GEOCHEMICAL CHARACTERIZATION OF WASTE ROCK

ANTAMINA MINE

PERU

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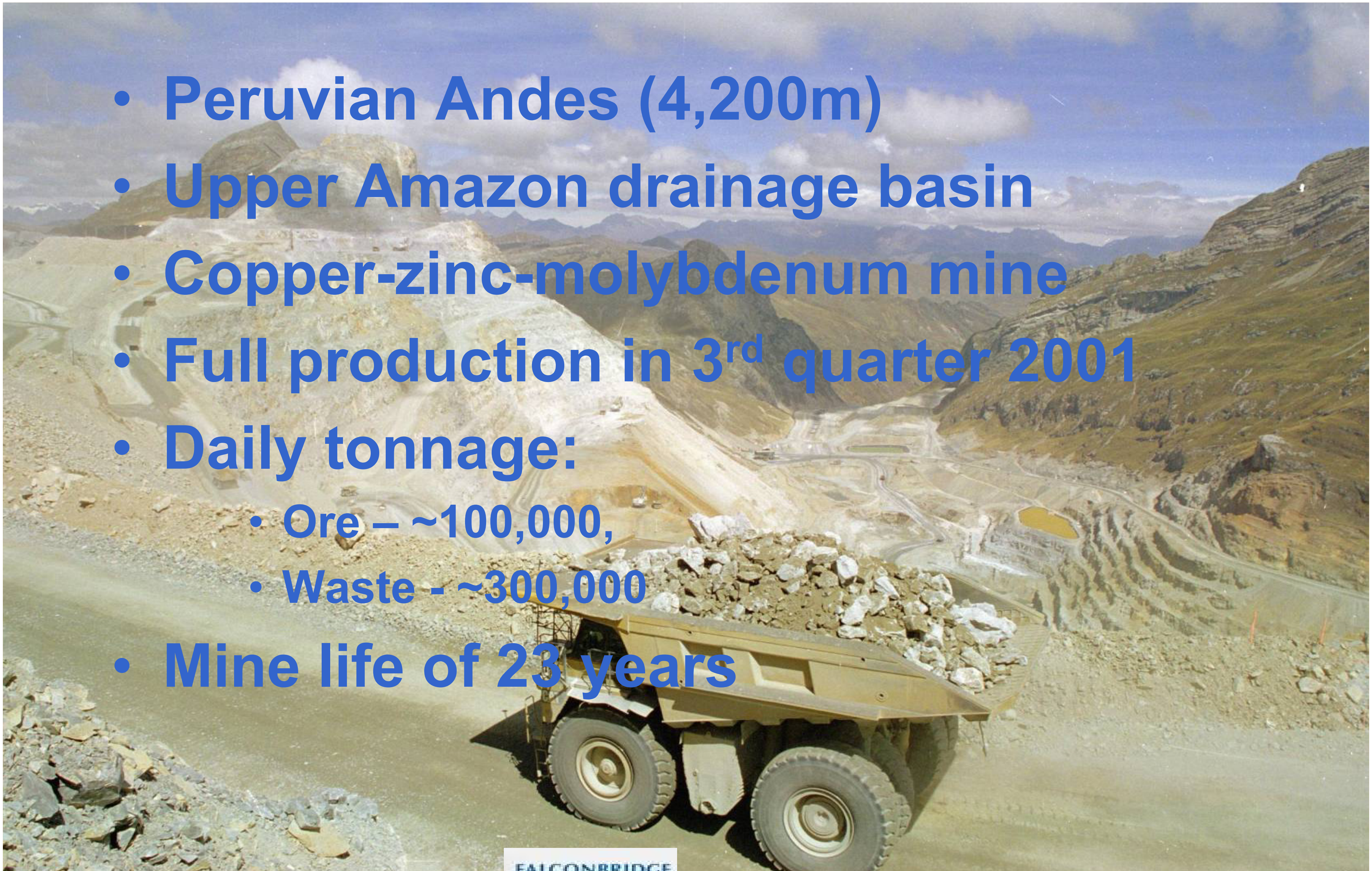
Presentation Overview

