

Giant Mine Milling and Roasting Process, Yellowknife, NWT



A Historical Summary

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The treatment plant operation at Giant Mine was complex with a number of metallurgical processes evolving over the early period of mine life in response to ore chemistry, gold recovery, and changing technology. The mill began as a gravity-amalgamation plant in 1948 and started processing sulphide ores in 1949 through roaster technology, which evolved throughout the 1950s to maximize gold recovery and reduce arsenic emissions. Treatment methods in use at Giant to recover gold included amalgamation, flotation, cyanidation, fluo-solids roasting, and activated carbon. From 1962 to closure in 1999, the milling process at Giant was essentially unchanged with only minor improvements in the circuit to account for ore chemistry.

History of Exploration and Development

The mineral claims that became the Giant Mine were staked early in the history of the Yellowknife gold camp, but it took many years of geological investigation and commitment by a select group of investors to bring the venture to production.

Prospector Johnny Baker staked the original group of mineral claims in July 1935 led there perhaps on the advice of Dene, who often helped early prospectors in the search for gold on Yellowknife Bay. Baker identified several small quartz veins along the Baker Creek Valley, including the Brock and Ole veins, which were the focus of early exploration. Giant Yellowknife Gold Mines Limited was formed in 1937 as a subsidiary of Bear Exploration and Radium. Shafts were sunk on the high-grade Brock and Ole exposures and bulk ore was sent out for testing and gold recovery, but investors pulled out of the project when war in Europe heated up, without understanding the full extent of gold deposition at the claims.

Interest was renewed by another group in 1943 when Don W. Cameron, a highly experienced prospector, re-examined outcrops near the property's southern end. More encouraging results were reported and Frobisher Explorations and Ventures Limited (later Falconbridge Nickel Mines) acquired control of Giant Yellowknife Gold Mines Limited. Frobisher's consulting geologist, Dr. Stuart Dadson, commenced a detailed examination of the claims, deducing that a major ore body might be found in a system of shear zones beneath the Baker Creek Valley. He laid out a drilling program to test the valley and the assay results from the first drill hole essentially confirmed the presence of a massive gold-bearing shear zone. It was beyond the imagination of even Johnny Baker, the original prospector, who did indeed choose a very appropriate name for the claims.

Giant Yellowknife Gold Mines was the Canadian stock promotion of the year in 1944. The encouraging drill results along the three kilometer valley provided incentive to proceed with underground development and construction of a treatment plant. Gold production began in June 1948 and an inaugural brick-pouring ceremony was held on August 24 to usher in the reign of Giant Mine, the largest gold mine in Yellowknife. (Giant Yellowknife Gold Mines Annual Reports, 1944-1949)

Geology and Mineralogy

Gold at Giant Mine occurs in a folded sericitic schist shear zone that cuts across a sequence of Precambrian volcanic rocks trending northeast and dipping steeply to the west. Although foliation is steeply dipping to vertical, the various elements of the shear zone may dip east or west, from flat to steep. Overall, the system simulates a folded stratigraphic unit with plunging anticlines and synclines. The schist zone has been traced for more than six kilometers to the north and to a depth of 2,000 feet. Ore bodies from the neighboring Con Mine, south of Yellowknife, are considered to be a continuation of the same ore zone displaced along the West Bay Fault.

Individual orebodies occur as irregular masses, lenses and veins within a complex zone of chlorite and sericite schist. The size, shape and attitude of each ore body are very diverse. The ore consists of 40 to 80 percent quartz carbonate, schist remnants, and about 10 percent fine-grained arsenopyrite and pyrite. There are also concentrations of stibnite and antimony. More than 20 metallic minerals have been identified approximating 15% of the ore. Most of the gold is intimately associated with the sulphide mineral arsenopyrite in the quartz and silicified schist, known as a refractory type of ore due to its resistance to conventional methods of mineral recovery.

Visible gold is extremely rare and only fine blebs of native gold can be observed in quartz and in fractures of arsenopyrite and stibnite. Most gold is believed to occur as submicroscopic inclusions in arsenopyrite.

Wide variations in dissemination and schistosity of the sulphide minerals presented surmountable problems in metallurgical treatment at Giant Mine. (Thomas, 1985)

Development of the Treatment Process

The development of Giant Mine was full of challenges that mining engineers, geologists, and the logistically inclined strived to solve in the 1940s. None were more than the challenge to create a metallurgical process to recover gold from the sulphide ores. Early prospecting and analytical testing of gold-bearing rocks at the Giant claims indicated a matrix of quartz and disseminated gold, capable of simple treatment through a free-milling process of amalgamation and cyanidation. These tests, conducted in the 1930s, were based on investigation of near-surface quartz vein deposits and were not indicative of the unknown geology at depth.

With the discovery of schist shear zones in 1944, it was clear that the complex ores of ultra-fine gold and associated sulphide minerals would require special handling to achieve optimal recovery. Ores were tested at the Bureau of Mines in Ottawa and at Nepheline Products in Lakefield, Ontario. Lab tests revealed that less than 20% of the gold could be extracted using mercury amalgamation and less than 33% by direct cyanide treatment. The most practical method using technology then available was to produce a sulphide concentrate through a gravity-flotation process, break the gold free from arsenopyrites through autogenous roasting, and then cyanide the calcine produced by the roaster.



Figure 1: Treatment plant 1948-1949. 1) crusher, 2) screen house, 3) conveyor gallery, 4) grinding and cyanidation plant, 5) original Allis Chalmers roaster and stack.

A treatment method was agreed upon based on the best available data on Giant ores. The first stage of the mill started ore treatment in May 1948 using a mercury amalgamation and flotation process at a rate of 235 tons ore per day. Occurrence of moderately coarse native gold from quartz justified the installation of a mineral jig and a barrel amalgamation unit in the original circuit, representing about 15% of the gold in feed. As flotation concentrate had to be stockpiled awaiting completion of the roaster, the only gold recovered in the first seven months of milling was through amalgamation. In January 1949, the roaster was completed together with a cyanidation circuit to treat roasted calcine. The object of the roaster was to render the gold physically and chemically free from the arsenopyrite matrix, so as to be soluble in cyanide solution.

The first roaster was a flat-hearth unit manufactured by Allis-Chalmers. It utilized the sulphides in the ore itself as a fuel mechanism thus was known as an autogenous roaster. This roaster proved inadequate to handle mill feed, and in 1952, a second roaster was added – a Dorrco fluo-solids prototype unit. To accommodate larger tonnages of underground ore, the gravity-flotation plant was enlarged in 1952, from 400 to 700 tons of ore per day. However, the mine was unable to make use of this added capacity with production bottlenecked because of worsening roaster operations.



Figure 2: Roaster stack construction, 1953. (*NWT Mining Heritage Society – Bruce Nikiforow Collection*)

The new Dorrco roaster was also plagued with problems, highlighted by several breakdowns including an explosion during startup, and a significant deficit in gold recovery. These were serious problems because the mine was proceeding with an expansion program that hinged entirely on the success of the treatment plant. Roaster temperatures were not as high as

expected and there were issues with corrosion in process pipes and low draft in the steel exhaust stack. The original five-foot diameter, 150-foot high steel stack was so corroded and plugged that in the summer of 1953 it was replaced with a nine-foot diameter, 150-foot acid-resistant brick stack with booster fan designed by Taylor Engineering Construction Company out of Toronto. Construction started July 19 and was completed October 16, 1953.

