KENT MORTON
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Giant Mine

Arsenic Trioxide Reclaim Project Overview

draft

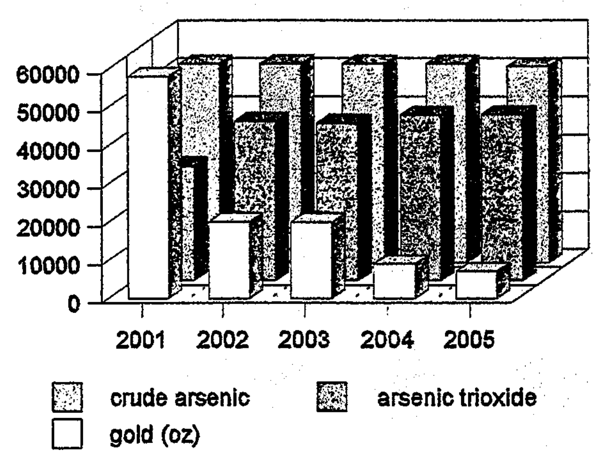
Arsenic Trioxide Reclaim Project

Table of Contents

Summary

The Warox Project of a decade ago was comprised of four major elements; underground reclaim, purification, shipping, and marketing. If the project is to be revived today, these will still be the key elements, but local conditions have changed and some modifications will be required. The modifications relate to the reclaim rate, environmental controls, surface storage requirements, and shipping procedures. The basic aim of the project remains the same however; to recover and process the stored material, and market it. Using purification procedures developed at Giant, the product will be superior to most that are currently being used by the manufacturers of wood preservatives, and will be readily accepted into the market at good rates and prices.

Because of the current controversy, the time frame for retrieval of the material has been compressed to five years from the original twenty years. Under this scenario, the crude dust will be recovered at a rate of 52,000 short tons per year to produce high purity As_2O_3 at rates ranging from 30,000 to 43,000 tons per year over a period of five years. Most of the crude dust will be recovered by means of a mechanical clamshell bucket. The material will be conveyed to surface via a tubular drag conveyor, dried if necessary, and stored in a bin as feedstock for the purification plant.



The purification plant consists of a fluidized sand bed fuming reactor, a sintered metal filter for particulate removal, a CIP circuit for gold recovery, a fabric baghouse for As_2O_3 recovery, a water scrubber for exhaust gas cleanup, and a small crystallization circuit to handle a small amount of arsenic in solution. Because of the low bulk density of the product, a compaction circuit will be required to compress the product into granules having a bulk density of about 110 lb/ft^3.

The As_2O_3 product will be either shipped or stored as required, and marketed as appropriate, perhaps up to 10,000 tons per year. The gold produced over five years, will be sold as produced. Half of the gold will be recovered during the first year of operation. Because of the economic advantage in maximizing gold production, the plant will process underground material first, while current production dust will be stored in an isolated section of the product warehouse until it becomes economically feasible to process in the plant, perhaps in year three.

Provided that permitting can be in place and funding made available quickly, it is expected that the plant can begin producing high quality As_2O_3 during the year 2000.

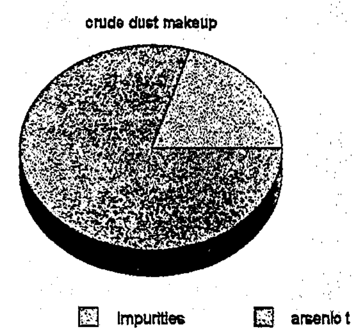
Introduction

The arsenic reclaim project that was shelved in 1990 when Royal Oak obtained ownership of the mine, was considered to be economically feasible at the time. Some changes in recovery rates, underground reclaim methodology, plant design and operation, and market conditions make the project, if not highly profitable, then at least quite attractive when compared to the alternatives.

This report outlines some of the reclaim and purification processes and provides an economic justification for the project. Naturally an up to date independent feasibility study of the project, including technical evaluation, marketing schedule and future market potential will be necessary in order to arrive at a much more accurate economic analysis.