- Site Background
- Waste Rock and Ore
  - Issues
  - Investigation
  - Results
- Ongoing Work and Conclusions

ANTAMINA MINE LOCATION



- 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

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Site Overview

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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

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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, H_2O_2): 100s of samples
- Mineralogy
- Kinetic testing (8 cells)
- Field cells (27 cells)
- Waste rock and LG/MG ore stockpile runoff monitoring

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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 (≈ 15 cm silica sand) overlain by filter fabric

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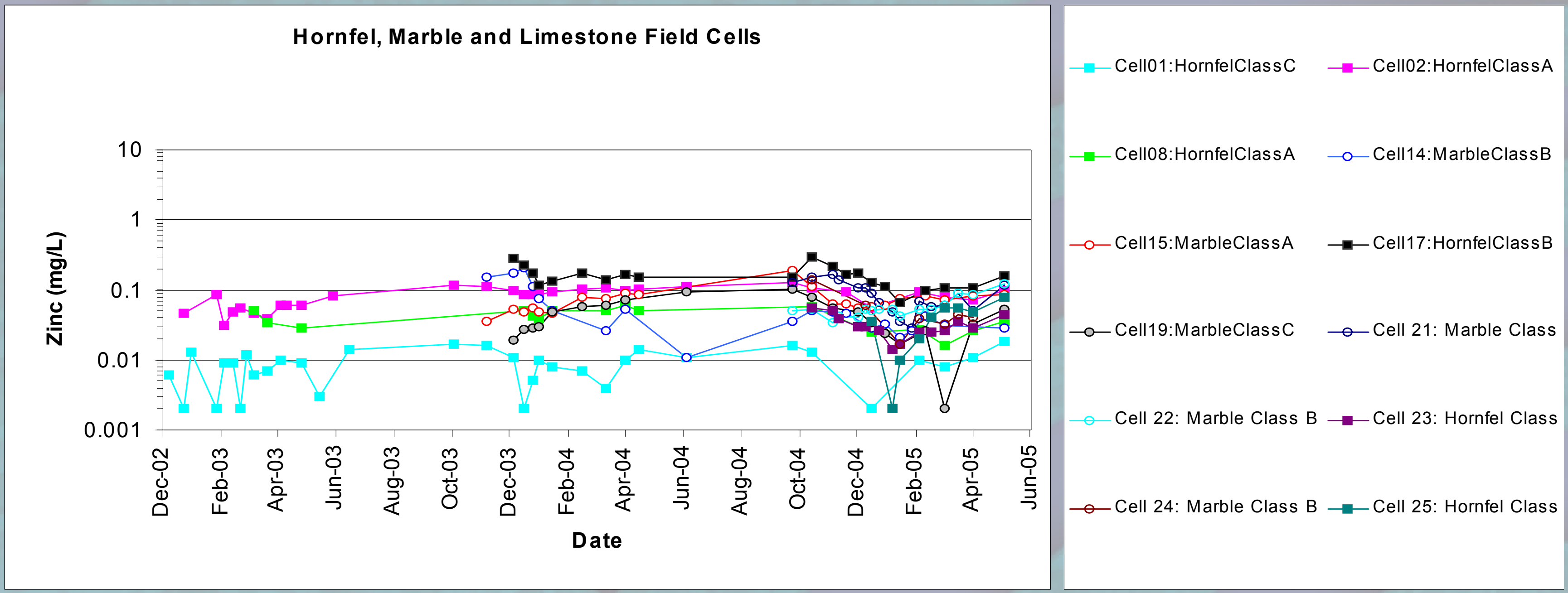
Field Cell Monitoring

- 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)



