameter diamond drill holes to attain maximum distribution over the storage area.

Baghouse dust is pneumatically conveyed into specially prepared underground stopes located in permafrost zones. These stopes are designed and excavated solely for the storage of arsenic trioxide dust. After excavation of a stope is complete, concrete bulkheads are installed to prevent the movement of any stored material from the stope. The permafrost is then allowed to permeate back into the area before any baghouse dust is placed in the stope.

The pneumatic conveying air used to transport the baghouse dust underground is vented back into the baghouse inlet flue through a parallel 6 - inch diameter pipe. The system is therefore completely enclosed, and no dust loss occurs during transportation.

**3) ACTUAL INSTALLED COSTS OF EMISSION CONTROL EQUIPMENT**

**Actual Installed Capital Cost of Emission Control Equipment:**

The previous section provided dates and descriptions of the changes that were implemented to the emission control system. It was requested that the actual costs of these equipment changes be included, however, from reviewing our records it has become evident that these changes were considered as a part of the entire mill operating budget for each year. Therefore, there is no separate breakdown of the costs for each equipment that was installed.

**Actual Operating Costs (Labour & Maintenance) of all Emission Control Equipment Presently Installed to Control Air Emissions:**

The following lists the 1995 budgeted costs including labour and maintenance that is required to operate the emission control plants. These include the Roasting Plant, the Cottrell Plant, and the Arsenic Handling Plant.

\*\*\*\*CONFIDENTIAL\*\*\*\*

**1) Roasting Plant:**

<u>Cost</u>	<u>1995 Budget</u>
Hourly - Operating	259,101
Hourly - Training	6,772
Supplies - Operating	24,000
Hourly - Maintenance	60,410
Supplies - Maintenance	150,000
 Total Roasting	 500,283

**2) Cottrell Plant:**

<u>Cost</u>	<u>1995 Budget</u>
Hourly - Operating	51,976
Hourly - Training	1,693
Supplies - Operating	12,500
Hourly - Maintenance	13,550
Supplies - Maintenance	20,000
 Total Cottrell	 99,719

**3) Arsenic Handling**

<u>Cost</u>	<u>1995 Budget</u>
Hourly - Operating	64,970
Supplies - Operating	16,800
Hourly - Maintenance	1,694
Supplies - Maintenance	48,000
 Total Arsenic Handling	 131,464

**Overall Budgeted Costs to Operate the Emission Control Equipment:**

1) Roasting Plant	\$500,283
2) Cottrell Plant	\$ 99,719
3) Arsenic Handling Plant	\$131,464

TOTAL	\$731,466
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#### **4) DESCRIPTION OF ANY EMISSION MONITORING PROGRAMS IN PLACE**

Royal Oak presently conducts annual source emission stack tests for both arsenic and sulfur dioxide in order to evaluate the efficiency of the emission control system. These source emission stack tests have been conducted over the past few years by both our own personnel as well as being contracted out on other occasions. The latest stack emission test was conducted by Entech Environmental on September 12th and 13th, 1995.

It should be noted that Royal Oak Mines is presently investigating the option/cost of a Continuous Emission Monitoring System (CEMS) for sulfur dioxide. However, it appears that there is no existing technology (approved method) which can provide continuous measurement of solid arsenic in a stack (see attached letters appended to this report dated October 16, 1995 from Rosemount and August 8, 1995 from AEM Systems).

#### **5) DESCRIPTION OF ANY ENVIRONMENTAL PROGRAMS OR STUDIES FUNDED**

Royal Oak Mines is presently funding or jointly funded two monitoring/investigative studies in the geographic vicinity of the Giant Mine in Yellowknife, they are as follows:

**a) Royal Oak Mine Inc and the GNWT's Renewable Resources Department jointly funded the Air Dispersion Modelling Report (May 1995).**

It is assumed that Environment Canada has received copies of this report.

**b) Royal Oak Mines Inc commissioned Dillon Consulting Engineers to complete a Roaster Stack Air Dispersion Mechanical Feasibility Assessment.**

This report reviews options and order of magnitude cost estimates for changes in the stack discharge parameters of stack height and exit gas temperature of the roaster exhaust ventilation system at Royal Oak Giant Mine. Options for increasing exit gas velocity were not investigated based on recommendations of the Air Dispersion Modelling Report (May 1995). A copy of this assessment, dated October 17, 1995 has been forwarded to Ms. Laura Johnson.

#### **6) DESCRIPTION OF EMERGENCY SYSTEMS OR PROGRAMS IN PLACE IN ORDER TO DETECT OPERATIONAL DISTURBANCES OR FAILURES**

On a day to day operational basis, there are a series of meters and alarms that pinpoint any operational disturbances or failures to the emission system, such as temperature flow level

changes. Trained operators conduct routine walk abouts on a 24 hour basis in the emission system plants.

### **Baghouse Monitoring:**

The baghouse is inspected (all eight compartments) every second month. Operators perform the following tasks:

- vacuum between the bags;
- remove any damaged bags (tie them off);
- conduct minor mechanical repairs; and
- inspect bearings and grease lines.

These inspections are performed by two experienced mill operators (Cottrell operators) who routinely work in the Cottrell/Baghouse area.

Each baghouse compartment is completely overhauled every eighteen months or as required. During this period, internal mechanisms are replaced with new or refurbished equipment and all of the 300 bags are replaced with new ones. Appendixed to the report is the complete overhaul baghouse maintenance record for the past eight years.

### **7) TABLE SHOWING ARSENIC MATERIAL BALANCE**

The table that you provided has been completed and is included with this report. It should be pointed out that some of the information reported on this table is data that has been averaged from the day to the day operation of the roaster stack (January - October 1995). While other data provided has been based on the operation conditions that were present during the latest stack sampling conducted on September 12th and 13th, 1995. This has been identified directly on the table.

The following outlines the operating conditions on the two dates of testing:

#### **September 12, 1995**

- Feed Rate = 5.3 tons/hr
- Stack Fan Setting = C ½

#### **September 13, 1995**

- Feed Rate = 5.4 tons/hr
- Stack Fan Setting = C ½

The reference conditions were 25° C and 760 m.m. Hg

7. A material balance for arsenic including the quantity and concentration of arsenic or arsenic compounds released from Giant Mine roaster stack. Please complete the following Table.

TABLE - Arsenic Material Balance:

ROASTER INPUT

Feed Rate (Tonnes/hr)	6.5 - 7.0
Arsenic Concentration (%)	5.0 - 7.0

ROASTER OUTPUT PRODUCT

Product (Tonnes/hr)	3.7
Arsenic Concentration (%)	1.7

ROASTER FLUE GAS

Flow Rate (Nm <sup>3</sup> /hr)	45000
Arsenic Concentration of Dust (%)	69.06%
Arsenic Concentration (mg/Nm <sup>3</sup> ) <small>DRY BASIS</small>	3.15

Averaged from Day to Day  
Operation of Roaster  
Jan - Oct 1995

← Data from latest  
Stack Test

MATERIAL COLLECTED

Quantity (kg/day)	9000
Arsenic Concentration (%)	69.06%

MATERIAL STORED

Quantity (Kg/Day)	9000
Arsenic Concentration (%)	69.06%

AVERAGED FROM DAY TO DAY  
OPERATION OF ROASTER  
Jan. - Oct. 1995

MATERIAL RELEASED FROM STACK

Quantity (Kg/Day)	3.216
Arsenic Concentration of Dust (%)	69.06%
Arsenic Concentration (mg/Nm <sup>3</sup> ) <small>DRY BASIS</small>	3.15

← Data from latest  
Stack Test.