By the mid 1950s, the company understood that ore mineralogy was more complex than originally believed. The ratio of refractory ore increased to a point where recovery of gold from straight amalgamation was extremely rare. Total sulphur content of ore at greater depth was almost double that of the original ore. Antimony, a friable mineral often found within the sulphides, caked and clogged up the roaster circuit.

Excessive gold-bearing dust loss from the roaster and the treatment of more refractory ores resulted in a drop in overall recovery in the mid-1950s. In the early stages of operations, an overall recovery of 85% was achieved using amalgamation to recover up to 20% of the gold in its free state. Now a decreased portion of free-milling gold was available representing only 1% of gold recovered by amalgamation. This method of treatment was ultimately abandoned in 1958 as Giant Mine ores became entirely sulphide in nature.

A large scale research program was started to keep the extractive techniques abreast of anticipated changes in mill feed. Important changes to the process improved recovery. For example, in 1956 additional equipment was installed to permit cyanide treatment of flotation tailings (previously discarded), and in 1957 a rotary Kiln Plant was built to recover gold from calcine tailings. Both modifications made important contributions to gold recovery at a very critical time but were not an answer to basic metallurgical problems. On a broader scale, less conventional recovery methods were investigated, including autoclave oxidation, pressure leaching, smelting, and a moving-bed hearth. The chief purpose of these changes was to permit the efficient handling of the volume of

concentrates resulting from an envisioned throughput of up to 1,000 tons a day, and of course to improve the overall gold recovery rate.

By 1958, overall recovery of the treatment plant had dropped to 68% and gold bullion output was seriously limited due to lack of roaster capacity from higher amounts of refractory ores and equipment that had been pushed beyond capacity without adequate maintenance. The urgency of the problem suggested that experimental techniques were too large a risk, and Dorrcoc was tasked to design a larger two-stage fluo-solids roaster which began operations in November 1958. The new roaster allowed better control of temperature and was of larger capacity, allowing a smooth transition to higher production as planned. Recovery increased rapidly to 88% in the mid 1960s where it was maintained through much of the life of the Giant Mine with only minor fluctuations. Small changes continued in 1959-1962 to boost gold extraction from the various recovery circuits.

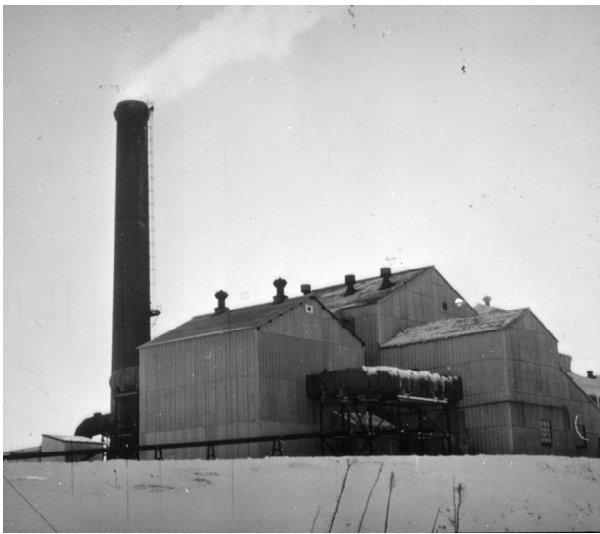


Figure 3: Roaster exhaust stack, Baghouse, Cottrell, Dorrcoc roaster. (*NWT Mining Heritage Society – Giant Mine Collection*)

Roasting also caused considerable problems due to arsenic emissions and its effect on the Yellowknife environment. In 1951, a Cold Cottrell electric-precipitation plant was installed to collect arsenic fume and dust from the roaster exhaust. The arsenic trioxide dust was then pumped underground into sealed chambers. Efficiency of the

system was found to be inadequate. In 1955, a parallel Hot Cottrell plant was installed and in 1958 a Dracoc baghouse was also added to improve collection of arsenic fume and comply with standards imposed by the Department of National Health and Welfare. By 1962, with further modifications, the arsenic collection efficiency was reported to be 98%, preventing about 17 tons of arsenic per day from entering the atmosphere. The new Cottrell installation also made it possible to collect gold-bearing dust that was previously lost. Commercial treatment of Hot Cottrell dust was applied through a carbon-leach circuit beginning in 1961.

In view of the extreme refractory nature of Giant's ore, the higher recoveries constituted a significant metallurgical achievement in the Canadian gold mining industry. The Giant Mine treatment process was considered to be top of the line technology after significant investment in the field of both gold recovery and pollution control. Notwithstanding the many difficulties, by 1960 Giant Mine was producing more than 175,000 ounces of gold annually and had become the fifth largest gold mine in Canada. (*Giant Yellowknife Gold Mines Limited Annual Reports*)

Construction of the Plant

The main treatment plant (or mill) was built in 1947-1948. The mill was built on a natural slope of bedrock and was pinned on a concrete foundation. During initial construction in 1947, space for future additions were reserved by blasting foundation rock so as to not disrupt operations – this addition was completed in 1952 to double the size of the treatment plant. The substantial structure was wood framed and shiplap sheathed, covered over in a fireproof asbestos tarpaper. Wood was the only material then available to build such a massive superstructure. Giant Mine operated a sawmill on the Slave River where much of the rough lumber for construction was harvested.



Figure 4: Construction of the sand plant mill addition, 1956. (*NWT Mining Heritage Society – Giant Mine Collection*)

The first Allis-Chalmers roaster, built in 1948, was also constructed of wood. The initial design was for a steel superstructure, which was more appropriate for high-temperature roasting. Because of a shortage of cast steel across Canada after the war, and lacking alternatives and a tight schedule, Giant used wood products, although the interior of the building was lined with special fire-resistant asbestos products. The roaster hearth itself was on a large concrete slab and made out of fire bricks. The first roaster exhaust stack was engineered from steel.