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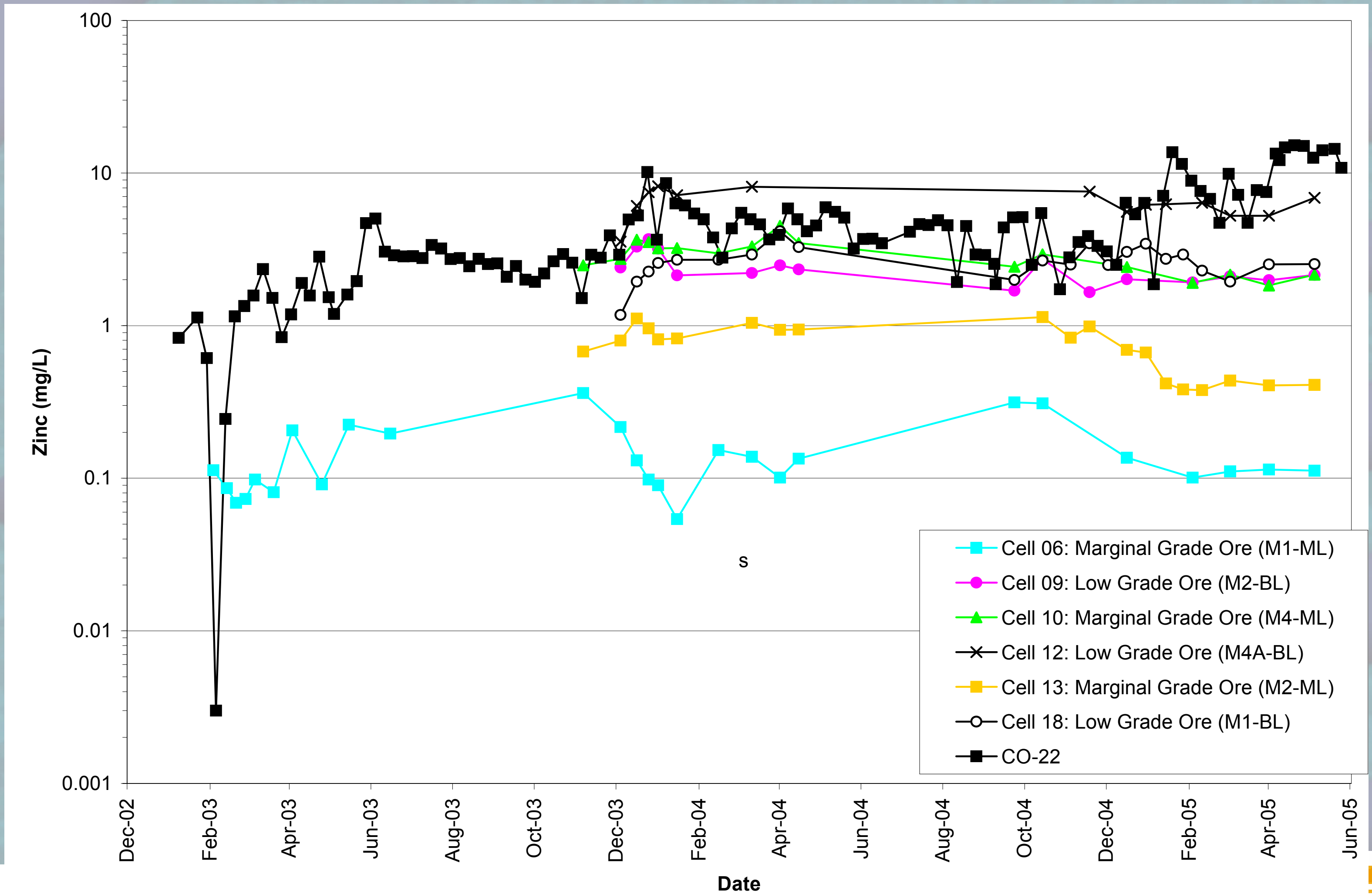
