3.11. ARD PREDICTION IN BRITISH COLUMBIA: POLICIES AND PRACTICES

Bill Price
Ministry of Employment and Investment, Energy and Minerals Division

ARD PREDICTION IN BRITISH COLUMBIA: POLICIES AND PRACTICES

by

Bill Price and Victor Koyanagi

of the Reclamation Section, Energy and Minerals Division

British Columbia Ministry of Employment and Investment

SLIDES SHOWN IN THE PRESENTATION

at

The 4th Annual B.C. ARD Symposium/MEND Prediction Workshop

November 7-8, 1996

1

ARD PREDICTION IN B.C.

- Policies and Practices

2

- Bill Price
- Victor Koyanagi

3

Mines with ARD or PAG

- 33 existing
- 14 proposed

4

Mines Act: Health, Safety and Reclamation Code

10.6.16 All potential acid generating material shall be placed in a manner which minimizes the production and release of acid mine drainage to a level that assures protection of environmental quality

5

B.C. MEI GUIDELINES

- Metal Leaching and ARD Guidelines for Mines in B.C.

6

The Recommended Methods for the Prediction of Drainage Chemistry at British Columbia Mines

7

ARD PREDICTION IN B.C.

- B.C. MEI Guidelines
- Recommended Methods
- Case Studies

8

GENERAL PRINCIPLES

PREDICTION

9

To operate a mine in an informed, environmentally responsible manner, the proponent must determine the metal leaching potential of all materials disturbed or exposed

10

- Mitigation requirements will be determined according to available information
- Generic conservative conditions established in the absence of refuting data

11

Prevention Through Prediction and Design

12

PHASED APPROACH

13

STEP 1:

- Identify all different geological materials potentially affected by the mine

14

STEP 2:

- Predict the metal leaching / ARD potential of each different geological material in the form(s) and environmental condition(s) in which it will be exposed

15

STEP 3:

- Based on the metal leaching potential and the environmental protection needs, create management units and determine their monitoring, mitigation, and materials handling requirements

16

STEP 2

Predict the Metal Leaching / ARD Potential

- Static testing
- Kinetic testing

17

STEP 1:
- Identify all different geological materials

STEP 2:
- Predict the metal leaching / ARD potential

STEP 3:
- Create management units and determine their monitoring, mitigation and materials handling requirements

18

The objective in step 1 is necessary to ensure that:

- the entire range of spatial and geological variability is addressed
- subsequent testwork is representative and comprehensive

19

- All bedrock and overburden
- Variability in metal leaching and ARD
- Separation into discrete "geological units"
- Identification, description and mapping

20

STEP 3

Based on the metal leaching potential and the environmental protection requirements, determine the mitigation and materials handling requirements for waste type, exposure type, geological unit combinations that will perform alike, and that can and should be handled together

21

What disposal/remediation methods are needed?

- Critical weathering reactions and
- Potential drainage quality and quantity

22

What are the quantity or area requirements for waste disposal?

- Mass or volume of material with the critical composition
- For lime treatment, acid and metal loadings, and the sludge disposal requirements

23

What QA/QC procedures will be required to inform the extraction, waste handling and disposal operations?

- Sampling requirements
- Laboratory and
- Data analysis procedures

24

How long will it take for significant metal leaching/acid drainage to develop?

- Pertinent to most prevention measures
- Slowly filling pits or underground workings
- Humidity cell tests

25

Step 2: Predict the Metal Leaching and ARD Potential

26

- In what minerals do the metals, trace elements, acidity and NP occur? The mineral source, along with the magnitude and the geological conditions, will determine the rate of release.

27

- What are the critical weathering reactions?

28

- Under what geochemical conditions will weathering occur?
- Parameters such as redox:
  -determined by depositional environment and mitigation procedures
- Other parameters:
  -controlled by concurrent weathering reactions

29

- What criteria should be used to identify and separate problematic materials?
- What criteria should be used to separate potentially ARD generating from non-ARD generating materials

30

- **Static Testing**
- **Kinetic Testing**

31

MINE COMPONENTS

32

Waste Rock

- High porosity, aerobic conditions
- Coarse particles, inert
- Drainage chemistry, fine sized particles
- Composition of fines may deviate from the whole

33

- Operational monitoring of the <2mm fraction* will be required to verify pre-mining material characterization based on whole rock analyses

*most of the mineral grains will be exposed

34

- Prior to waste rock production, the relative contribution of different mineral types to the fine-sized fraction may be estimated from the spatial distribution observed in petrographic testwork