Giant's subsequent roaster buildings – the Cottrell, the Dorrco roaster, Kiln plant, and Baghouse – were built of steel products. These were now available from steel foundries in the 1950s and were a more acceptable construction style considering the nature of high-temperature processing. Fire-resistant asbestos products in the amount of 47,000 square feet were used in the roaster building. (Golder Associates, 1999) Steel, however, did not work in favour of the original roaster exhaust stack. By 1953, excessive corrosion combined with general poor performance of the roaster forced its replacement with an acid-resistant brick stack. Giant's new chimney, nine-feet in diameter and 150-feet high, containing an inner and outer wall of brick divided by steel plate, was Yellowknife's first substantial brick structure, and also its tallest for many years. It was completed by a southern brick laying contractor, Taylor Engineering, in October 1953. An estimated 70,000 fire bricks went in to the construction of the stack.¹

¹ Estimate provided by James Carss, Parsons Corporation, July 19, 2013

Building	Building #	Dimensions	Construction	Date of Construction
Crusher House	101	4171 feet squared	Timber	1947
Screen House & Conveyor	102	26' x 25.5'	Timber	1947
Mill & Sand Plant	106	52244 feet squared	Timber (Mill) – Steel (Sand Plant)	1947 (mill) 1955 (Sand Plant)
Switch House (Mill)	108	1219 feet squared	Timber	1947
A.C. Roaster (later Pipe Shop & Carbon Plant)	110	50' x 228' plus 14.5' x 90.5' compressor addition	Timber	1948
Cottrell	134	53' x 90'	Steel (Dominion Bridge & Engineering Works)	1950, 1953
Dorrco Roaster	143 (previously #166)	51' x 77' plus 42.5' x 84'	Steel and Trafford Tile (Dominion Bridge & Engineering Works)	1951, 1958
Roaster Stack & Fan House	148	9' diameter x 150' high	Brick (Stack) – Steel (Fan House)	1953
Calcine Plant	162	6270 feet squared	Steel (Standard Iron & Engineering Works)	1957
Baghouse	167	40' x 39'	Steel (Standard Iron & Engineering Works)	1958
Refinery (new)			Steel	1981

Table: Construction details of treatment plant structures

Construction of the roaster buildings was a monumental and specialized task, involving contracts with some of the largest Canadian steel construction firms, including Dominion Bridge & Engineering Works, and Standard Iron & Engineering Works. Design, engineering, and implementation of patented processes and equipment were carried out by the leading metallurgical companies, including Dorr Oliver Long (for the Dorrco fluosolids roaster), Dracco Corporation (baghouse), Precipitation Company of Canada (Cottrell electro-static precipitation process), and Allis Chalmers Co. (Edwards flat hearth roaster and rotary kiln), not to mention the many commercial treatment equipment manufacturers and distributors.

Metallurgical and Roasting Operations

The main treatment plant (or mill) was built in 1947-1948 with an expansion to double its size built in 1952. In this structure, the ore was treated to initial grinding and flotation. The solutions were then pumped to the roaster, and the gold-bearing calcine was pumped back to the mill structure for cyanidation and precipitation. Giant was unique because of the need to frequently change the treatment process in its early experimentation period. There was little foresight or vision to create a compact flowsheet. Getting out the gold was the prime objective, and a visitor to the mill in later years would have a hard time following the flow of the gold solutions through the complex. A slurry tank designed for one purpose might be re-piped for another purpose, and then changed again. By the time Giant had figured out the best treatment strategy, the plant was a confusing maze of process pipes and tanks. And yet there was a highly skilled group of men (and later women) who knew the process like the back of their hand, and at least one fellow who has worked at Giant for over 45 years claims to know every pipe joint in the place.



Figure 5: Grinding circuit with ball mill and spiral classifier. (*NWT Mining Heritage Society – George Hunter Collection*)

The roasting plant, located to the north of the mill, was a six-structure complex, each a modification to the original design flowsheet in hopes of improving gold extraction. It too was a complicated labyrinth of pipes, exhaust conduits, tanks, conveyors, and furnaces. The purpose of roasting gold-bearing sulphide concentrates prior to cyanidation was to convert dense sulphide grains to porous structures so that the gold particles were exposed to the cyanide leach solution. Strict control of temperature during the roasting phase was necessary to produce a clean calcine product and the process could be complicated by the introduction of minerals such as stibnite or antimony. Arsenic and antimony were converted into a gaseous state, pyrite was altered to hematite, and sulphur in the ore acted as the fuel for roasting. (Tait, 1961)

The roaster was a dangerous place to work. Constant cleaning and maintenance of conduits and the roaster bed was required. One of the early achievements of Giant's union was bargaining for "dirt pay" in 1958, a pay premium of 25 cents an hour for work deemed more hazardous. This was followed an 'arsenic time' premium in 1962. Both applied primarily to work in the roaster plant because of the risk of arsenic contamination. Safety standards increased through each union negotiation. (NWT Steelworkers Area Council, 1977) While there were no direct work-related fatalities associated with on-the-job work in the roaster, anecdotal accounts from some workers,

and epidemiology studies in the 1970s, suggests there were some occupational health concerns from working in the treatment plant. (Department of National Health & Welfare, 1977) Early arsenic emissions over the Yellowknife area, before the advent of stricter environmental controls in the 1950s, were also attributed to illness and at

“Everyone scattered when it was time to re-line the roaster. It’s called the roaster job. The guys would shudder and hide. You get paid good money - you get like double time and a half working in the roaster. You’d be in like 15 minutes and out.”

– Ken Hall, mill operator

least one documented death and perhaps more in the aboriginal community, caused by the likely ingestion of arsenic contaminated meltwater. (Sandlos & Keeling, 2012)²

The treatment plant at Giant Mine operated from 1948 to 1999, processing 18 million tons of ore grading 0.49 ounces per ton and recovering 7 million ounces of gold, with an average recovery of 85.5%. More than 17 million tons of tailings were produced and over 237,000 metric tonnes (or 250,000 imperial tons) of arsenic trioxide created as a by-product of roasting. (Silke, 2009)

The following is a summary of specific treatment plant operations at it was in the late 1960s, a process that remained largely the same for the remainder of the life of Giant Mine. (Mortimer & Tait, 1959; Tait, 1961; Pawson, 1973; Connell & Cross, 1981; Halverson, 1990)

Crushing:

Mined ore was crushed underground on the 1450-foot level and then hoisted up the main production shaft (C-Shaft) where further crushing using cone crushers reduced the ore to less than 3/8-inch size. Three-stage crushing with screens was required to ensure the product was of appropriate size for treatment in the grinding circuit. Crushed ore was conveyed from the crushing plant adjacent to the C-Shaft up the gallery to the main treatment plant.

“The mills used to have steel liners and steel balls. And you get steel on steel crushing rock, well it wore a lot of stuff down. Then they went to rubber liners. And that was a lot quieter! This is why I’m wearing hearing aids today, is because of the loud mills that I worked around and the blowers in the roaster and stuff. It was just unbelievable.”

– William Hall, mill shift boss

Grinding:

Fine ore was conveyed to four mill storage bins of 500-ton capacity and was drawn into two parallel conveyors feeding grinding mills. These were 8’ x 10’ Dominion ball mills carrying a steel ball charge to pulverize the fine ore into a slurry by combining water and diluted cyanide solution. They operated in closed circuit with a spiral classifier to return oversize material to the ball

² Sandlos and Keeling provide original reference for arsenic illnesses: National Archives of Canada, RG 29, Volume 2977, File 851-5-2. This file was not reviewed during current research.

mill feed for further grinding. The classifier used the specific gravity of the ground ore particles to separate fine particles from coarse ones. Fine particles overflowed the classifier and were pumped to flotation.