Stockpile Characteristics

As of the end of December,1998, the fifteen arsenic storage chambers at Giant contained a total of 258,286 short tons of crude baghouse dust, accumulating at the rate of approximately 300 tons per month since that time. The average concentration of arsenic in the dust is about 60% which corresponds to an As_2O_3 grade of 79% The weight of arsenic trioxide is about 205,000 tons. The remaining impurities are made up of iron oxide, insoluble silicates, antimony oxide, and a small amount of gold.. Average gold assay of the dust is 0.534 oz/t, about 138,000 ounces.



When baghouse dust first began to be placed in underground storage chambers, gold collection efficiencies were very poor, eg., gold concentration in one of the chambers, B2-34, is 2.33 oz/t, while the arsenic concentration is 48%. Current production dust grades about 0.16 oz/t Au and 88% As_2O_3.

Although some of the earlier stopes have been topped up with more recently produced dust, a drilling/sampling program conducted by Geocon in 1981 confirmed the contained values that had been recorded when the dust was placed. The program also provided information with respect to moisture content, density, compaction, etc. It was found that the dust in several of the stopes had elevated moisture concentrations, up to as high as 6%.

The following description of the dust in stope B2-08 is an example of the kind of physical information that is available.

B2-08

density (lbs/cu.ft)

maximum	minimum	S.G.	angle of repose	% moisture	tons
69.1	39.7	3.22	46.4 deg	2.8	32,368

Prior to being topped up with fresh baghouse dust in 1986, the surface of the arsenic dust was 32 feet below the back of the stope and the sampler penetrated 64 feet of dust before encountering rock. It seems that B2-08 had quite a rigid crust about a foot thick, thr remainder of the dust being loose and dry. Since topping up, the surface is now light and fluffy and occurs about 5 feet below the back of the stope

Reclaim

The in-situ density of the dust in storage ranges from 40 lb/ft^3 to 100b/ft^3, moisture content ranges from 1% to 6% and the angle of repose ranges from 46^0 to 55^0. Reclaim will be accomplished using a variety of methods, depending upon the physical characteristics of the material and the stage at which extraction is being done. Because much of the material contains too much moisture to be vacuumed, an electro/hydraulic clamshell will be used for the bulk of the material. As the stope is depleted, the ability to recover the last of the material by this method will be limited. A remote controlled LHD (scooptram) will be used to convey most of the remaining material to where it can be accessed by the clamshell.

Final cleanup will be done using a hydraulic monitor (water cannon) to wash down the walls and floors of the stopes, the resulting slurry being pumped to a closed circuit dewatering system in the process plant. Water will be continuously recycled, reducing the amount of water to be treated in the tailings pond.

Where the dust is dry and loose, vacuum recovery will be done using remotely controlled winches and closed circuit TV to position the pickup point of the vacuum hose. As with the clamshell, final cleanup will be done using remote controlled LHD and high pressure water. Obviously access from the lower bulkheads will be required, though removal of dust via the underground workings may not be required.

Reclaim rates will be as high as 52,000 tons per year to produce more than 43,000 tons of As_2O_3. This requires an average daily rate of about 142 tons. Assuming an eight hour, five day work week, the required hourly rate at 80% availability is about 30 tons, a relatively small amount for the type and size of equipment being contemplated.

Typically, a mechanical or vacuum reclaim system will be installed in a chamber cut out above or at one end of the stope being accessed. A catwalk suspended from the back of the stope will permit installation of a monorail crane for access to the dust by either clamshell or vacuum hose. In the case of clamshell recovery, the clam will dump onto a vibrating feeder which will feed into a tubular drag conveyor for delivery to surface storage. The system will be totally enclosed and the danger of dust losses to the environment will be minimal. For vacuum recovery, a rotary blower will be installed downstream of a fabric baghouse. The reclaimed material will be collected on the fabric filters and will discharge into the surface storage bin.

Clam operation will be done remotely through the use of computer control and closed circuit TV.

The storage chambers have been grouped by location and the reclaim sequence will be done by group. Area I contains five of the richest (in gold) chambers, which are located beneath the mill baghouse area. This group includes B2-30, B2-33, B2-34, B2-35 and B2-36. Access to the chambers will be done via a new ramp as shown in the drawing. B2-30, the smallest of the chambers, is located at a much lower elevation and a spiral ramp will be required. These chambers have been deliberately constructed for the purpose and are quite regular in shape. Some of the larger chambers, B2-12-13-14 for example, are worked out stopes and are not at all regular in shape. Reclamation procedures in these chambers will have to be very well thought out before equipment is installed.

