

Background

The original Giant group of 21 claims were staked in July 1935 by C.J. Baker and H.M. Muir for Burwash Yellowknife Mines Ltd. Giant Yellowknife Mines was incorporated in August 1937 to develop the property. Frobisher Explorations took over management control in 1943 and between 1945 and 1947 three shafts were developed and the mine infrastructure had been constructed. The first gold brick was poured at Giant in May of 1948.

By 1949, an Edwards type hearth roaster had been brought on line to treat arsenopyrite gold bearing ores. From 1949 to 1951, approximately 7,400 kilograms of arsenic per day were released to the air from this roaster. In an effort to reduce arsenic emissions, the Sherrit Gordon leaching process was investigated in 1950 as an alternative to roasting the refractory ores. In October 1951, upon orders from the Government of Canada, a cold Cottrell Electrostatic Precipitator (ESP) was added to the process stream to remove a portion of the arsenic trioxide from the roaster gases. The arsenic trioxide dust was placed in a mined out stope for storage.

In 1952, a two stage slurry roaster was installed to replace the hearth roaster. The new roaster allowed the milling rate to increase from an average of around 400 tons per day (tpd) to approximately 700 tpd. Data for arsenic releases to the air were not available for 1952 or 1953, but in 1954, 5,500 kg/day were being released. In 1955, a hot Cottrell ESP was installed in parallel with the cold Cottrell. Arsenic releases in 1956 are estimated at 2,900 kg/day. Also in 1956, Giant investigated the use of pressure leaching to treat the mill concentrate.

A higher capacity two stage fluidized bed slurry roaster was installed in 1958. Subsequently, the milling rate was increased to approximately 1,000 tons per day. A Dracco baghouse was added at the same time to improve the arsenic trioxide collection efficiency. Arsenic releases dropped to 52 kg/day in 1959. In subsequent years, arsenic releases ranged between 75 and 880 kg/day.

The last significant physical change to the roasting/dust collection process occurred in 1962 when the cold Cottrell ESP was converted to a hot ESP. Since that time, the dust control system has undergone operational modifications to improve collection efficiency, but the overall system today is essentially the same as it was in 1962.

Until 1977, there was very little market for arsenic trioxide, and the dust produced at roasting operations was generally stored in sealed stopes. Improving market conditions in the late 1970's provided an incentive for arsenic producing mines to market their by-product. In 1979, Giant began researching methods for producing a marketable grade of arsenic trioxide, and in 1980 signed a contract with Koppers Corp. of Pittsburgh, Pa. for sale of crude arsenic trioxide from the mine. Construction was begun on a transfer facility to accommodate Koppers transport vehicles. The scheduled completion date was early 1981.

Shipping of crude arsenic trioxide commenced in February of 1981. A total of 1,205 tons were shipped that year, and test work was begun to determine the feasibility of increasing production by accessing the arsenic trioxide stored in the underground stopes.

A total of 6,700 tons of arsenic trioxide were successfully sold from 1981 to 1986. At this time, Koppers stopped purchasing crude arsenic trioxide due to the falling prices of commercial grade arsenic trioxide and the high cost of disposing of their treatment residue. Giant began researching methods for producing commercial quality arsenic trioxide.

A fuming process, commonly called WAROX, was chosen as the purification method. It was expected that the process would use a 50:50 combination of production dust and dust taken from the underground storage chambers. A production decision was expected in late 1990, and a 7,000 ton per year plant was to begin operation in 1991.

In November 1990, the Giant mine was purchased by Royal Oak Mines Inc. The WAROX program was discontinued shortly thereafter.

The Con mine roasted refractory ores in Yellowknife. In August 1949, a wet scrubber was added to the process to remove arsenic from the roaster gases. The resulting slurry was pumped to storage basins where it settled to produce an arsenic trioxide sludge. In 1970, Con began mining non-refractory ores and the roaster was shut down. Concern

regarding the potential environmental health hazard associated with the arsenic storage basins prompted the NWT Water Board to attach a condition to the 1977 water licence requiring that the mine develop a plan to reclaim all arsenic trioxide storage areas on the property. In 1983, a hot water leach program was begun with the dual objective of purifying the arsenic trioxide sludge into a saleable product and recovering the entrained gold and silver values. Process difficulties were encountered, and ultimately the sludge was treated in an autoclave constructed in 1991.

The Campbell Mine in the Red Lake district of Ontario has a similar history. Refractory ores were roasted from 1951 until 1973, during which period, approximately 3.1 tpd of arsenic was released to the air. In 1973, vegetation studies found that leaf damage attributable to arsenic was found on most aspen trees within approximately 6.5 km of the release point. An ESP and baghouse were installed in late 1973 and the collected arsenic dust was directed to former production stopes for storage. This procedure continued until 1991 at which point the roaster was replaced with an autoclave. From 1981 to 1987, the crude arsenic trioxide was sold as feedstock to other industries. The company currently has between 40,000 and 50,000 tons of arsenic containing dust stored underground.

In October, 1997 the Giant Mine Arsenic Trioxide Management Technical meeting was held in Yellowknife. The meeting objective was to provide a venue for government agencies to develop a sound technical understanding of the situation at the Giant mine. As a first step towards developing a management plan for the arsenic trioxide, research was initiated by both Royal Oak Mines and DIAND to fill in the technical data gaps identified during discussions at the meeting.