Flotation:

In the flotation circuit, the sulphide minerals were separated from the ground ore slurry. The sulphide minerals contained in the Giant ores were principally arsenopyrite and pyrite. Copper sulfate was added and coated the sulphide mineral surfaces. A chemical flotation collector called xanthate was then added and attached itself to the coated sulphide minerals. The xanthate has a high affinity for air, which was bubbled through the flotation cells. A frothing agent called Dowfroth was also added to provide a stable air froth when air was bubbled through the slurry.



Figure 6: Flotation cells. Hector Tremblay monitoring the froth. (*NWT Mining Heritage Society – George Hunter Collection*)

The xanthate and the sulphide minerals attached to the air bubbles and floated to the surface of the flotation cell, where it was skimmed into a launder and collected for further processing. Two circuits of flotation were in use – a rough and scavenger circuit. Tailings material that did not float off the first circuit was reground in ball mills in closed circuit with cyclone classifiers and subjected to a second flotation circuit called

scavenging. All flotation concentrate that was skimmed off into the launders united to form the roaster feed. Final flotation tailings were jettisoned as waste or for underground backfilling (flotation tailings were subjected to additional cyanidation treatment from 1956 to 1967).

Roasting:

Physical and chemical breakdown of the sulphide minerals was necessary prior to cyanidation of the flotation concentrate. This was accomplished through a two-stage fluo-

solids roasting process at a high temperature. The purpose of the roasting was to produce porous particles by volatilization of arsenic, sulphur and antimony thereby exposing the fine gold. The roaster product, known as calcine, could then be amenable to cyanidation. The physical condition of the calcine was very important and the

“In the roaster one time, our burner blew up. Blew me down the stairs! Lloyd Ross said, ‘Oh, it was just a little POOF.’ Blew me down a set of stairs! Dislocated my shoulder! ‘A little chuff!’ I had to go to the hospital and get my shoulder put back in place.”

– Alec McBeth, roaster operator

thermodynamics of the roaster had to be carefully controlled to produce a calcine of satisfactory porosity. The presence of stibnite and antimony also interfered with the control of the roaster and thus inhibited the extraction of gold. Much trial and error was required to create an appropriate roasting technique at Giant Mine. Antimony, for example, was a friable mineral and clogged up the circuit while also consuming excess atmospheric oxygen, forcing the operator to increase air flow to the roaster thereby affecting dust loss later in the Cottrell. Experience demonstrated that by removing unknown chemical variables prior to roasting, metallurgists had better control of conditions inside the roaster.

“In the old Allis Chalmers roaster, it was quite a different experience driving that thing. When you cleaned the dust chambers out, you wore a little paper mask. That’s all we wore. And we used to shovel it, open the door, and that hot dust would run out. Stuart McIelwain dancing around, his rubber boots just about on fire. You shovel it up, into the cans, set them to the side. And sometimes you would get 60 to 80 cans out of that thing. But that was dust, I’m telling you.”

– William Hall, mill shift boss

The flotation concentrate was pumped from the main treatment plant to the roaster complex where it was blended, agitated, thickened and filtered to achieve consistency in assay grade and pulp density. Slurry was fed into the Dorcco first-stage roaster by a low-pressure feed gun positioned near the top of the vessel tank. A 5,000-cfm blower supplied air to the first stage for fluidization and to support autogenous roasting (the sulphur in the ore oxidized generating the heat to fuel to process). Air entered a windbox through nearly 200 tubes (tuyeres). The first stage reactor was commonly called the arsenic elimination stage. The arsenic contained in the arsenopyrite was partially oxidized at elevated temperature (500°C) driving off the sulphur as gaseous sulphur dioxide.



Figure 7: Thickener where solution was dewatered with cyanide. (NWT Mining Heritage Society – George Hunter Collection)

Dust-laden gas left this stage by flowing through a fluoseal and air lift arrangement, into a second stage roaster compartment known as the oxidation stage. Air was forced into the second-stage roaster through tuyeres where a complete oxidizing atmosphere was created to facilitate formation of volatile arsenic oxide and to convert magnetite to hematite. Dust laden roaster gases were directed to cyclones where underflows

were water quenched and joined the bed calcine. The remaining calcine dust and gas exited the cyclones at 470°C and were air tempered to 370°C before entering the Cottrell precipitator for dust collection. Temperature and pressure was closely monitored in the roasting process. Temperature was controlled by regulating spray water through rotometers. The material left after roasting the flotation concentrate was called calcine – the gold-bearing remains of the pyrite and arsenopyrite after the majority of the sulphur and arsenic have been driven off as a gas. The calcine was composed primarily of iron oxides (magnetite and hematite).

Calcine Washing:

The calcine washing process removed excess acidic water and increased the slurry density for subsequent cyanide leaching. Roaster calcines were water quenched and reground in a ball mill in closed circuit with cyclone classifiers. Regrinding the slurry broke down the size of the iron oxides contained in the roaster calcine, further exposing the contained gold. The solution was then thickened (dewatered) and filtered, with cake repulped in fresh water and reground in a second ball mill with cyclone before reporting to the main cyanidation plant, located in the main treatment plant.



Figure 8: Drum filter separating waste from pregnant solution. (*NWT Mining Heritage Society – George Hunter Collection*)

Cyanidation:

Cyanidation was the final stage of gold leaching, whereby cyanide dissolved gold into a pregnant solution amenable to precipitation. Sodium cyanide both in the form of recycled barren solution, mine water, and fresh cyanide were added to the calcine. The solution was further agitated, thickened (dewatered), and filtered, producing a final filtrate

residue that was discarded as tailings waste. The gold was dissolved into a pregnant solution as a gold cyanide complex.

Precipitation:

All of the gold bearing pregnant solution recovered from the cyanidation circuit was combined and filtered in a lead clarifier using canvas bags coated with diatomaceous earth. Lead nitrate was added to the pregnant solution at the clarifier. The clean pregnant solution was deoxygenated in a Merrill-Crowe unit. Zinc dust was added to the solution slowing the gold cyanide complex to precipitate onto the zinc dust through a plating reaction. The zinc dust was then filtered from the solution using a precipitation press filter. The gold-bearing filtered zinc dust was removed once or twice a week and melted

to form a gold bar bullion. The solution that passed through the press was aerated and returned to the cyanidation circuit as a barren solution.

Refining:

Refining was conducted using two oil-fired furnaces to produce gold bullion bars containing about 75% gold, 20% silver, and remaining impurities. In the 1960s, the mine was pouring between six and eight gold bricks per day. Each bar typically contained between 800 to 900 ounces of gold and could weigh up to 70 pounds.

Figure 9: Cottrell plant in the roaster complex. Lloyd Ross, mill foreman, at the controls. (*NWT Mining Heritage Society – George Hunter Collection*)



Arsenic Removal:

From the start of roasting, it was necessary to collect the arsenic contained in the roaster gases and recover the gold in the fine dust mixed with these gases. The off gases from the two stages of roasting were cycloned to remove coarse engrained dust particles and then passed through an electrostatic precipitator called the Cottrell. The original process was a Cold precipitation followed by experimenting with Hot precipitation (370°C) which was determined to be a better method for dust recovery. The Cottrell used electrical energy (50,000 volts) to charge the fine particles of entrained dust in the roaster off-gases and then removed the particles from the gas stream by collecting them on oppositely-charged rods. Time-controlled rapping hammers struck the collecting and discharge electrodes to dislodge dust from the rods. The Cottrell calcine dust fell into V-shaped hoppers and was conveyed to quench tanks.

