The Owl Creek Pit Part 1: Relocating Mine Rock from Surface Stockpiles to the Pit to Mitigate Acid Drainage

Jeff Martin\textsuperscript{1}, Thomas Sulatycky\textsuperscript{2}, Brian Fraser\textsuperscript{1}, Rina Parker\textsuperscript{1}, Bruce Rodgers\textsuperscript{1} and Ron Nicholson\textsuperscript{1}

\textsuperscript{1}-EcoMetrix Incorporated
\textsuperscript{2}-Goldcorp, Porcupine Gold Mines
Owl Creek
History

- Timmins Area: 250 Mt mined to produce 60 M oz of gold prior to 1980, mainly underground mining
- Prior to Owl Creek, Acid Rock Drainage (ARD) from waste rock had typically not been a significant issue for Timmins area gold mines
- Mining at Owl Creek began in 1981 (Kidd Creek Mines Ltd.) and closed in 1990 (Falconbridge Gold Ltd.)
- 1.7 Mt ore, 5 Mt waste rock and 3 Mt overburden removed from Owl Creek open pit
- Ore processed at Kidd, Bell Creek and McIntyre
Owl Creek Minesite in 1991
Owl Creek Minesite – Present Conditions
Owl Creek Pit – Local Geology

- Stratigraphy – moderate to steep dip to north
- Massive to pillowed basalts
- Metasediments (greywacke and argillite) some graphitic argillite with pyrite
- Ore within east/west deformation zone
- Graphitic schistose contacts on both sides of main ore zone, 10-35 m wide on south, 0.5 m on north
- Waste rock; carbonate, sericite, sulfide (1-10% pyrite) alteration.
- Ore: free gold and gold in pyrite associated with quartz veins, carbonate, graphite, and disseminated sulphides (pyrite, marcasite, pyrrhotite, arsenopyrite, chalcopyrite)
Breaking News

Investigation is continuing into discharge

Acidic runoff stopped

Crew cleaning up spill

AT KIDD CREEK

EcoMetrix Incorporated
First Signs of Trouble

- June 1990 – ten years after mining started
- Ministry of Natural Resources (MNR) pilot observed a “reddish-brown colour” in a 2 km reach of the Porcupine River
- Drainage with pH = 2.3 and 7 g/L Iron traced back to the North waste rock stockpile
- Flow from waste rock ~ 8 L/s into Porcupine River with flow of ~ 130 L/s
<table>
<thead>
<tr>
<th>Constituent</th>
<th>Flow from North Waste Rock</th>
<th>Upstream in Porcupine River</th>
<th>Provincial Water Quality Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>2.3</td>
<td>7.5</td>
<td>6.5 – 8.5</td>
</tr>
<tr>
<td>Aluminum</td>
<td>1,400</td>
<td>0.09</td>
<td>NA</td>
</tr>
<tr>
<td>Copper</td>
<td>69</td>
<td>0.007</td>
<td>0.005</td>
</tr>
<tr>
<td>Iron</td>
<td>7,000</td>
<td>0.26</td>
<td>0.3</td>
</tr>
<tr>
<td>Lead</td>
<td>6</td>
<td>&lt;0.001</td>
<td>0.005</td>
</tr>
<tr>
<td>Nickel</td>
<td>48</td>
<td>0.01</td>
<td>0.025</td>
</tr>
<tr>
<td>Zinc</td>
<td>100</td>
<td>0.006</td>
<td>0.03</td>
</tr>
</tbody>
</table>
Immediate Actions

• Constructed cutoff berms
• Constructed impoundment at North Dump
• Piping to pump acidic water to the Kidd Creek tailings management area for treatment
• Local application of lime on stockpiles
• Initiated surface and groundwater monitoring
• Hired consultants to investigate cause
The Investigation (SENES 1990)

- Field program
- Waste rock samples from:
  - Surface (14)
  - Drill Cuttings (12)
- Rock Analyses: Acid Base Accounting, Metals, Mineralogy
- Water Analyses: general chemistry and metals
Reactive Argillite / Leachate Impoundment

Golder Associates, 1991
Spreading Lime on the stockpiles as an Interim Measure
Waste Rock Characteristics

Original Data from SENES (1990)
Argillite (PAG) and Other (non-PAG) Rock Types

Original Data from SENES (1990)
Conclusions of the Investigation

• Three main waste rock types, with pyrite & carbonate alteration:
  
• Metavolcanics and Greywacke
  – typically less than 1% S & classified as non-PAG