In April 1999, Royal Oak was placed into receivership.

The mine site at Giant has been operating for over 50 years. During this period, steps were taken to control the arsenic according to the technology and understanding of the day. If construction of a treatment plant using the current level of technology were begun immediately, it would still be several years before it could begin operating. Due to the large volume of material to be processed, it may be another 10 or 20 years before the arsenic trioxide can be completely treated.

Summary of Previous Workshop

A technical meeting was held October 28-30, 1997 which included participants from federal, territorial and municipal governments, along with representatives from the mining industry, health, various universities and the private sector. The focus of the technical meeting was to, first, develop a common understanding of the history of the mine, the gold processing, the by-product (arsenic trioxide) and current storage procedures. Secondly, technical experts in the fields associated with various aspects of arsenic trioxide provided an information base from which discussions and management options could be determined. The following is a summary of the key issues touched upon during the October 1997 workshop.

1. Extraction

Giant Mine's current gold extraction method produces approximately 10-13 tons per day of arsenic trioxide containing dust from its roasting process. This dust contains an average of 78% arsenic trioxide by mass and an average of 0.5 ounces of gold per ton. The product is pneumatically conveyed underground to a depth ranging from 75 to 250 feet below surface where it is stored in rock vaults. Five of the underground containment locations are former production stopes and are irregular in shape. All other storage vaults were constructed specifically for the purpose of storing the arsenic trioxide and have a more regular rectangular shape.

2. Underground Storage

The arsenic trioxide dust is currently stored in 15 underground storage vaults or chambers. Design of these chambers was to consider the following criteria: the chambers were to be developed in permafrost; chamber accesses or openings were to be bulk-headed in accordance with the Mine Safety Act; the storage areas were excavated in competent rock; the area was to be dry before arsenic trioxide storage proceeded.

If underground storage of the arsenic trioxide is considered an option, several operational refinements could be considered:

- move the arsenic trioxide to a deeper level
- treat in-situ
- provide a new underground area for storage
- consider developing preferential pathways for groundwater and relocate Baker Creek. This will require geotechnical, hydrologic and hydrogeologic studies.

3. Transport and Handling of Arsenic Trioxide

Should the decision be made to treat the arsenic trioxide, either for purification and further gold extraction or as a stabilization process, removal from the underground storage chambers to surface, surface transportation and temporary surface storage will be required. The challenges to be overcome in removing and transporting the dust to the surface include: confining the dust to prevent contamination during movement; minimizing worker exposure; applying removal techniques to variable stope geometries and material characteristics; and cleaning/securing the storage chambers for abandonment. Technologies under consideration include: vacuuming, slurry pumping, remote "clam" mining and drawpoint mucking. Surface transportation could be via truck or using an upgraded pneumatic system similar to what is currently being used. Surface storage could be carried out in a number of ways. The material could be stored in drums or bags, in existing decommissioned TRP storage tanks (80% usable capacity), or in a facility constructed specifically for the purpose.

4. Material Processing/Upgrading for an Economic End Use

Before arsenic trioxide can be successfully sold on the open market, it must be processed to a minimum of 97% and preferably to 99+% purity with contaminant concentrations in the range of:

- 0.05 - 0.30% Sb,
- 0.025 - 0.03% Fe
- 0.001 - 0.1% Cu.

There are several methods available to achieve these levels.

- The arsenic trioxide can be evaporated at a temperature of around 193 °C while impurities remain as solids until temperatures in excess of 1000 °C. The purified arsenic can then be condensed out in brick cooling chambers, air-cooled condensers or a cold air quench.
- The arsenic trioxide can be dissolved using a solvent which solubilizes the arsenic at a higher level than the impurities. The arsenic trioxide is then crystallized out in a purified form. Hot water, ammonia and methanol have all shown promise for use as solvents in this process.
- In the late 1980's work on a variation of the evaporation method was begun at Giant Mine (WAROX filter). A sintered metal filter was used to remove impurities from the arsenic trioxide vapour exiting the baghouse. Difficulties were encountered meeting antimony and iron specifications, and the process was never fully developed.

All of these processes leave behind a residue which will probably contain some arsenic as well as the other contaminants, and consideration must be made for disposal of this material.

5. Arsenic Trioxide Stabilization

Due to the relative uncertainty of the world arsenic trioxide market and the presence of arsenic in waste streams from any purification process there may be a need to develop a process to stabilize arsenic trioxide for long term storage. Arsenic trioxide can be converted to less soluble arsenic compounds such as ferric arsenate or arsenic sulfide using an autoclave, a microwave reactor or, if the volumes were small enough, biological processes. Arsenic sulfide is considered stable on an indefinite basis if it can be kept under anaerobic conditions as it oxidizes and solubilizes in the presence of oxygen. Ferric arsenate, however, does not require specific storage conditions.

Arsenic trioxide can also be encapsulated in a cement medium to increase its stability. The use of Portland cement alone, however, does not allow for a very high loading rate (1% arsenic trioxide). On the other hand, when used in combination with additives such as zeolite capacity is considerably increased potentially providing a viable storage alternative. In order to encapsulate the amount of arsenic stored at Giant, however, an excessive amount of cement would be required.