“When I first got there, the arsenic was just blowing out all over the place. And then they put the Baghouse in. They put a bag house in about five years after I arrived, and that was the first winter I’d ever seen a ptarmigan! Apparently our arsenic fumes blew over a five mile area around the town.”

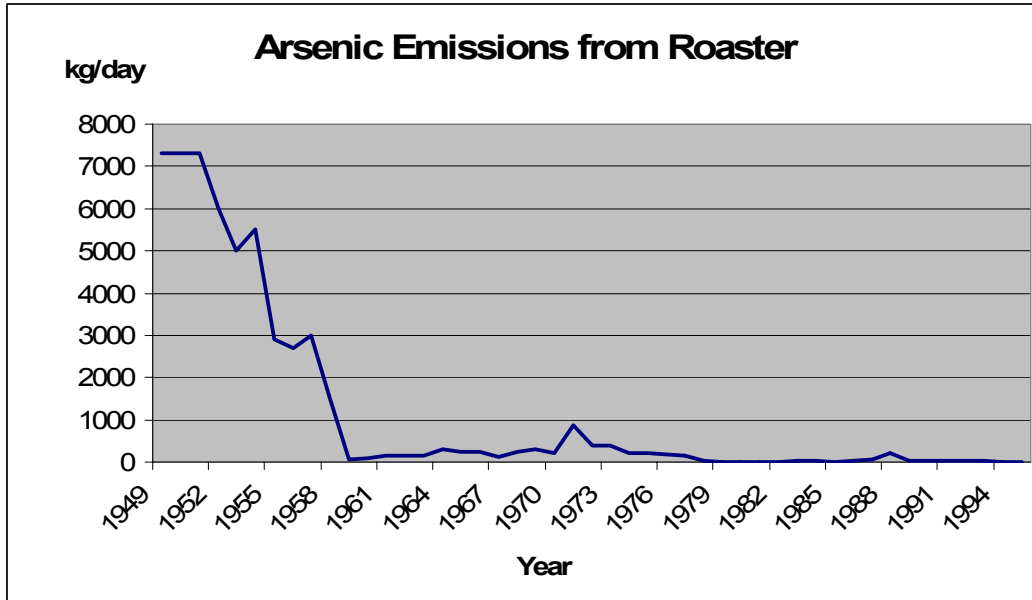
– Lorne Wrigglesworth, geologist

The tail gas from the Cottrell was cooled (90°C) by mixing the off-gas with large volumes of outside air. The cooled gas caused the formation of a solid arsenic trioxide compound. The arsenic trioxide was filtered from the gas stream in the Baghouse – a giant dust collector. The remaining gas stream, which was a dilute mixture of sulphur dioxide and air, passed through the

Baghouse fabric dust filter and was exhausted to the atmosphere through a 150-foot high brick stack. On average, 20 to 25 tons of dust was collected from the Baghouse per day,

and 12 tons from the Cottrell. The filter cloth was cleaned through a regulated shaking cycle. (Connell & Cross, 1981; Halverson, 1990)

Stack emission varied depending on the efficiency of the system. In the 1970s, about 200 kilograms of arsenic were jettisoned per day from the roaster stack, and under 50 kilograms per day in the 1980s and 1990s. Stack gas typically consisted of small amounts of arsenic, sulphur dioxide, carbon dioxide, and 10% oxygen, and 78% nitrogen. (Thomas, 1985)



Source: Department of Renewable Resources, GNWT, 1993

Arsenic Disposal and Shipment to Market:

From 1949 to 1951, arsenic produced by the roasting process was emitted directly into the atmosphere. Starting in 1951, roaster off gas was collected in the Cottrell and underground storage of arsenic begun. For most of the life of the Giant Mine, Baghouse dust was pneumatically conveyed into specially prepared underground storage vaults located in permafrost zones. Baghouse dust was typically (in weight) 85 to 95% arsenic trioxide, 1.0 to 2.5% iron, 0.3 to 0.7% antimony, and 0.10 to 0.15 oz/ton gold. After excavation of the vault, concrete bulkheads were installed to prevent movement of stored material into underground workings. The permafrost was then allowed to permeate back into the area before any Baghouse dust was placed there. The pneumatically conveying air used to transport the Baghouse dust underground was vented back into the Baghouse inlet flue. (Connell & Cross, 1981)

From 1981 to 1987, more than 7400 tons of arsenic trioxide was collected and trucked to southern markets for use in wood preservative products and a special transfer and loading facility was constructed for this purpose. The Baghouse dust was pneumatically conveyed to a 15,000 cubic foot storage silo and shipped in 1,500 cubic foot transport trucks to a

refinery in the United States. To prevent dust leakage during the silo and truck loading cycles, both the silo and the truck were vented under negative pressure back into the Baghouse inlet flue. (Connell & Cross, 1981; Silke, 2009)

Roasting operations produced an accumulation of calcine and solidified off-gases in ducts/flues that had to be cleaned out regularly. This material was typically high in arsenic content but it could not be disposed of through the Baghouse/underground storage system, and would be drummed for impound and buried in the tailings.³

Carbon Plant:

Cottrell dust historically contained up to two ounces of gold per ton, thus an early imperative was to find a method of retreatment. This dust was not amenable to standard cyanidation treatment due to its arsenic and antimony content, but a method was devised in 1960 to treat the Cottrell dust through a cyanide leach/carbon strip process. The carbon plant was located in a renovated section of the original A.C. roaster building and began commercial gold recovery in 1961. Quenched Cottrell dust was pumped to a thickener for overnight settling, and a solution of 30% solids was conditioned and processed in a 'leaching' agitator with cyanide for a period of 24 hours.

Fresh activated carbon was added to a second 'stripping' agitator. After another day, the now barren solution and pulp were separated from the carbon by screening and was discarded. The carbon was returned to the leaching agitator and the process repeated until enough gold had been collected in the laden carbon. Fresh carbon was added daily to the stripping agitator. Several times a month, the carbon with accumulated gold content was removed by screening, washed, dried, and packed in xanthate drums and marketed to a smelter. Later, the carbon was treated and refined directly on site and refined into gold bullion. (Foster, 1963)

Kiln Plant:

The Kiln Plant treated old stockpiled calcine residue wastes with considerable gold content in the summer months when the stockpile near B-shaft could be reclaimed. It ran from 1957 to 1964, and again during 1969 and 1970, when it was closed for the last time because of environmental concerns. It was a short-lived scavenger operation and did not form a normal function of gold treatment in later years. The facility was converted into the calcine washing plant.

