D.4. Performance of the Albino Sub-Aqueous Waste Disposal Facility at the Eskay Creek Mine

by

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Effects of Mining on Natural Water Bodies

Performance of the Albino Sub-Aqueous Waste Disposal Facility at the Eskay Creek Mine

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Our Message

- Use committee approach for ARD prediction.
- Expect operation to not mirror the PLAN - maintain flexibility.
- Mass balance modelling, combined with monitoring, was a useful predictive tool.
- Sub-aqueous deposition of oxidized and PAG waste met both the environmental and practical operational needs of mining at Eskay Creek.
Eskay Creek Mine
Introduction and History

- First staked in 1932 - Discovery hole (CA-88-6).
- ARD assessment program started in 1990.
- Exploration adit construction started July 1990.
- Mine start-up January 1995 - direct ship raw ore to smelter.
- Waste rock and mine fines trucked to Albino.
- Mill start-up Nov. 1997 to produce doré gold from gravity concentrate and a bulk flotation concentrate.

Ore Reserve History

- Year End Ore Reserves
- Year End Resources
- Cumulative mining
**Mine Waste Disposal Quantities**

<table>
<thead>
<tr>
<th>YEAR</th>
<th>WASTE ROCK (tonnes)</th>
<th>WASTE ROCK (m³)</th>
<th>TAILINGS (tonnes)</th>
<th>TAILINGS (m³)</th>
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</table>

**Planning, Presentations and Papers**

- ARD sub-committee was formed to oversee ARD waste rock prediction work
- Numerous ARD committee and MDAP presentations starting in 1990
- BC ARD Task Force Symposium 1993
- Association of Women Geoscientists and Cordilleran Section of GAC 1994
- BC Mine Reclamation Symposium 1996
- ICARD 1997
ARD Summary

- **Phase 1** - static and kinetic testing with drill core
- **Phase 2** - static and kinetic testing during underground exploration program
- **Phase 3** - ore characterization
- **Phase 4** - exploration waste rock stabilization and re-location
- **Phase 5** - Operational waste characterization and monitoring
- **Phase 6** - Modeling to predict Albino characteristics and control waste plans

Albino Disposal Facility

- Albino Lake is small alpine tarn (el. 1048 m) forming a blind cul-de-sac tributary to Tom MacKay Creek - 4km west of mine
- Surface area of 13.4 ha, littoral area 9.4 ha and a drainage area of approximately 63.5 ha. Mean depth of 7 m to maximum depth of 20m. Volume is 1.08x10⁶ m³
- A causeway was constructed on upper third of the lake for deposition of waste which is spread using a loader.
- Overflow elevation has not changed.
Albino Disposal Facility

- Albino Lake is classified as oligotrophic with a rock and mud substrate
- Annual outlet flow is 1 - 1.5 million cubic metres
- On average 55% of outflow is in May and June, 10% Nov to April

Massive and Brecciated Rhyolite

- The Rhyolite Unit comprises the dominant footwall material to the ore deposit
- Sampling and assessment of rhyolite was conducted during three different periods with some different results
  - Drill Core Program
  - Exploration Adit construction
  - Underground Sampling Program
Disposal of Oxidized Waste Rock

- 100,000 tonnes of waste rock from Upper Adit during the Underground Exploration program in 1990-91
- Deposited in a temporary waste dump adjacent to the portal.
- Rhyolite 81,000 tonnes
- Dacite 7,600 tonnes
- Argillite 2,900 tonnes
- Andesite 7,500 tonnes

Disposal of Oxidized Waste Rock

- During exploration adit development - much of waste rock was brecciated and highly sericitised
- Sampling of waste dump seepage started in August 1991 - drainage pH was neutral
- Sulphate trended upward in March 1992 pH started down in July 1992
- Onset of acid generation very fast compared to original predictions
- Mis-perception due to high percentage of massive rhyolite in the “rhyolite” category during Phase 1
Disposal of Oxidized Waste Rock