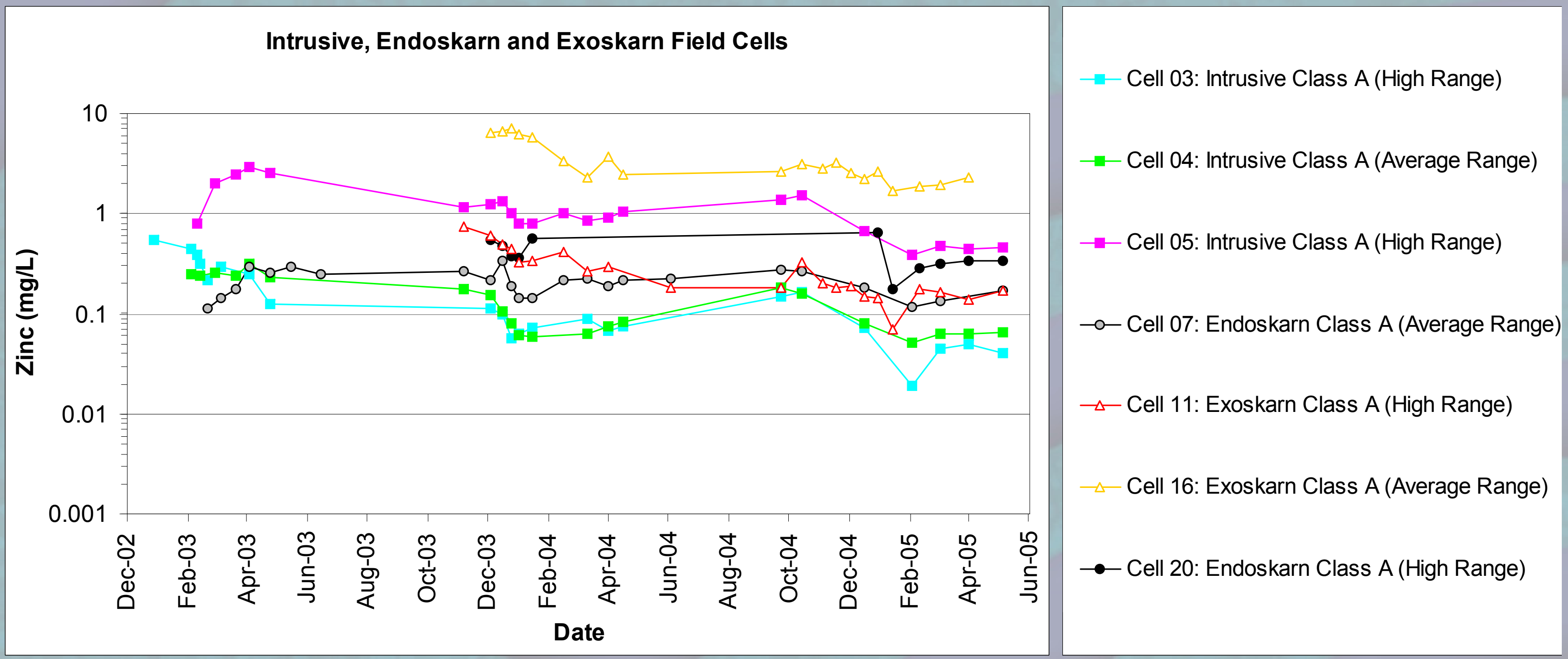