Tailings Retreatment Plant:

In the 1980s, Giant identified a large gold resource in the old tailing waste, created because of inefficient treatment in the earlier years. In 1986, Giant Yellowknife Mines Limited was bought-out by Pamour Inc., an Australian company that had new ideas on gold recovery from old wastes. There was a seven million ton resource of tailings grading 0.070 ounces of gold per ton, containing approximately 470,000 ounces. The Tailings Retreatment Plant (T.R.P.) went into operation for the summer season of 1988 using a carbon-leaching circuit. The flowsheet was complex and the building made quite a sight

³ Information provided by Ken Hall, July 4, 2013

on the hill above Giant Mine. Six large steel agitation tanks made up the bulk of the facility, a structure that can be seen miles away in Yellowknife's Old Town. It was monstrous both in sheer size but also in the cost, with a price tag of \$15 million. The plant ran for three summers (1988-1990), processing three million tons of old wastes, but producing only 49,000 ounces of gold – far short of expectations. The T.R.P. is sometimes called 'Peggy's White Elephant' referring to Royal Oak president Peggy Witte; however Royal Oak bought the Giant Mine from Pamour in 1990 and had nothing to do with the construction of the T.R.P. – in fact, Royal Oak made the decision to shut down the unprofitable plant in 1990. (Giant Yellowknife Mines Limited Annual Reports, 1986-1990)



Figure 10: Albert Hall with roaster temperature monitor. (*NWT Mining Heritage Society – George Hunter Collection*)

Employees:

A highly skilled contingent of men (and later women) worked in the treatment plant to keep the facility operational. In the 1950s, there were up to 50 people on the payroll with responsibilities for mill operation. These included (in 1952) a mill superintendent, a mill clerk, a mill foreman, up to five mill shiftbosses, four assayers, amalgamator, a crusher operator and helper, three ball mill operators, three flotation operators, eight roaster operators, 12 mill helpers, four solution operators, and a Cottrell operator. Most of the mill machinery operated every shift (three 8-hour shifts per day) but some of the circuits only operated one shift per day – for example the crusher and the Cottrell plant, thus requiring only a minimal crew. There were also a maintenance crew which included, in the 1950s, a mill oiler (who made sure moving equipment was well-oiled) and a pipefitter. The hourly-workers made wages of between \$1.06 to 1.21 per hour in the 1950s (compared to wages of up to \$23 per hour in the 1990s).

In the 1970s, as the treatment plant aged, a larger crew was required under the supervision of the mill mechanical foreman to take care of ongoing repairs. Around the same time, staffing in the treatment plant changed with more focus on automation of equipment requiring less supervision and thus fewer employees on payroll.

Notable Incidents

Arsine Gas Poisoning:

Over a period of a week in April 1954, 21 men working in the treatment plant out of a crew of 24 were hospitalized. It was quickly determined that a toxic condition existed in the mill building which was immediately addressed. Patient symptoms included nausea,

weakness, changes in complexion, and low blood count of hemoglobin. Symptoms suggested the toxic substance was arsine gas (AsH_3), confirmed by detection in the building atmosphere. Only at one location in the mill did tests show arsine gas to be concentrated enough to be toxic, and this was at the point of discharge of the barren solution from the zinc precipitation presses. The company installed proper ventilation of this area to prevent toxic buildup of gases, and all the men recovered and returned to work.

Roaster Blast:

In the 1970s (exact date uncertain), the underground crews were getting ready to make their final blast of an arsenic disposal raise behind the roaster complex. Accounts of the incident differ but likely the mill workers on night shift were not notified of the upcoming blast, and the underground crews may have used too much explosives. Workers in the roaster and mill recount the moment of the explosion, which violently shook the buildings, tossing around workers, kicking up arsenic dust, and blowing out most of the windows from the mill and roaster complex. Incredibly, nobody was seriously injured.

#7 Agitator Destruction:

In the 1990s, one of the original agitation tanks in the mill burst due to severe corrosion of the metal bands. Employees claim they had warned management about the safety of the bands on the old agitators for many months leading up to the incident. The tank, which was full of cyanide solution at the time, blew apart flooding a section of the mill and taking out stairs and gangways. Luckily, there was nobody in the area at the time.

Work Related Fatalities:

There were only a few known fatalities associated with ore processing and treatment operations. Most fatalities at Giant Mine occurred underground. In 1956, a carpenter fell from a scaffold onto the cement floor while building cyanidation tanks in the mill. In 1957, a crusherman was caught in a conveyor belt and pinned between equipment.

Arsenic Illness:

The health impacts of arsenic are varied depending on the dose. In humans, arsenic is toxic at minimum dose level ranging from 70-180 milligrams. Ingestion of dose levels below the lethal threshold produces a range of health effects including vomiting, diarrhea, muscle pain, skin rashes, and paresthesias. Arsenic emissions from the Giant Mine during its early operations posed a health hazard to the community until more strict environmental controls were instituted. Arsenic trioxide is soluble in water, and would have posed a health threat to organisms who drank from, and potentially those that lived in, streams, lakes and puddles contaminated by falling arsenic dust. Illness within the local Dene population was reported in the 1950s. There is one documented case of a two-year old Dene boy dying in April 1951, plus several more anecdotal accounts of deaths in the Dene population around the same time. Dogs and local dairy cows were also reportedly killed by drinking contaminated ponded water. (Sandlos & Keeling, 2012) Government-mandated improvements in arsenic capture as part of the gold recovery process put a stop to dangerous levels of emission, and despite considerable concern in

the 1970s about the measure of public exposure to arsenic pollution there were no further official reports of serious illness or death. Mill employee surveys in 1975-1976 by the government through urinary and hair tests further showed that arsenic exposure was not severe although skin rashes in mill employees were a common symptom of direct contact with arsenic. (Department of National Health & Welfare, 1977)

The Roaster Today

The treatment plant at Giant Mine has been inoperable since November 1999 when the final ores were put through the mill and roaster circuits and the last gold bricks were poured. Miramar Mining continued to mine gold ores at Giant until July 2004, and while the ore was crushed here, the rock was trucked to the Con Mine on the south side of Yellowknife for processing. The aging treatment plant was no longer fit for duty and would require significant upgrading to make it economic and environmentally compatible with modern gold milling practices.

While some gold-bearing material was salvaged by Miramar during its tenure, little work was done inside the mill and roaster buildings. Left to the elements, the structures now pose a significant safety hazard, made all the more serious by its arsenic contamination. At closure of the mill in 1999, several hundred tons of 'arsenical materials' were left in ducts and caked onto the bottom of roaster tanks. Upwards of 3000 tons of material with significant arsenic content is believed to still remain inside the roaster buildings today. (Northwest Consulting, 2003) In the summer of 2013, work began under the direction of the Federal Government to decontaminate the roaster complex as part of its first stage of site remediation. In 2013 and 2014, the roaster buildings – including the A.C. Roaster, Dorco Roaster, Cottrell, Baghouse, Kiln Plant/Calcine Washing, arsenic silo, and brick stack, will be carefully cleaned of arsenic and asbestos materials and finally dismantled, removing from the Yellowknife landscape one of the most interesting metallurgical experiments in Canada and a source of great contamination.