• Graphitic Argillite (schist)
  – typically 1 to 10% S and classified as PAG

• Only 10% of waste rock was Argillite but it was mixed with non-PAG rock and overburden
## Material Inventories (tonnes)

<table>
<thead>
<tr>
<th>Location</th>
<th>Varved Clay and Till</th>
<th>Greywacke and Volcanic Rock</th>
<th>Graphitic Argillite</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>150,000</td>
<td>1,500,000</td>
<td>300,000</td>
<td>1,950,000</td>
</tr>
<tr>
<td>South-East</td>
<td>1,000,000</td>
<td>1,500,000</td>
<td>200,000</td>
<td>2,700,000</td>
</tr>
<tr>
<td>South</td>
<td>1,050,000</td>
<td>10,000</td>
<td>5,000</td>
<td>1,065,000</td>
</tr>
<tr>
<td>West</td>
<td>850,000</td>
<td>0</td>
<td>0</td>
<td>850,000</td>
</tr>
<tr>
<td>NEW (test)</td>
<td>0</td>
<td>0</td>
<td>25,000</td>
<td>25,000</td>
</tr>
<tr>
<td>Roads</td>
<td>0</td>
<td>1,055,000</td>
<td>7,000</td>
<td>1,062,000</td>
</tr>
<tr>
<td>River Channel</td>
<td>0</td>
<td>170,000</td>
<td>0</td>
<td>170,000</td>
</tr>
<tr>
<td>Total</td>
<td>3,050,000</td>
<td>4,235,000</td>
<td>537,000</td>
<td>7,822,000</td>
</tr>
</tbody>
</table>

Data from Blakey (1993)
Additional Conclusions

• North and New stockpiles highly acid generating

• Southeast stockpile has substantial volume of PAG material with less acid leachate observed

• South pile has small volume of PAG – mostly clay

• West clay pile – no waste rock – from channel excavation
## Potential Water Treatment Requirements

<table>
<thead>
<tr>
<th>Location</th>
<th>Estimated Lime Requirement (tonnes CaO/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Dump</td>
<td>1,875</td>
</tr>
<tr>
<td>Other Locations including Southeast Overburden &amp; Waste Rock, South Clay Dump</td>
<td>975</td>
</tr>
<tr>
<td>Total</td>
<td>2,850</td>
</tr>
</tbody>
</table>

Adapted from SENES (1990) and Golder (1991)
## Options Assessed

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
<th>Estimated Cost ($1991)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Continued Collection and Neutralization of Water</td>
<td>$7.4M</td>
</tr>
<tr>
<td>1</td>
<td>Encapsulation and Flooding in Place</td>
<td>$9.6M</td>
</tr>
<tr>
<td>2</td>
<td>Relocation to Kidd Tailings Basin</td>
<td>$9.2M</td>
</tr>
<tr>
<td>3</td>
<td>Relocation to Open Pit</td>
<td>$6.2M</td>
</tr>
<tr>
<td>4</td>
<td>Encapsulate with Geomembrane</td>
<td>$7.6M</td>
</tr>
</tbody>
</table>

Adapted from Golder Associates (1991)
Selected Option – Relocate to Pit

- Relocated 3.26 M tonnes to pit in 1991-1992
- Placed as 1.5 m thick layers of rock and overburden
- Crushed Limestone added at a rate of 5.5 kg/t-rock for a total of 15,400 tonnes, spread between layers of waste rock
- Pit allowed to flood naturally with some pumping of water from Porcupine River
- Water level rose above backfilled rock in Spring 1993
- Overburden side slopes around pit were graded for stability
Owl Creek Pit prior to backfilling and flooding
Schematic Cross-section: Flooded Owl Creek Pit

- **0 m**: 2011 water level [Surface-depth Monitoring]
- **8 m**: Meromictic Interface (Chemocline)
- **12 m**: Mid-depth Monitoring
- **16 m**: 1994 water level [Surface-depth Monitoring]
- **22.5 m**: Bottom-depth Monitoring
- **23 m**: Bottom of pit lake/
  Top of backfilled waste rock (~80 m of rock)
- **100 m**: Bottom of pit
Lessons Learned

• Don’t rely on entirely on historical precedent
  – testing required

• ARD can still occur even if only small volumes of Potentially Acid Generating (PAG) material are mixed with non-PAG rock

• Best to segregate potentially problematic materials

• Management of PAG waste rock in a flooded open pit is an extremely effective remedial option
The Outcome

• Implemented closure plan very effective!
• Stay tuned for Part 2