Giant Mine Oversight Board

Research Program Overview & Next Steps

Research Program Context

The Giant Mine Oversight Board (GMOB) was established as a condition of the 2015 Giant Mine Remediation Project Environmental Agreement. GMOB is an independent body whose mandate includes **managing a research program to find a permanent solution to the risks posed by 237,000 tons of arsenic trioxide dust stored underground at the former Giant Mine site**.

At the time of the Environmental Assessment of the Giant Mine Remediation Project, the frozen block method was considered the most appropriate technical solution available. It is intended to freeze the chambers that contain the arsenic trioxide dust and the surrounding rock, preventing liquid water from entering the chambers, dissolving arsenic trioxide dust and potentially releasing contaminants to the environment.

However, the Mackenzie Valley Environmental Impact Review Board (MVEIRB) considered it a ***temporary*** solution (i.e., no more than 100 years). The MVEIRB identified the importance of studying emerging technologies to identify a ***permanent*** solution. Pursuant to the Environmental Agreement, GMOB was mandated to lead the research program.

The goal of the GMOB Research Program is to identify and recommend a permanent solution for the underground arsenic trioxide dust in a manner that will:

- prevent the release of arsenic to the surrounding environment;
- minimize public and worker health and safety risks during implementation;
- be cost-effective and robust over the long term; and,
- require minimal to no long-term maintenance and monitoring.

This overview document provides:

- a summary of the research steps completed by GMOB and its partners;
- the current state of the research programs; and,
- A summary of GMOB's approach to prioritizing and completing the remaining research activities.

This overview will be regularly updated to reflect progress to date and evolving research priorities.

Contamination of the region around the former Giant Mine through stack emissions prior to dust collection, and the storage and containment of arsenic and other contaminants in tailings ponds, are being addressed through the surface remediation program being implemented by the Giant Mine Project Team. This work is not directly within the scope of GMOB's Research Program, but oversight of the remediation is a component of GMOB's overall mandate.

GMOB regularly updates the Project Team on its research program. This is important because the Project Team is continually making decisions that may impact the implementation of any arsenic trioxide dust extraction and treatment proposals, and they need to be aware of the implications of the research program for those decisions. Similarly, GMOB needs to understand the constraints that the remediation program may have for extraction and treatment options.

Another document, the Strategic Research Plan, provides additional detail on the history and considerations guiding development of the research program as well as an implementation plan. The Strategic Research Plan is available at gmob.ca.

The GMOB Research Program Approach and Progress to Date

To date, GMOB has undertaken the following broad activities:

- **Research option evaluation:** GMOB has sought guidance for its research program through, among other things, reviewing existing documentation (e.g., State of Knowledge studies) and commissioned advice from outside experts.
- **Research program funding:** GMOB has invited proposals for research projects and has funded projects that align with both GMOB's priorities and guidance from independent experts.

Prior to making decisions regarding research directions and options, GMOB commissioned a State of Knowledge review, building on the one commissioned by the federal government in 2000. The GMOB review examined alternative options for dust recovery and stabilization, defined performance criteria, and conducted a technical assessment of the options against these criteria.

The GMOB State of Knowledge review presented the following conclusions:

- Hydraulic borehole mining could be expected to perform effectively and safely for extracting the arsenic dust.
- The frozen block method performed very well against the performance criteria.
- Vitrification (transforming the arsenic into glass) was the top-ranked dust stabilization and processing method based on its potential for long-term stability, moderate costs and potential for gold recovery. This approach was recommended for further research.
- Cement stabilization/cemented paste backfill and mineral precipitation (transforming the arsenic into a mineral that does not dissolve easily) were considered the next-best options and were also recommended for further research.

In addition to considering the results of the GMOB State of Knowledge report and previous studies, GMOB struck a partnership with the TERRE-NET group, a consortium of university experts supported by the National Science and Engineering Research Council (NSERC). Based on the results of the State of Knowledge review and TERRE-NET expertise and advice, GMOB approved and fully funded four research initiatives in 2019. They were:

1. examining the composition of the arsenic trioxide dust, how it varies within and among chambers, and how it dissolves in water and other liquids;

2. understanding the stability of arsenic-iron sludge, a common remediation technique;
3. transforming the arsenic trioxide into an arsenic-sulphide mineral that does not dissolve easily in water;
4. using naturally occurring bacteria to produce a necessary sulphide ingredient for transforming the arsenic into a more stable arsenic-sulphide mineral; and
5. testing the stability and potential for leaching from arsenic trioxide dust that has been turned to glass (vitrified).

In 2022, GMOB co-funded two additional NSERC-supported projects, bringing the total number of GMOB-supported projects to seven. The additional projects are:

6. testing the stability of arsenic trioxide dust that has been physically trapped in a cement;
7. testing potential applications of stable isotope analysis for monitoring arsenic in water on the site.

In addition to these studies, GMOB also considers other research on an ad-hoc basis and reviews their merit for implementation.

Research Project Findings to Date

Most of the projects are not yet considered "complete," in that their findings are in the process of being prepared or peer-reviewed. Initial project findings are summarized below and more detailed summaries of each project can be found on GMOB's Research Program webpage.

- Project 1: Examining the composition of the arsenic trioxide dust, how it varies within and among chambers, and how it dissolves in water and other liquids.
    - The results of this project have been used to inform the other six projects.
    - The arsenic trioxide dust behaves very differently than pure arsenic trioxide, which has important implications for stabilization options.
- Project 2: Understanding the stability of arsenic-iron sludge, a common remediation technique.
    - Making an iron rich arsenic solid is a common way of treating arsenic waste materials however there are many unknowns regarding the long term stability of these solids.