Chronology

- 1935, July – Giant group of mineral claims are staked by Johnny Baker and Hugh Muir.
- 1947, September – Excavation and concrete work for the treatment plant (crushing, mill, and roaster) foundation is completed.
- 1948, May – First ore is processed in the treatment plant using a gravity, amalgamation, flotation process. Flotation concentrates are stockpiled awaiting completion of roaster.
- 1948, June – First gold brick is poured at Giant Mine.
- 1948, August – Inaugural gold brick pouring ceremony is held at Giant Mine official opening.
- 1948, October – Treatment plant is now powered by Snare River Hydro Plant.
- 1949, January – Allis Chalmers hearth roaster and calcine cyanidation circuit in operation to treat flotation concentrates. Arsenic dust is first emitted from the roaster stack over the Yellowknife environment. An estimated 7,300 kg of dust per day is sent up the stack.
- 1951, October – Cold Cottrell plant is commissioned to eliminate or at least reduce arsenic dust emissions. First arsenic trioxide is discharged to underground storage.
- 1952, April – New Dorrco fluo-solids roaster commissioned.
- 1952, September – Treatment plant is enlarged to process 700 tons of ore per day.
- 1953, October – New brick roaster stack is completed to replace original steel stack which is corroded out.
- 1954, April – Twenty-one mill employees are hospitalized for arsine gas poisoning due to insufficient ventilation in the treatment plant, where gasses had accumulated from precipitation process.
- 1955, February – Hot Cottrell precipitation plant is commissioned to improve arsenic dust capture and to recover potential gold-bearing dust. Unit is converted to cold temperatures almost immediately due to poor performance in arsenic dust collection.
- 1956, April – New cyanidation circuit for the treatment of flotation tailings is commissioned, recovering nearly 7,000 ounces of gold that would otherwise have been jettisoned as waste in its first year.
- 1957, January – Backfill plant which combines mill tailings with cement for pumping to underground stopes is commissioned.

1957, November – Kiln plant to treat calcine residues (grading 1.7 ounces gold per ton) is commissioned.

1958, November – New two-stage Dorrco roaster plant is commissioned. Gold recovery improves for the first time in years. A Baghouse is placed in operation to further remove arsenic from process gases, with the stack now releasing less than 100 kg of arsenic dust into the atmosphere per day. Ore treatment capacity is now 1,000 tons per day.

1958, December – Amalgamation process is discontinued as only 1% of gold is free-milling.

1959 – One Cottrell is converted back to Hot precipitator.

1960, June – Hot Cottrell gas dust is treated with an experimental carbon-strip circuit to recover fine gold.

1961, May – A commercial carbon-strip circuit is begun in the renovated A.C. Roaster building to treat Hot Cottrell gas dust.

1962 – Giant's union negotiates 'arsenic time' pay premium for all hazardous work to be completed while on roaster cleaning or maintenance. Both Cottrell precipitators converted to run as Hot Cottrell units.

1963, February – It is realized that the Dorrco roaster is over designed for the concentrate volume being treated, and the interior of the roaster vessels are relined with brick to decrease their internal diameter.

1964 – Kiln plant closes.

1967, June – Cyanidation of flotation tailings is discontinued.

1969-1970 – With higher gold prices, the Kiln plant re-operates during the summer months only to retreat low-grade stockpiles of calcine and is shut down permanently due to environmental concerns.

1971 – Continued rise of the free market price for gold resulted in gold sales being switched from the Royal Canadian Mint to the open market.

1974 – Open pit production is added to mill feed representing much lower-grade material. The efficiency of the treatment plant is adversely affected by shortages of ore, lower grades, and resulting lack of concentrates. The roaster vessels are again bricked-in to decrease the overall diameter, helping to achieve maximum velocity for the volume of concentrate being processed.

1975/1976 – Government and independent testing of Yellowknife residents and mine and mill workers (hair and urine samples) suggests that public exposure of arsenic is not

severe, and that symptoms exhibited by occupational exposure is not necessarily typical of arsenic poisoning.

1977 – Research reveals that collection of arsenic dust from the Baghouse is poorest during automatic shaking cycle, possibly because filter bag shaking dislodges fine-grained arsenic from entering stack emissions. The shaking cycle is converted from a timed cycle to a pressure drop cycle reducing the frequency of bag shaking from 32 to four times per day and improving overall Baghouse collection efficiency.

1979 – Lower grade, sulphur deficient ores continue to affect roaster operations. Research continues to determine how best to adapt the roaster to lower grade ores now being mined. New Environment Canada standards for emissions in gold roasting are announced. Due to improvements in operating procedures, Giant Mine reports it can meet these standards.

1980 – Significant repairs and replacement of roaster equipment is completed. New filtering systems are installed in the Cottrell and Baghouse to improve safety and health conditions. The mill is non-operational during a summer labour strike.

1981 – Gold recovery drops to 83% from 86% in 1980. Extensive research is performed to improve operations, with modifications to the treatment plant including new flotation cells and expansion of the carbon plant. A new water treatment plant substantially reduces cyanide, arsenic and heavy metals in the final effluents. Shipments of arsenic trioxide begin to United States markets.

1983 – Very high antimony levels in the ores results in multi-failures of the roaster. A carbon-column recovery unit is installed at the final decant point from the tailings area to capture trace amounts of gold in the effluents.

1985, November – Giant Mine pours gold bar #10,000.

1986 – Falconbridge sells its interest in Giant Yellowknife Mines Limited to Pamour Inc., an Australian consortium.

1987 – Arsenic trioxide shipments to market cease.

1988 – A tailings retreatment plant (T.R.P.) begins operation using a carbon-leach method to recover gold from historic tailings, deposited in the 1940s-1950s when gold recovery from the treatment plant was very poor. An estimated seven million tons of waste containing 470,000 ounces of gold was available. Cost of the facility was \$25 million.

1990 – Royal Oak Mines acquires control of Giant Mine. Many cost-cutting measures are imposed including shutting down of the tailings retreatment plant which processed a total of three million tons but only recovered a meager 49,000 ounces of gold.

1992-1993 – Gold treatment operations continue at Giant Mine despite a long labour strike.

1999, November – Giant Mine shuts down treatment plant operations following bankruptcy of Royal Oak Mines.

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All stories from William Hall, Ken Hall, Alec McBeth, and Lorne Wigglesworth collected by Ryan Silke in 2009 and 2011.

Appendices

William Hall complete story – collected by Ryan Silke, 2009

Giant Yellowknife Mines Milling Flow Sheet, May 1969

Story by William Hall

– collected by Ryan Silke June 2009 –
Based on original transcription of audiotapes

I started on the 28th of April 1957. I just went into the mill as a labourer and continued from there for years and years. My first wages in the mill was \$1.51. We worked seven days a week. The big incentive for that was time and a half for Saturday and Sunday. I ended up being a shift boss there in charge of the whole flipping place.

When I first went there, they used to do the grinding circuit, flotation, and then they pulled off the flots and went for roasting. All the discharge from the bottom part of the flotation went to what they used to call flotation tails circuit, and they used to cyanide that. That was just the waste ore but there was still some gold in it. We had two circuits. We had the calcine circuit which left the roaster and come back as calcine after we roast it., and we had the flotation tail circuit they called it. They had the amalgam, and they had the jig pumps at the ends of the ball mills. Jack Robertson, he was an amalgam man at that time. That was the very first thing they did away with was the amalgam, then they did away with flotation tail circuit.