Purification

The manufacturers of arsenical wood preservatives, by far the largest users of arsenic trioxide, require that As_2O_3 used in their processes meet certain minimum specifications. These specs are somewhat flexible in that the manufacturers can use material grading as low as 95% As_2O_3, provided that certain elements do not exceed relatively low concentrations, and these concentrations vary, depending upon the manufacturer. All users however, prefer to receive higher grade product because of the lower cost of processing and especially because of the high cost of disposal of arsenic bearing residues. The three major manufacturers have quoted the following as required feedstock specifications.

Hickson, Inc.
95% As_2O_3, <400 ppm Fe, <1000 ppm Pb, <100 ppm chloride

Chemical Specialties, Inc.
95%-99% As_2O_3, 500 - 5000 ppm Fe, 0.5 - 1.0% Sb, <300 ppm Hg, <100 ppm chloride, <0.5% water

Osmose, Inc.
99% As_2O_3, <0.02% Fe, <0.02% Pb, <0.01% chloride.

Giant's crude dust, even the cleanest material grading >90% As_2O_3, does not meet the minimum specifications and upgrading is required before it can be marketed.

One of the key elements of the Warox project is the use of high temperature gas filtration technology to remove impurities from the arsenic fume. The concept was first tested in Falconbridge Metallurgical Lab in the late 70's when Giant was beginning to sell crude dust. The test consisted of a 1" fluidized bed reactor (roaster) having a sand bed and using nitrogen as the carrying gas. Crude arsenic dust was introduced into the heated reactor and the resulting fume/particulate mixture was passed through a fibrefrax filter. The gas was cooled to precipitate the As_2O_3 which was then analyzed for purity. When it was found that the arsenic trioxide was 99.7% pure, it was clear that this technology showed a great deal of promise.

Unfortunately, this type of filter is not suitable for full scale operation, and it was several years before suitable filtration equipment became available. In the meantime sand bed filters were investigated and ceramic filters were tested at Research Productivity Council's pilot scale roasting plant in New Brunswick. Though the ceramic filters were capable of producing an As_2O_3 product meeting the specifications, durability of the filters was a serious problem at the high pressure drop required for antimony elimination, and it did not seem likely that filters of this type would be suitable in full scale.

It was at this time that the idea of using sintered metal filters was considered, and a filter of this type was installed in RPC's facility to replace the ceramic filter. The test results were very encouraging and the test was followed up by a visit to a large chemical plant in Houston to see sintered metal filters in full scale service and in a similar application. The operators of the plant reported complete satisfaction with the filters.

The test program at RPC proved that, using high temperature filter technology, a high quality As_2O_3 product could consistently be produced from the crude dust in underground storage. Dust grading 3 - 5% Fe and 2 -3 % Sb was readily purified to meet the specification of 0.2% Sb and .02% Fe. In fact antimony levels of 0.05% were achieved when filters were operated at a higher pressure drop.

The RPC testwork was followed up by a pilot test at Giant, the purpose being to test the filters under actual roasting conditions. Five sets of filters from three different manufacturers were tested and results from the testwork enabled full scale plant design to be done.

A small amount of very high purity crystalline product will be produced from scrubber liquor and from slurry reclaim procedures. The scrubber located downstream of the baghouse will collect more than 100 tons of high purity As_2O_3 that has escaped the baghouse. A bleed stream will be drawn off the scrubber solution tank to the vacuum crystallizer to improve collection efficiency in the scrubber. Depending upon the demand for crystalline product, a bleed stream of As_2O_3 saturated thickener overflow from slurry reclaim operations may be treated in the crystallizer circuit as well.

