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

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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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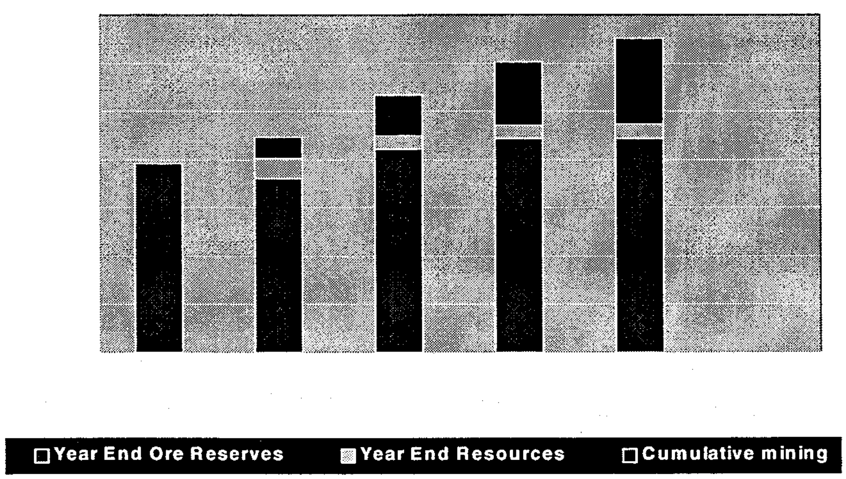
Our Message

- 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.
- Exploration adit waste rock stabilized with lime and moved to Albino in 1994 and 1995.
- Mill start-up Nov. 1997 to produce doré gold from gravity concentrate and a bulk flotation concentrate.

Ore Reserve History



Mine Waste Disposal Quantities

YEAR	WASTE ROCK (tonnes)	WASTE ROCK (m3)	TAILINGS (tonnes)	TAILINGS (m3)
1994	46700	27471		
1995	146394	86114		
1996	42700	25118		
1997	86134	50667	4683	3122
1998	64198	37764	39526	26351
1999	50950	29971	51781	34521
2000	56750	33382	56524	37683
2001	48190	28347	56524	37683
2002	56960	33506	64085	42723
2003	57870	34041	64085	42723
2004	51030	30018	62200	41467
2005	55990	32935	60488	40325
2006	47020	27659	60488	40325
2007	28280	16635	60488	40325
2008	0	0	44459	29639
TOTAL	**839166**	**493627**	**625331**	**416887**

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 1.08×10^6 m^3
- 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

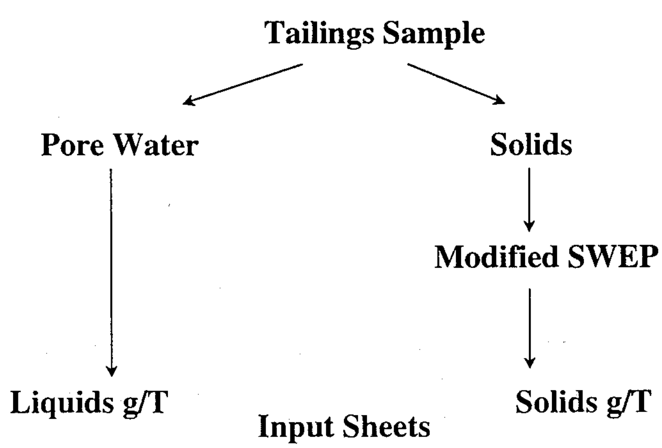
Antimony Issue

- 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 contained contain high concentration of stibnite (Sb_2S) - forms “halo” around ore
- Sb became a primary focus of subsequent modeling and assessment work.

Albino Lake Water Quality Model
Derivation of Inputs



Albino Lake Water Quality Model
Mass Balance

Previous Month's Prediction C_{n-1}

Input Sheets, ME

Lake Vol, V

$$C_n = \frac{\Sigma inputs}{V+Q} + \frac{V}{V+Q}(C_{n-1} - C_{b,n-1}) + C_b$$

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

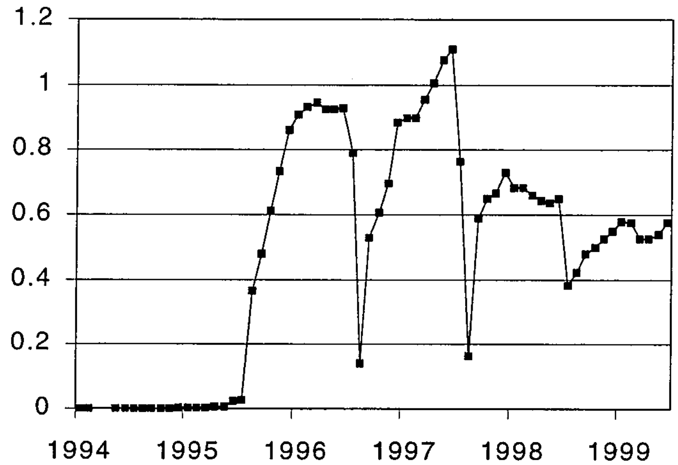
Monitoring

- 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.

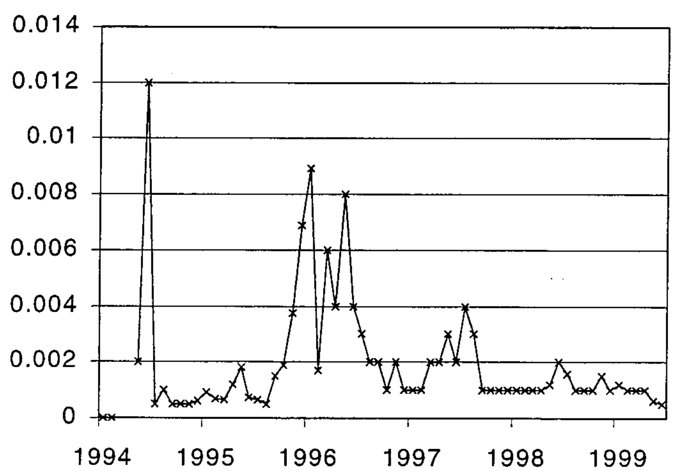
Water Quality Performance

- 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.