On dayshift, there was always mechanics and pipefitters and electricians running around. At one time, there was five in the mill, two in the roaster, then you had four down in the crusher...so that was 11 people on nightshift, plus the shiftboss. Then they went to three people in the crusher, two in the mill, and one in the roaster, because they eliminated the roaster helper. On dayshift, they had people in the Cottrell and Baghouse, because that was a separate circuit. Manpower took a beating, but they were expected to do more work. They didn't really make the mill more efficient, they just eliminated the help.

I was a helper in the A.C. Roaster, and then I started operating the A.C. Roaster. Next door to it they had the first old Dorrco roaster, which was one tank with a wall in between the first and second stage, and just a little hole in it, like a port, and it used to roast here, flow through, and roast here, and then out. And then they decided they were going to build a new Dorrco roaster with two full stages with a discharge pipe between the two. They eliminated the old A.C. and the old Dorrco. But I ran that sucker for years. I was one of the first operators on the new one after I learned the old one, then they built the new one and I was right into that. I was 18 years in the roaster. I knew quite a bit about the old roaster I can tell ya.

After we got the new Dorrco going, they went and checked the old, old tailings pond from years ago, the old tailings from the calcine circuit. It was not mixed with the tailings from the flotation, it was just calcine discharge. They ran that over by B-shaft and they filled ponds over there with calcine. That's where the Kiln plant came in. The mill was so inefficient at the time they were doing that, that they were losing a lot of gold. That stuff sitting there leaching over the years with the cyanide and everything that was still in it, there was lots of gold in it. But how do we get it outta there? So they built the Kiln plant,

which was a long cylinder. It revolved and they had a big blast furnace in at the end roasting this stuff. For the first year they only ran it in the summer, and then they built more and they used to run it year round. They dug a big hole, they put a pump in the bottom and a box around it, and then they started hosing the tailings and running it into the box. They thickened it and then they agitated it and then they run it over a big drum with string filter. There's a scraper and air blows, and it blows the feed off onto a belt. They dried it and then it fell down onto the belt and into the Kiln, and they re-roasted it. When they first started it, it clinkered up on them so badly they ended up having to put a ball mill in there, so they re-grind it before they sent it back to the mill. Then they started adding cyanide into that ball mill over there, grinding it in cyanide solution, pumping it to the mill and it went into another thickener over there and then over more filters to get the gold out of it.

The old Kiln plant, when it was running, I mean I've seen dust. But man, when that place plugged up, you couldn't see your hand in front of your face when it would start dusting. They decided they'd put in a new discharge fan. Well this fan they put in was like a jet engine. Well, they fired it up. We had no dust. It was gone. It was like POOF. And it's all outside, but you know how long that lasted? It never lasted an 8-hour shift. It was sucking so much dust through those blades it just ground them right off. There was nothing left but the shaft. All the blades that were in that thing, they were just dust, they just disappeared. She lasted eight hours.

The mills used to have steel liners and steel balls. And you get steel on steel crushing rock, well it wore a lot of stuff down. Then they went to rubber liners. And that was a lot quieter! This is why I'm wearing hearing aids today, is because of the loud mills that I worked around and the blowers in the roaster and stuff. It was just unbelievable.

I was over in the roaster one day and my helper, he was going over to pump the Baghouse arsenic dust underground. He just got up to go and check, cuz he already got things going over there, and what was it, two o'clock in the morning? He was just reaching for the door handle to go out of the panel room and, I'm telling you, to this day I swear, the floor in the roaster came up a foot, and went back down. There was dust flying all over, you couldn't see anything. Well, my helper, he turns around, and his eye balls are as big as saucers... 'What is this!??' Well, I said, 'I don't know but we'd better check.' ...because we are running around checking everything to make sure everything is still running. I said, 'You go check the Baghouse.' He goes over to the Cottrell, he opened the Cottrell door...he couldn't believe it, there was just dust all over the place.

That was when they blew the raise to surface to let the arsenic down. Jack Robertson phoned me, and he said 'How's the roaster?' I said, 'What happened over there?' He said, 'Underground just blasted a hole through.' I said 'Ohhhh'. My boss Lloyd Ross comes in the morning and he drove through there and you know just never noticed a thing. He goes into the Cottrell and there's dust all over. The building shook so bad that all the dust fell off all the beams and everything, it was four inches thick on the floor. Well, he comes over to the roaster to see, and he's all over me like a dirty shirt. 'What did you guys do in the Cottrell???' I said, 'We didn't do anything.' He said, 'What do you mean.' I said,

‘Underground did that!’ ‘What did underground do??’ I said, ‘Well they blasted a hole through and shook everything and all the dust fell down. You just drove past the mill, didn’t you notice anything? Go have a look, all the windows are gone!’

In the old Allis Chalmers roaster, it was quite a different experience driving that thing. When you cleaned the dust chambers out, you wore a little paper mask. That’s all we wore. And we used to shovel it, open the door, and that hot dust would run out. Stuart McElwain dancing around, his rubber boots just about on fire. You shovel it up, into the cans, set them to the side. And sometimes you would get 60 to 80 cans out of that thing. But that was dust, I’m telling you.

Lloyd Ross wouldn’t believe what the temperature on the roaster panel was telling him. Joe Zuppan didn’t speak that good of English, couldn’t understand two words, and if the boss says you do it, you do it. He hands Joe a thermometer and he said, ‘Go in there and stand up and hold this thing up and get a true reading.’ Well as soon as Joe stood up, his ears....He comes out of there with big blisters all over his ears. He said, ‘It’s definitely hot!’

The antimony really fouled up the roaster. Antimony will melt at a lower temperature than gold will. And if you don’t keep the air up in the roaster, it forms a hard shell over it. When you don’t get the air through it, you don’t get the movement, and you had to shut the roaster down to clean it out. So when underground wanted that stuff because it was reading high in gold, we tried to talk to them. ‘Look, you’re gonna give us antimony, you know where it is, you guys are mining it. Give us one car of antimony ore, ten cars of good ore, then one car of antimony ore, ten cars of good ore.’ If they mixed it, a little here a little there, we could handle it a lot better. But it took a long time to get it through their heads, that this is what you had to do. You had to run higher air on your roaster when that was happening which the lab didn’t like because as soon as you run higher air you can actually glaze the little particles of rock that have the gold in. You can put a burnt glaze over it, then the cyanide can’t get in there to cut the gold out. You lose it anyway. If it worked really well and we got good cooperation from underground, then we could handle it. But sometimes they’d send ten cars of antimony ore and one car of good ore and then we got an awful load of concentrated antimony in the system and you’d have problems with the roaster.

In the roaster we were always in hazardous stuff. If you had a plug up or something in one of the tanks, you had to shut the roaster down and clean it out. Dust flying around and stuff...it’s amazing, you know, really when you think about it. We didn’t even wear dust masks to clean those things out. And I’ve been checked out. After I got out of there, they checked me out...nothing, I got nothing.