Byproduct Recovery

The crude dust contains impurities ranging from 10 to 50% of the total mass, depending upon when the dust was placed, equipment efficiencies at the time, roaster feed makeup, etc.. Aside from trace elements, the impurities typically consist of insoluble silicates, iron oxide, antimony oxide, and gold. The gold concentration has an overall average of 0.54 oz/t and is an obvious candidate for recovery as a valuable byproduct. The antimony oxide concentration averages about 1.6%. This is a significant amount of antimony oxide, most of which will be processed during the first two years of operation. Though good antimony recoveries will be experienced in the plant, the product quality will be too low to be marketed without secondary treatment.

Gold will be recovered in the hot filter residues. Gold recoveries of 85% to 90% can be expected using a carbon in pulp extraction process similar to that now in use for Giant Cottrell precipitator dusts. The fuming reactor must be operated under reducing conditions to prevent the formation of ferrous arsenate. If ferrous arsenate is formed, excessive levels of arsenic are collected in the hot filter residue and poor gold extractions are experienced.

To recover antimony oxide in a purified form, secondary treatment is required. Either the hot filter residue can be reprocessed for antimony oxide recovery, or a relatively pure product can be recovered using two stage filtration. The insoluble silicates and iron oxides can be filtered out quite readily in a relatively porous first stage filter, one that captures coarse particulate but will let fine particulate pass through. A second stage filter operating at a lower temperature and a substantially higher pressure drop will recover the fine particulate, mostly antimony oxide, that has passed through the first stage.

Waste Handling

Some waste emissions from the project are inevitable, though the amounts will be quite small. Some potential sources of environmental impact, not including highway spills, breakdowns of process equipment, and operator error, include:

Baghouse losses from vacuum reclaim operations
Baghouse losses from fuming operations
Treatment of hot filter residues.

Baghouse recoveries, when operated at low air to cloth ratios, are typically in the order of 99.93% (1.4 lb of As in emissions per ton of As collected) Assuming 15% of the dust will be recovered by vacuum, baghouse losses might be 21 tons over the life of the project. Baghouse losses from fuming operations, 140 tons. Combined losses will average 175 lbs per day over the 5 year life of the project. A simple scrubber using water as scrubbing medium will reduce losses from these sources to less than 2 lbs/day. The nearly 60,000 tons of hot filter residues will be treated in a carbon in pulp circuit for gold recovery prior to being discharged to the tailings pond. The major arsenic species in the residue are insoluble ferric and ferrous arsenates and will be permanently stored in the tailings solids. If arsenic trioxide is collected in the filter residue, it will dissolve in the CIP circuit and will be discharged to tailings in the CIP solution tails. The arsenic will be removed in the normal operation of the effluent treatment plant, just as is being done now with Giant tailings.

Arsenic contaminated waste from reclaim and plant cleanup operations will, whenever possible be processed in the fuming reactor. Other contaminated waste, such as reclaim screen oversize, baghouse filter bags, worn out equipment parts, etc, will be washed as thoroughly as possible, and the wash water will be discharged to tailings. The cleaned waste materials will be stored underground and will eventually be backfilled.

Storing, Shipping and Marketing

The product will be recovered and processed at rates substantially in excess of what the market can absorb, and a large quantity will have to be stored prior to shipment. Assuming that shipments can be made at a rate of 4,000, 6,000 and 8,000 tons respectively during the first three years of operation, and 10,000 tons per year thereafter, a maximum of 163,000 tons will have to be stored by 2005, diminishing at a rate of 10,000 tpy until 2022. Naturally the question of whether or not there will be a market for the product must be considered. There are alternative wood preservatives, though none that combine low cost, low toxicity, and effectiveness of use that characterize CCA. Because of its popularity and value to the environment, it is unlikely that there will be any urgency to find a replacement in the foreseeable future.

EPA has published a report (May 1997) that states, in part, "EPA reviewed the use of CCA in pressure treated wood extensively during the 1980's and concluded that pressure treated wood did not pose unreasonable risks to children or adults, either from direct contact with the wood, (e.g., as used for playgrounds and decks) or from contact with surrounding soil where some releases may have occurred. Based on scientific data that EPA has reviewed to date, the Agency has not identified any significant health concerns from short or long-term exposure to arsenic residues from pressure treated wood."