- Mine plan called for disposal of all waste rock underwater in an impoundment referred to as Albino Lake
- Methods developed to characterize and stabilize the waste to prevent release of acid and dissolved metals
- Approach - blend hydrated lime with the waste rock during the dump disposal program to neutralize acid and precipitate metals
- Testwork showed that lime addition effectively stabilized oxidized waste rock

Antimony Issue

- No evidence during planning phase to indicate that antimony would be an environmental issue
- Disposal of PAG waste rock to Albino was approved in the MDAP
- Disposal of the stabilized waste rock started to Albino in 1994 and continued into mine start up in 1995 when waste switched to mine fines at 18 tonne/d and production waste at 169 tonne/d.
Antimony Issue

- Mitigation for Sb started in fall 1995 with ferric sulfate addition to fines.
- Lab study in January 1996 confirmed fines as the major contributor of Sb.
- High pHs during disposal of oxidized waste in '95 added significant load of Sb to Albino and increased Sb mobility.
- Fines contain high concentration of stibnite (Sb₂S) - forms "halo" around ore.
- Sb became a primary focus of subsequent modeling and assessment work.

Albino Lake Water Quality Model
Derivation of Inputs

```
Tailings Sample
   /   \
  /     \
Pore Water   Solids
   |       |
   V       V
  Modified SWEP
   |       |
  Liquids g/T   Solids g/T
     |       |
     Input Sheets
```
Albino Lake Water Quality Model
Mass Balance

\[ C_s = \frac{\sum \text{inputs}}{V + Q} + \frac{V}{V + Q} (C_{s,n-1} - C_{b,n-1}) + C_b \]

- Previous Month's Prediction \( C_{n-1} \)
- Input Sheets, ME
- Lake Vol, \( V \)
- Background Quality, \( C_b, C_{b,n-1} \)
- Background Quantity Flow, \( Q \)

Albino Lake Water Quality Model
Key Points

- calibration performed using mobilization efficiencies (ME)
- metal release dominated by inputs during deposition (water quality will slowly improve with cessation of disposal activities)
- during operation, equilibrium concentration is determined by mass balance
- the model is a tool to be used with monitoring
Monitoring

- Albino O/F sampled and assayed daily for pH, TSS, conductivity plus Total & Dissolved Cu, Fe, Pb, Sb and Zn
- Flow recorded continuously with data logger and checked manually daily.
- Weekly samples collected for Total Cu, Fe, Pb and Sb and sent to ASL as external check.
- LC$_{50}$ 96 hour bioassays conducted quarterly.

Water Quality Performance

- Metals increased from background following start-up but did not exceed Permit Limits.
- There has only been one exceedence in pH (10.12). This was corrected by reductions in lime consumption in the mill from 4.93 to 1.72 kg/tonne of ore in 1998.
- Albino pH currently near 7.5.
- All bioassays have registered 100% survival and all parameters in compliance.
Dissolved Antimony, mg/L

Dissolved Copper, mg/L
Environmental Effects Monitoring

- Environmental Effects Monitoring (EEM) Program jointly developed in 1997 by Homestake, BC MOELP, Environment Canada and EVS.
- EEM relies on repetitive measurements using biota to test specific hypotheses and causal relationships.
- Program monitors potential environmental effects from entire mining and milling operation including potential cumulative effects downstream.

Environmental Effects Monitoring

- Field work over three seasons '97 to '99.
- '97 and '98 included sediment sampling stations, reference stations, two periphyton stations, water quality monitoring and toxicity tests. '99 assessed bioaccumulation.

*Conclusions:*

- No evidence resident communities are adversely affected.
- Limited risk for bioaccumulation.
Recommendations

- Evaluate chemical stability and disposal options for wastes early.
- Investigate sub-aqueous disposal of PAG waste rock and tailings in natural or man-made impoundments.
- Develop modeling tools to predict impact and assist decision making process.
- Maintain flexibility in design and operation to accommodate unexpected changes after start-up.

Conclusions

- Oxidized waste rock can be stabilized and deposited in a small natural water body without exceeding water quality standards.
- Subaqueous disposal of PAG production waste rock and tailings to a natural water is acceptable from both environmental and operational perspectives and provides long-term security.