Identification of Underground Inflow Water Types and Preliminary Geochemical Monitoring during Reflooding

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GIANT MINE

- Operated 1948 to 1999
  - 7 million ounces gold recovered
  - high arsenopyrite content
  - produced soluble arsenic trioxide dust as waste product

- Dust Handling
  - originally vented up stack
  - 1951: developed UG storage in frozen ground
  - 15 stopes and engineered chambers with 237,000 tonnes dust

- 1970s: permafrost found to be discontinuous and warming

- Under Federal control in 1999

- Technical Advisor - recommend frozen block alternative
Objectives

- Water typing for inflow source identification and control
- Long-term arsenic source identification

The primary objectives of the geochemical sampling program were:

- Characterize the geochemical and isotopic signatures of water types entering the mine;
- Identify and characterize “type” samples representing distinct sources of arsenic within the mine;
- Delineate main flow paths within the mine;
- Develop overall water and load balance;
- Establish seasonal variations in water chemistry in the mine
Water Quality Sampling

- Sampling Programs
  - 1998/1999 Fracflow (Jan98, Mar98, Sept99)
  - DIAND/SRK (Apr00, May00, Nov00)

- Sample Types
  - Discrete Flows (seeps in fractures and faults, drill holes)
  - Major Ditch Flows

- Parameters
  - Major ions, nutrients, trace metals, isotopes
Definition of Water Types

- **Spatial Information**
  - Used to identify seepage types (e.g. surface water, NW Tailings Pond water, arsenic chamber water etc.)

- **Geochemistry**
  - Plots of major ion chemistry (scatter plots, Piper plots) used to identify characteristics of known waters and to identify unknown seeps
  - Mixed samples were not used as “type” samples.

- **Isotopes**
  - Used to determine source of water (direct infiltration, creek water, lake water, deep groundwater)
Water Types

- **Clean Water Entering Mine**
  - Precipitation
  - Baker Creek
  - Great Slave Lake (as service water)

- **Surface Tailings Ponds**

- **Water moving through /past**
  - Arsenic Chambers
  - Backfill (waste rock and tailings)
  - Mine Walls

- **Deep Groundwater**
Mass Balance Calculations

- Simple Calculations to see if the amount of arsenic pumped from the mine could be “explained” by our sources

- Plan area weighted average of source concentrations

- Comparison to actual sump concentrations (As, Ca, Mg, Na)
Mass Balance Conclusions

- Preliminary calculations indicated that the arsenic chambers accounted for approximately 50% of the arsenic in sumps.
- Later sampling raised this estimate to 80% or more.
- “Backfill” could account for most of the remainder:
  - Other sources might include road beds, spills in drifts…
  - Plan area averaging does not allow other surface sources to be definitively ruled out.

Implication is that mine water will not be below discharge criteria (0.5 mg/L) even if all the arsenic trioxide dust could be removed or isolated.
### Geochemistry

<table>
<thead>
<tr>
<th>Source</th>
<th>Arsenic Concentrations (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soils, bedrock, and Mine Walls</td>
<td>0.05</td>
</tr>
<tr>
<td>Northwest Tailings Pond Seepage</td>
<td>5</td>
</tr>
<tr>
<td>Tailings Backfill</td>
<td>5</td>
</tr>
<tr>
<td>Waste Rock Backfill</td>
<td>1.5</td>
</tr>
<tr>
<td>Arsenic Chambers &amp; Stopes</td>
<td>4000</td>
</tr>
</tbody>
</table>
Redistribution of Arsenic in Mine

- Surface infiltration flows through arsenic dust
- Dissolved arsenic ~4000 mg/L
- Dissolved arsenic forms precipitates along “high test” flow paths (drifts, stopes, etc.)
- Below 750 Level, dissolved arsenic flows to bottom of mine, but along specific routes (raises and ditches)
- Therefore, there was a limited potential for high arsenic water to spread throughout the mine
Mine Workings

Mine water containing arsenic pumped from mine
C-Shaft Monitoring System
Location of Underground Tailings Backfill
Arsenic and Chloride

Dissolved Arsenic and Sodium

Chloride and Calcium

Port Depth (m)

0 2 4 6 8 10 12 14 16

mg/L

As-D  K-D

Port Depth (m)

0 200 400 600 800 1000

mg/L

Cl  Ca-D
Preliminary Conclusions on Mine Reflooding

- Rapid water level rise corresponds to freshet inflow from surface
- Mine water in C-Shaft does not appear to be picking up high arsenic levels from redistributed arsenic at this time
- Gradient of inflow away from shaft
- Arsenic salts may be dissolving, but physical gradient keeping it away from shaft at this time
- Arsenic levels expected to increase once stratification begins to form (diffusion)
- Pumping from Achaitcho Shaft likely to pull “clean” water from south end of mine and higher arsenic water to north end
Mine Water Flow through Tailings Backfill

10 to 20 mg/L
Thank You