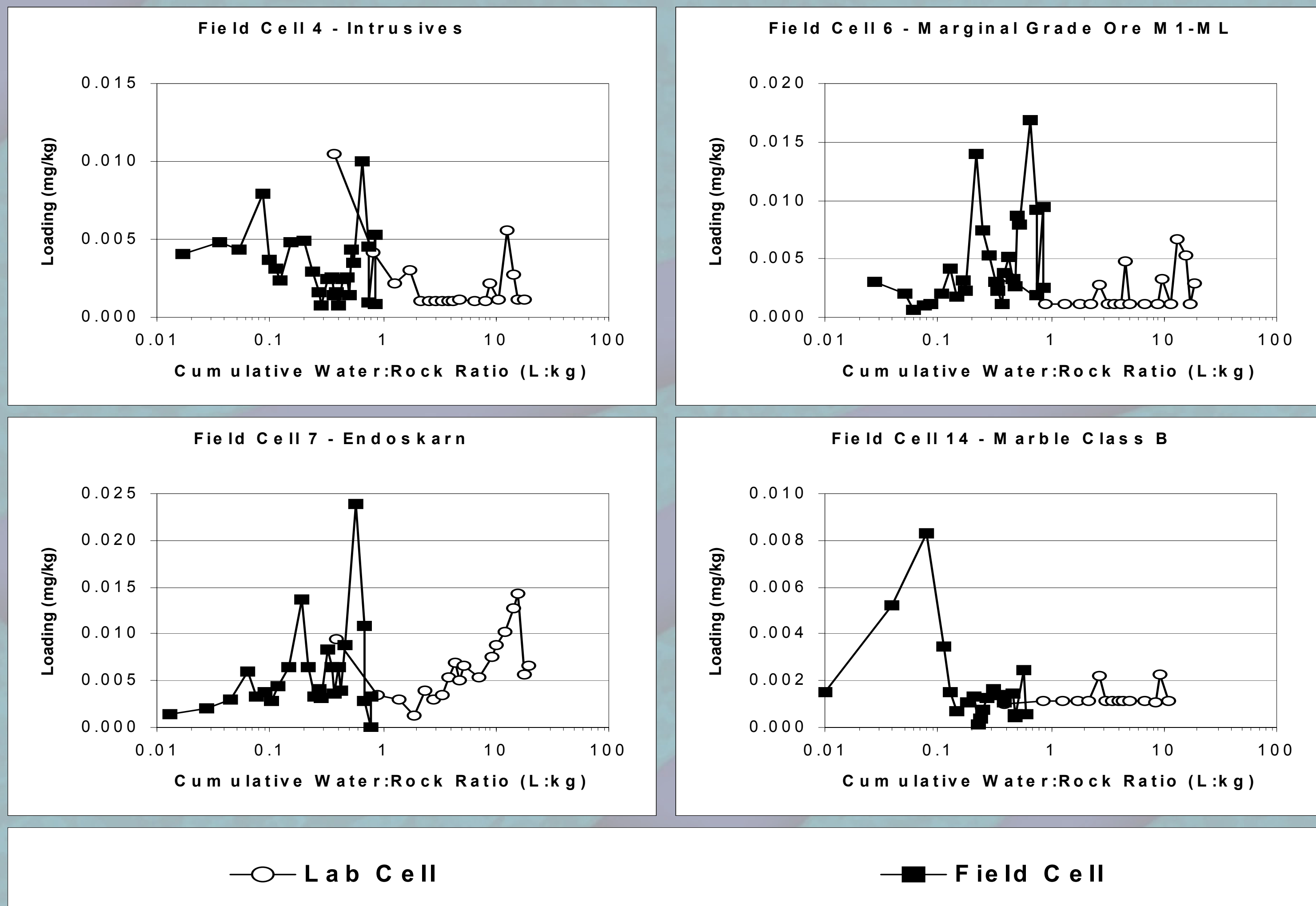
Rock Field Cell Results
Zn (LG/MG Ore Cells)



