GEOCHEMICAL CHARACTERIZATION OF WASTE ROCK

ANTAMINA MINE

PERU

David Brown, Golder Associates
Rens Verburg, Golder Associates
Henri Letient, Antamina
Celedonio Aranda, Antamina

BC/MEND Workshop
November 30, 2005
Presentation Overview

• Site Background
• Waste Rock and Ore
  – Issues
  – Investigation
  – Results
• Ongoing Work and Conclusions
• Peruvian Andes (4,200m)
• Upper Amazon drainage basin
• Copper-zinc-molybdenum mine
• Full production in 3rd quarter 2001
• Daily tonnage:
  • Ore – ~100,000,
  • Waste - ~300,000
• Mine life of 23 years
Site Overview
Geochemical Issues

- Potential impacts to water quality from
  - Sulfide oxidation
    - Acid generation
    - Metal leaching
    - Dissolution of stored oxidation products
  - Mineral dissolution
    - Metal leaching (under neutral conditions – e.g. Cu, Zn, Mo)
Waste Rock Issues

• Over 1.3 billion tonnes of waste rock, to be distributed in three major dumps
• LG/MG Ore processed year 23 (LOM)
• Operational/post-closure site drainage management
Objectives

- Establish long-term monitoring plan of waste dumps and stockpiles
- Refinement of waste rock classification
- Define operational criteria for waste rock routing
- Optimization of closure requirements and operational/post-closure site drainage management
Gap Analysis

• Significant static geochemical waste rock characterization completed prior to mining
• Samples not always representative of current rock
• Additional information available through pit development
• Develop characterization program to take advantage of exposed rock
Waste Rock Classification

• Three classes: A, B, C
  – A: skarn, intrusive
  – A, B, C: hornfels, marble, limestone
    • Sulfide, zinc, arsenic content
• Current system protective of environment, but refinement feasible
Geochemical Characterization Program

- Static tests
  - Metals, ABA, leach tests (DI, H₂O₂): 100s of samples
- Mineralogy
- Kinetic testing (8 cells)
- Field cells (27 cells)
- Waste rock and LG/MG ore stockpile runoff monitoring
Summary of Field Cells

• 27 Field Cells Constructed (2002 - 2005)
  – Hornfels & Marble  
    • Class A – 4 Cells  
    • Class B – 7 Cells  
    • Class C – 3 Cells  
  – Class A Skarn & Intrusives  
    • Intrusives – 3 Cells  
    • Endoskarn – 2 Cells  
    • Exoskarn – 2 Cells  
  – LG Ore – 3 Cells  
  – MG Ore – 3 Cells
Waste Rock Program
Field Cell Construction

- Field cell construction
  - Clean 55-gallon plastic drum
  - Drum placement on terraced and secure area
  - Bottom drainage layer ($\approx 15$ cm silica sand) overlain by filter fabric
Field Cell Monitoring

- Leachate sample collection
  - Variable sampling frequency
    - monthly during wet season, more frequent at beginning of wet season, and not in dry season
  - Field parameters & laboratory analysis
Rock Field Cell Results
Zn (Hornfels & Marble Cells)
Rock Field Cell Results
Zn (LG/MG Ore Cells)
Rock Field Cell Results
Zn (Intrusives and Skarn Cells)

Intrusive, Endoskarn and Exoskarn Field Cells

- Cell 03: Intrusive Class A (High Range)
- Cell 04: Intrusive Class A (Average Range)
- Cell 05: Intrusive Class A (High Range)
- Cell 07: Endoskarn Class A (Average Range)
- Cell 11: Exoskarn Class A (High Range)
- Cell 16: Exoskarn Class A (Average Range)
- Cell 20: Endoskarn Class A (High Range)
Zn Field and Lab Cell Results

Field Cell 4 - Intrusives

Field Cell 6 - Marginal Grade Ore M1-ML

Field Cell 7 - Endoskarn

Field Cell 14 - Marble Class B

Lab Cell

Field Cell
Rock Field Cell Results
Mo (LG/MG Ore Cells)
Rock Field Cell Results
Mo (Intrusives & Skarn Cells)

Intrusive, Endoskarn and Exoskarn Field Cells

Molybdenum (mg/L)

Date


Cell 03: Intrusive Class A (High Range)
Cell 04: Intrusive Class A (Average Range)
Cell 05: Intrusive Class A (High Range)
Cell 07: Endoskarn Class A (Average Range)
Cell 11: Exoskarn Class A (High Range)
Cell 16: Exoskarn Class A (Average Range)
Cell 20: Endoskarn Class A (High Range)
Mo Field and Lab Cell Results

Field Cell 7 - Endoskarn

Cumulative Water:Rock Ratio (L:kg)

Loading (mg/kg)

Lab Cell

Field Cell
SO$_4$Mo Field and Lab Cell Results

Field Cell 6 - Marginal Grade Ore M1-ML

Field Cell 7 - Endoskarn

Field Cell 14 - Marble Class B

Field Cell 15 - Marble Class A

Cumulative Water: Rock Ratio (L:kg)

Loading (mg/kg)
Water Quality Simulations

- LG/MG ore and waste rock metal release simulated using existing field cell loading rates (supplemented by evaluation of data from laboratory kinetic testing and short-term leach testing)
Water Quality Simulations

• Predictive water quality modelling completed to evaluate potential impacts to the receiving environment from:
  – existing waste rock classes (Life of Mine)
  – potential modifications to waste rock classification system and placement strategies
    • Varying Class A skarn and intrusives content
    • Varying Class A hornfels/marble
    • Varying Class B hornfels/marble content
Water Quality Simulations
Key Findings

• Continued treatment of East Dump and LG/MG ore stockpile drainage
  – Simulated concentrations similar or higher than current levels

• Tucush Dump drainage quality very sensitive to the amount of Class A skarn and intrusive material placed in the dump
  – Increase in proportions of Class A skarn and intrusives has adverse impact on water quality in the Tucush drainage

• Varying the Class B material content in the Tucush Dump minimal impact on water quality
Ongoing Work – Waste Rock Classification

• Development of quality control and characterization procedures for waste rock placement
• Continued refinement of the waste rock classification system
• On-going monitoring of field cells
• Instrumentation of test piles ~6,000 tonnes, ~38m x 38m x 10m high (UBC)
Characterization of Other Materials

• Tailings
  – Static testing (metals, ABA, short-term leach)
  – Mineralogy
  – Laboratory and field cell
  – Tailings porewater quality collected from piezometers installed in beach
  – Tailings impoundment pond and seepage water quality monitoring data

• Lake Sediments
  – Static and laboratory kinetic cells
Conclusions

• Importance of initiating this type of program early on in the mine life
• Field cells more reliable than lab tests (if time permits)
• Need for ongoing testing and monitoring
• Water quality prediction based on field cells data used for waste rock management and long term planning
THANK YOU