    - This is a two stage project - Stage 1 is to generate and characterize the iron arsenic compounds, the second step is to evaluate their leaching performance under a range of conditions. .
- Project 3: Transforming the arsenic trioxide into an arsenic-sulphide mineral that does not dissolve easily in water.
    - Arsenic sulphide is produced; this is an energy and material intensive process.
    - A residual (containing 5 to 10% of the original arsenic) is left behind; this material needs additional evaluation.
- Project 4: Using naturally occurring bacteria to produce a necessary ingredient (sulphide) for transforming the arsenic into a mineral.
    - Bacteria samples were collected from around the Giant Mine site.
    - Looking for two types of bacteria: those that produce sulphide, and those that could transform arsenic into a less soluble form.
- Project 5: Testing the stability and potential for leaching from arsenic trioxide dust that has been trapped in glass (vitrified).
    - This technique performed well against leaching tests. A company that conducts large-scale vitrification has indicated that it would be possible to build a vitrification plant on the former Giant Mine site.
    - Additional work will be done to refine the recipe for the glass to improve leaching behavior.
- Project 6: Physically trapping the arsenic trioxide dust in cement.
    - The arsenic dust caused the cement mixtures to behave differently than expected.
    - After testing hundreds of recipes, one cement paste recipe containing the arsenic dust was found to solidify fully when cured. Further testing would be required to determine if arsenic would leach from the cement when exposed to the environment.
- Project 7: Testing the potential applications of antimony stable isotope analysis for monitoring the arsenic in the environment.
    - Antimony and arsenic are close cousins, but only antimony can be used for stable isotope analysis.
    - Antimony is present in the arsenic dust and could potentially serve as a useful tracer for monitoring the movement of arsenic in water on the site.

Next Steps

There are four broad categories of activity within a permanent solution for the arsenic trioxide dust: Extraction, Stabilization, Storage and Residuals Management. These components are described in more detail in the following section. GMOB initially focused on the Stabilization component, because this was identified as a critical unknown, i.e. if the dust cannot be effectively stabilized then there is no point extracting it, and the storage and residual management activities would not be required. As the availability of a viable stabilization method becomes more certain, GMOB has begun to direct research efforts towards the other components.

In the immediate future, GMOB will support additional arsenic dust characterization studies, further refine the vitrification option, and support new research as appropriate. GMOB will also expand its examination of the other components, namely extraction of the arsenic trioxide and storage of the transformed (e.g., vitrified) material.

Extraction

Objective

Identify one or more methods that will extract the arsenic dust safely, cost-effectively, and as completely as possible from the underground chambers where it is currently stored.

Status

Two preliminary studies examined dust extraction, namely the State of Knowledge assessment (2017) and a review of extraction technologies in 2021. Extraction is one of the first steps needed before a stabilization process can occur. Engineering studies and infrastructure development must occur before any extraction can take place.

Next steps

Action	Status
Identify or establish a research network that can conduct research into potential extraction methods. Call for Proposals is released and one or more research projects is funded.	Initiated 2025

Commission study into required extraction efficiency - i.e. how much ATRW can be left behind and still achieve target arsenic flux.	Initiated 2025

Stabilization

Based on the results of the studies to date, vitrification is considered a promising option for addressing the challenges posed by the arsenic trioxide dust. It is a proven technology used elsewhere, the vitrified product has been lab-tested at the University of Waterloo and shown to release little arsenic in leachate, and could be scaled up from the current desk-top scale to an industrial-scale facility at the former Giant Mine site. Additional work is underway to produce potentially more robust vitrification formulations that will be further tested.

Objective

Confirm that vitrification is a safe, cost-effective, operationally feasible method for stabilizing the arsenic trioxide dust.

Status

Preliminary or final results of each of the seven projects have revealed vitrification to be a promising permanent solution for the arsenic dust.

Action	Status
Conduct additional work on refining and improving vitrification products.	Initiated 2019
Characterize additional dust samples collected in 2023.	Initiated 2024

Storage

Objective

Identification of the parameters for safe storage of the stabilized dust to enable the development of on-site or near-site storage requirements and associated infrastructure.

Status

Storage has been investigated mainly as a component of research projects by evaluating the resistance of transformed products to leaching. Additional work on storage requirements will begin once a stabilization method is confirmed.

Action	Status
Storage requirements, including on-site vs off-site storage, are identified and recommended for the selected stabilized product.	Not started

Residuals Management

Objective

Identify management requirements for any residual material that may remain in the chambers after extraction.

Status

This component has not been initiated. Information on the extraction method and expected efficiency are required prior to beginning work on residuals management.

Action	Status
To be determined pending selection of an extraction and stabilization method.	Not started

Towards a Recommendation for a Permanent Solution

GMOB is using a stepwise approach to develop its research program. In 2015 the Government found freezing in place and no extraction was the best solution for the arsenic trioxide waste. In 2015 GMOB's own analysis found freezing in place to be the most defensible but vitrification (as stabilization) and hydraulic borehole mining (as extraction) as the most promising options. In 2025 after focused work GMOB has found that vitrification can produce a stable product using Giant Mine arsenic dust and hydraulic borehole mining remains the most promising extraction method. To date these two approaches are forming a promising basis towards a permanent solution.

Stay tuned for further updates!