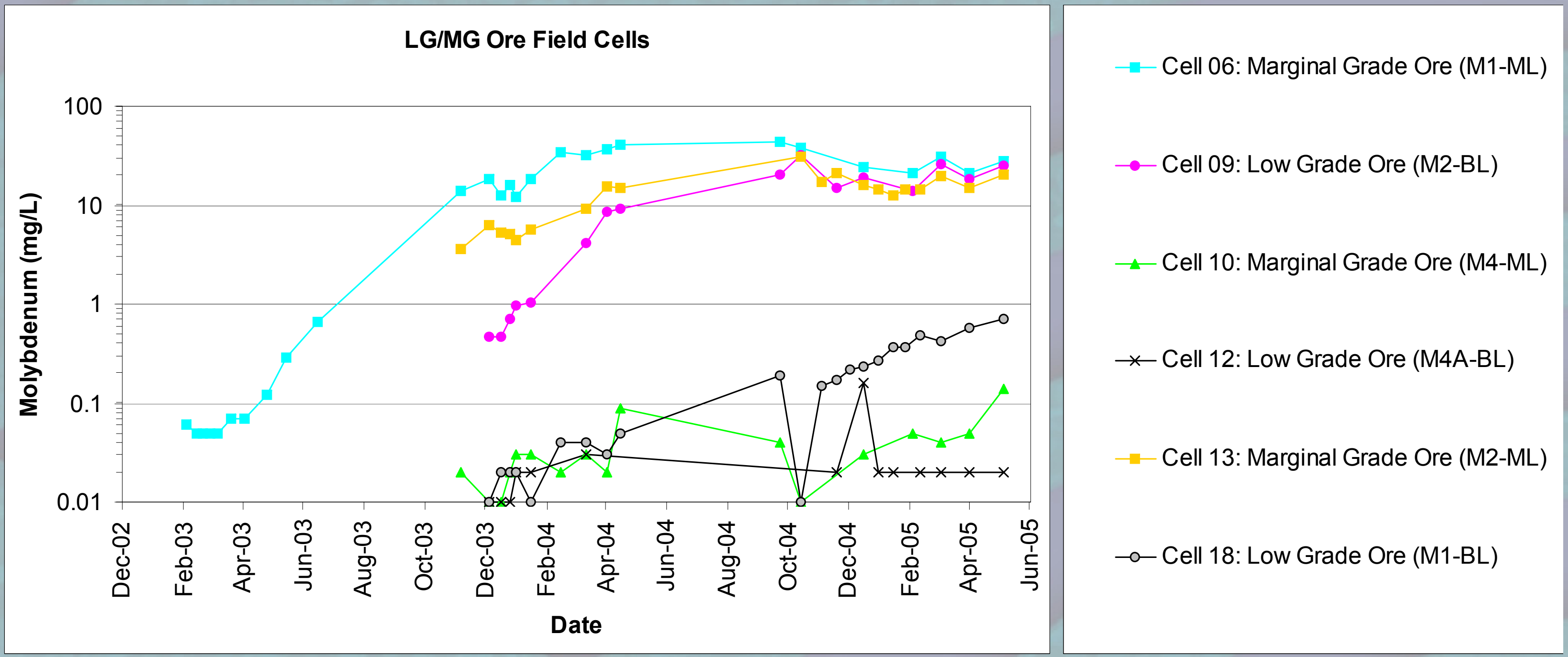
Rock Field Cell Results
Zn (Intrusives and Skarn Cells)



