

FAX TRANSMITTAL

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SUBJECT: Giant Mine Arsenic Trioxide Technical Workshop
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May 13, 1999

By Fax**To: Steve Schultz
Royal Oak Mines**

Your file Votre référence

**Re: Requested Attendance for a Technical Workshop
on the Management of Giant Mine's Arsenic Trioxide**

Our file Notre référence

The Department of Indian Affairs and Northern Development (DIAND) is holding a workshop of experts to review and discuss the technical aspects of management options for treating the arsenic trioxide stored underground at the Giant Mine site in Yellowknife, NT. This relates to the developed management options from the workshop held 18 months prior. The objectives of this meeting are enclosed in this information package. The workshop will be held on June 22, 23, and 24, 1999 in the Katimavik Room B of the Explorer Hotel in Yellowknife. Your attendance at this meeting is requested but should you be unavailable, we would appreciate that a representative from your agency attend. This person should be familiar with and be capable of discussing the issues.

The focus of the technical workshop will be to, first, present a detailed overview of the range of available engineering and scientific options explored to date. Second, a draft evaluation matrix will be developed for assessment of the various options using engineering and scientific criteria as well as other key evaluation criteria. The participants will amend this matrix to achieve agreement on appropriate assessment for the evaluation and identification of viable arsenic trioxide treatment options. Third, the participants will determine which options are the most promising and appropriate, based on the assessment criteria, and which should be further developed for potential use at Giant Mine. Finally, the participants will identify and discuss what needs to be done to take the selected option(s) to a level of confidence that could permit development of a formal environmental assessment. This will include the development of a detailed *Action Plan* for each viable option.

Dillon Consulting Limited has been retained by DIAND to facilitate and organize this workshop. Should you have any questions, please contact Gary Strong of Dillon by phone (867) 920-4555, fax (867) 873-3328, or e-mail at gstrong@dillon.ca. Neill Thompson of DIAND can be contacted by phone (867) 669-2653, fax (867) 669-2716 or e-mail at thompsonn@inac.gov.ca.

Please return a completed attendance form (attached) to Dillon Consulting Ltd. by May 25, 1999. The purpose and objectives for this workshop, background information on the mine, and a summary of the proceedings of the previous workshop are enclosed for your review. A list of presenters, their abstracts and an agenda for the meeting will be forwarded to the participants once we have confirmation of attendance.

Thank you for your consideration of this important request. We look forward to your participation.

Yours sincerely,

Neill Thompson
Special Project Manager
Water Resources Division
Department of Indian Affairs and Northern Development
attachment

Canada

*Giant Mine Arsenic Trioxide
Technical Workshop*

May 13, 1999

Giant Mine Arsenic Trioxide Technical Workshop

June 22 - 24, 1999

Katimavik Room "B", Explorer Hotel, Yellowknife

Workshop Purpose and Objectives

Context

The *Giant Mine Arsenic Trioxide Technical Workshop* is a key part of a commitment to a broader *Giant Mine Arsenic Trioxide Management Strategy* being led by the federal government. The *Management Options and Technical Assessment Workshop* is a key element in developing the engineering and scientific aspects of the broader *Management Strategy*. Other elements of this *Management Strategy* will address: public information and communication; public health and safety; environmental safety; future ownership and operations; and, legal liabilities. Taken together, the elements provide the basis for informing the public and addressing the issues related to the management of arsenic trioxide.

Workshop Purpose

The workshop will develop evaluation criteria and a comparison matrix to assess engineering and scientific options for the management of arsenic trioxide at Giant Mine. An *Action Plan* will identify what the most promising options are, what needs to be done to more fully develop the most promising and appropriate option(s), including addressing data gaps, tasks, responsibilities, required resources and time lines.

Workshop Objectives

The *Management Options and Technical Assessment Workshop* is intended to achieve the following specific objectives:

- Outline the commitment to and elements of a broader *Giant Mine Arsenic Trioxide Management Strategy* being led by the federal government
- Provide an historical overview of arsenic trioxide management at Giant Mine and the chronology of events related to the work completed to date on arsenic trioxide management practices and options at Giant Mine, including a summary of the legislative and regulatory regime, operational, geophysical, engineering & environmental parameters and the associated issues and challenges

*Giant Mine Arsenic Trioxide
Technical Workshop*

May 13, 1999

- Confirm the proposed objectives of the *Giant Mine Arsenic Trioxide Management Project Description*. This will include an outline of the planning, and anticipated environmental review and decision making process
- Present a detailed overview of the range of available engineering and scientific options explored to date, including existing issues, data gaps, and work (ie. research and technology development; marketing and feasibility studies) in progress related to the various options
- Present and discuss a comparative matrix to *assess and rank* the various options using engineering and scientific criteria as well as other key evaluation criteria including economic, health and social factors that need to be considered
- Amend the comparative matrix (as necessary) to achieve *agreement* on suitable and appropriate assessment criteria for the evaluation of arsenic trioxide management options
- Based on objective application of the assessment criteria determine which arsenic trioxide management option(s) are the most promising and appropriate
- Identify and discuss what needs to be done to more fully develop the selected option(s), including the identification of data gaps. This will include the development of a detailed *Action Plan* identifying tasks, responsibilities, required resources and time lines
- Present the findings and results of the workshop to the public and interested organizations

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 Sheritt 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.

Giant Mine Arsenic Trioxide Workshop Presentation Guidelines

The options for Arsenic Trioxide management will be rated against each other and against criteria developed and agreed upon at the workshop. The evaluation criteria matrix will be confirmed in Day 1 of the workshop. Each process must meet the minimum performance criteria in order to be considered further. Once it has passed these minimum criteria, each process will be evaluated against the others using the desirable criteria as a guideline. To allow for evaluation, your presentation shall respond to the following questions:

Minimum performance criteria

Process Understanding:

- Is the process a proven technology?
 - *Does the process provide a permanent solution to arsenic management?*
 - *Can implementation of the process be completed within 50 years?*
 - *Can the process be operated in the Yellowknife environmental conditions?*

Public Health and Safety:

- Has the process been proven safe in upset conditions?
- Has the end product been proven to be stable?

Desirable criteria

What are the risks of this process?

- Has this process been used for As_2O_3 before? Has it been used in a similar environment?
- What level of confidence is there in the data/information available?
- What are the safety issues for workers during normal and upset conditions?
- How vulnerable is the process to upset?

What is involved in the operation of this process?

- What reagents are required, what is the source of these reagents?
- Can this process replace the roaster?
- How flexible is the process to changes in feedstock quantity and quality?
- What is the level of recovery of arsenic and gold?
- What is the product production rate (in terms of tons/day As_2O_3)?

What are the possible environmental impacts associated with this process?

- What is the displacement/disruption of natural features?
- What are the land/space requirements?
- What is the volume of the stored end product material?

What are the costs associated with this process?

- Capital costs?
- Overhead & maintenance costs?
- Closure costs?
- Revenue?

A 3-5 minute summary at the end of your presentation is strongly recommended.