The manufacturers of wood preservatives have their plants in the southeastern US and freight costs are relatively high. The most economical methods are to ship compacted product in bulk, either by truck or by rail. The plant will have a truck loading facility for product that can be shipped directly or for product that is to be taken for storage.

Giant's original 1989 proposal intended that a truck to rail transfer facility be built near Enterprise. Rail freight costs are costs substantially lower than the cost of trucking and a very short payback period will be realized from this installation..

US markets consume from 27,000 to 35,000 tons of As_2O_3 a year in the manufacture of arsenical wood preservatives, and the price ranges from $US 0.26/lb to 0.33/lb depending upon quality and availability of product. The consumption fluctuates with the state of the US economy, most of the material being used in residential applications. There is currently a plentiful supply of medium quality product available from China and Chile and some high quality material from Mexico. The Chilean source will dry up within the next year as the El Indio mine has ceased production and is just getting rid of stockpiled material. Having a superior quality product, and with our North American location, we are in a good position to assume a large share of the North American market for the foreseeable future.

There are substitutes for arsenical wood preservatives but none so effective or safe to use. Because of the great benefit provided by arsenical wood preservatives, and the minimal adverse environmental impact, there is no urgent pressure on manufacturers to find substitutes that are likely to be less effective and more costly.

Capital Equipment

Reclaim

Major items of equipment that will be used in reclamation of the product must be duplicated because of the compressed reclamation schedule. As one setup is in use, another must be in the process of being installed to avoid interruptions in production. This is particularly true with the smaller chambers, where up to four separate chambers may be reclaimed within a year. The apparatus required for final cleanup; pumps and scooptrams, will also need to be readily available. Underground development must proceed well in advance of equipment installation

The average 30 ton per hour reclaim rate does not require particularly large or sophisticated equipment. A clamshell bucket to hoist product from the stope will be required. The bucket will dump onto vibrating screen to eliminate rock fragments and other deleterious materials. The screen undersize will feed into a tubular drag conveyor which will move the material to surface storage. For final cleanup of the stope, perhaps 10% of the total, a remote scooptram will be used to move the material to where it can be picked up with the clamshell. Hosing of the walls and floors and pumping the resulting slurry to surface will complete the cleanup.

Purification

The purification plant will consist of a large storage bin and a smaller daybin for plant feed. Some of the material will need drying before treatment and a dryer will be available as required. The dryer will also be used to dry dewatered material collected from the final cleanup stages. The dry crude dust will be injected into a fluosolids fuming reactor to sublime the arsenic trioxide. The resulting gas and particulate mixture is passed through a hot sintered metal filter for particulate removal. The cleaned gas is mixed with cool air to precipitate the pure arsenic trioxide into a white solid powder having low bulk density. This powder is collected in a fabric baghouse. To reduce shipping and storage costs and to make the product more desirable to the buyers, the powder is compacted in a roll compactor to a dense, dust free flake.

Operating Personnel

Mine development has been dealt with as capital cost, and no additional development costs have been considered in the operating cost category.

Reclaim

The clamshell bucket will be operated up to 3,744 hours per year
The remote scooptram will be operated up to 2,080 hours per year
the pump/monitor system will be operated up to 960 hours per year

Purification

The plant will have 25 operators and maintenance personnel, as shown below:

supervisors	4
control room operators	4
compaction operators	4
crystallizer operators	4
utility operators	4
loadout operators	2
millwrights	2
elec/inst	1

It is considered likely that Giant Mine technical personnel, ie. assayer, environmental tech, mine planner, etc., will perform the work on a cost plus basis. The work can be contracted out if Giant personnel are not available.

Schedule

If work begins on this project at once, it is possible that the plant could be in production by the end of next year.

Schedule #1 shown here includes surface handling, purification, and transfer facilities. Schedule #2 shows underground development and equipment installation.

Conclusion

The project has been thoroughly studied and the various elements are well understood. The purification process uses well tested technology that has been proven in pilot scale and can be expected to perform well when scaled up. The market for As_2O_3 is presently healthy and is likely to remain so for many years. There is reason to be confident that an independent feasibility study will support the premise that the crude arsenic trioxide in storage at Giant can be safely and economically reclaimed, processed and marketed.