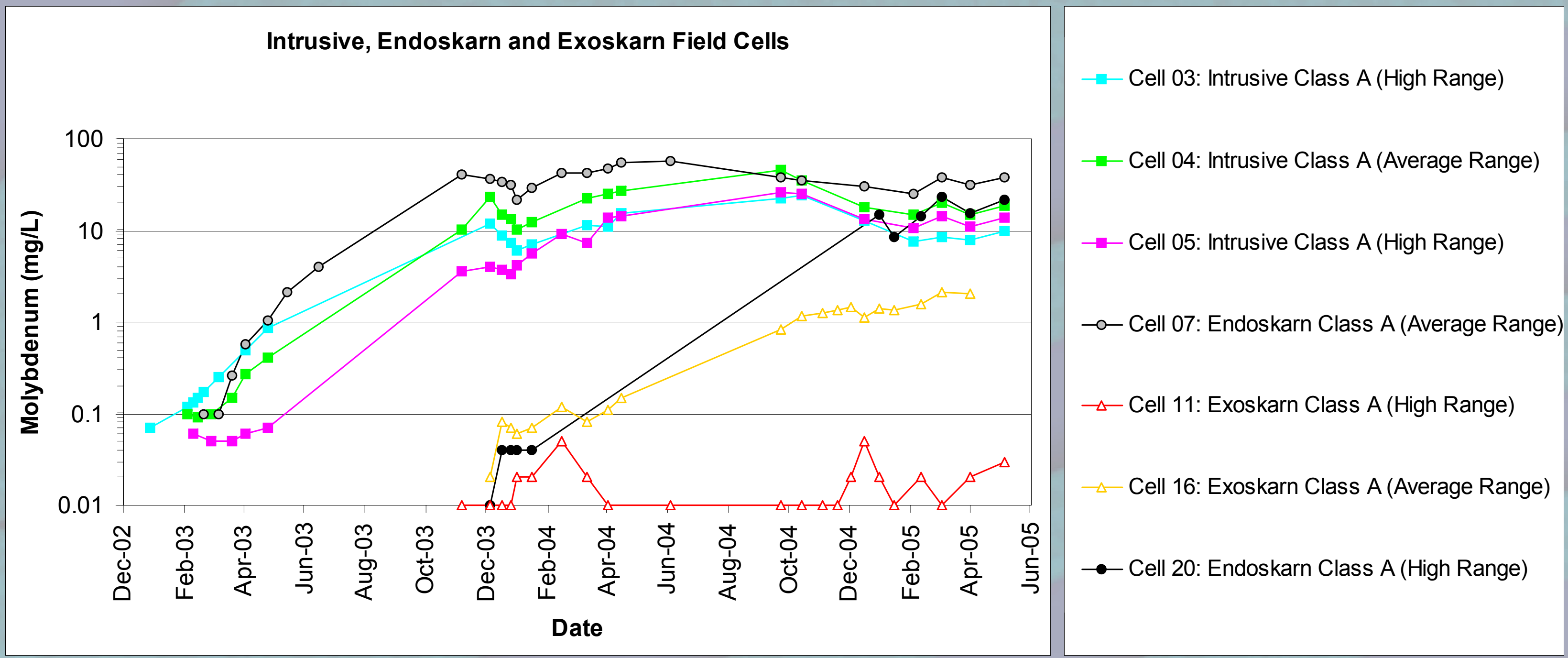
Zn Field and Lab Cell Results



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



Rock Field Cell Results
Mo (Intrusives & Skarn Cells)



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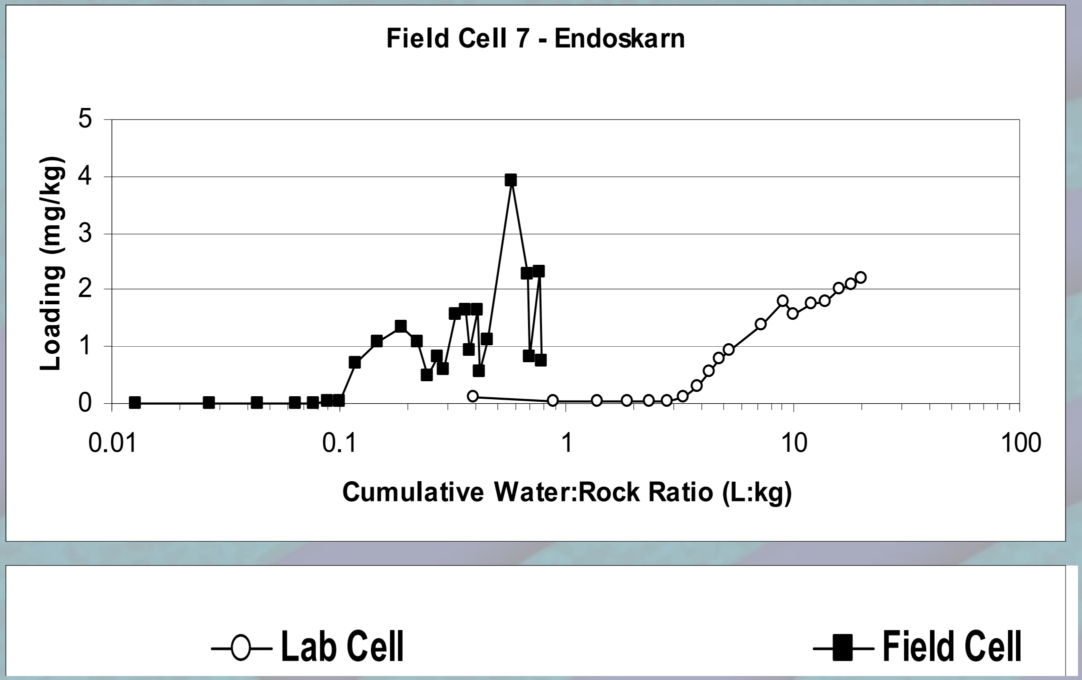
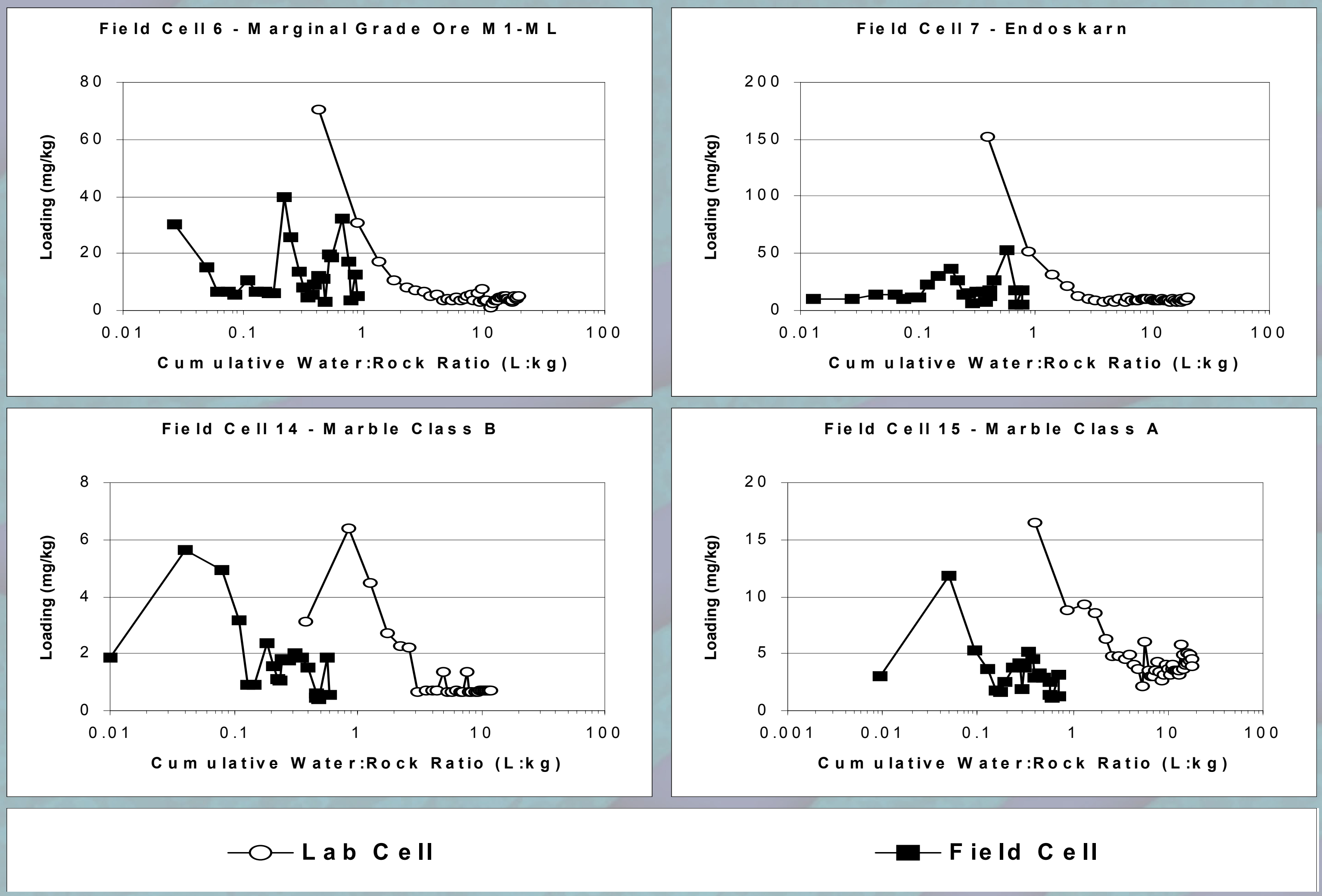
Mo Field and Lab Cell Results



SO_4Mo Field and Lab Cell Results



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