35

Tailings

36

Pre-mining predictions based on ore should consider the changes in composition that will result from milling

- Remove sulphides
- Add alkalinity
- Reduce the metal leaching/ARD potential
- Milling tests should allow extrapolation to entire range of ore composition

37

Reduced Porosity

- Lower conductivity for both air and water
- Raised water table
- Restricted drainage loss (porous surround)
- Limited oxygen replenishment

38

Open Pits and Underground Workings

39

Kinetic Testwork

40

Used in conjunction with static test results, to answer two main questions:

- the relative rates of acid generation and neutralization
- the drainage chemistry under the possible geochemical conditions

41

The answer to these questions will depend on:

- The reactivity and acidity of metal sources
- The reactivity of neutralizing minerals
- The solubility of the released metals

42

A variety of information sources

- similar materials at other sites
- soils and outcrops
- on-site drainage monitoring
- laboratory tests
- on-site field trials

43

Three generic kinetic test procedures should be used at all sites

- Laboratory humidity cell tests
- On-site field test pads
- On-site wall washing stations

44

Humidity Cells

- Relative rates of acid generation and neutralization

45

Humidity Cells

- With geochemical modelling, predict drainage chemistry

46

Required items in humidity cell testing:

- Until a long term steady state is reached (minimum 40 weeks)
- Desired geochemical conditions are reached, gypsum
- Comprehensive static testing, pre-test and after-test
- Minimize the loss of fine particles during flushing events

47

- On-site field test pads and wall washing stations

48

- Results cannot be extrapolated

49

Column Studies

- Simulate the critical geochemical conditions
- Drainage chemistry information
- Cannot extrapolate

50

Site Monitoring

- Drainage chemistry under different geochemical conditions
- Trends in metal leaching over time
- Mineral weathering
- Fine particle replenishment
- Correlation between important factors

51

Site Monitoring

- Source of prediction data for closure plans

52

AVOIDING ERRORS

53

Common errors include:

- testing unrepresentative materials
- incomplete analyses of the test materials
- erroneous assumptions regarding the parametre measured

54

- **Detailed static test information**
- **Parameters measured are true indicators**
- **Drainage concentration and loadings**
- **Consideration of test conditions**

55

Both on the mine site and in test work, the absence of acid conditions does not in itself prove that there will not be future ARD

56

Static Testing

STATIC TESTING

57

- **a wide variety of analyses**
- **quality and quantity of different constituents**
- **information used in conjunction with previous experience forms the basis for preliminary estimates of metal leaching or ARD potential**

58

- **Unique site and geological conditions**

59

- Generic procedures

60

STATIC TESTING

a) Trace Element Content
- Total Concentration
- Soluble Concentration

b) Acid Base Accounting
- Total, Sulphate, and Sulphide Sulphur
- Bulk Neutralization Potential
- Carbonate Neutralization Potential
- pH

c) Mineralogy and Other Geological Properties
- Petrographic Examination

61

Total Concentration of Trace Elements

- multi-element total concentration analysis
- anomalous concentrations
- focus future work

62

- Common trace metals: Cd, Cu, Mn, Mo, Ni, Pb, Sn and Zn
- Less common contaminants: Ag, As, Hg, Sb, Se
- All materials impacted by the mine should be screened

63

- Normal range of concentrations found in rock and soil
- NOT to be taken as a measure of the threat to the environment
- Additional testing and analysis

64

Concentration of Soluble Constituents

65

Materials may be already weathered or oxidized as a result of:

- Historic supergene processes
- Previous mining
- Delay in the use of prevention measures

66

Solubility Testing - Shake Flask

- 24 hours
- distilled water
- 3:1 water to solid ratio

67

Solubility testing should be used selectively:

- Initial characterization of geological materials
- Sulphate content
- Results of petrographic examinations

68

Elements of Concern:

- Discharge objectives reported in the provincial Pollution Control Objectives for the Mining, Smelting and Related Industries (MELP 1979)
- Determination of potential impact and a need for mitigation will depend on the site specific conditions

69

Acid Base Accounting

- Total-S, acid leachable sulphate-S, acid insoluble sulphate-S, and sulphide sulphur
- Bulk neutralization potential
- Carbonate-Carbon
- Ba
- pH

70

Sobek Procedure

- **Used by most mines and in most ARD research**
- **Most experience to date is calibrated with this measure**
- **In the absence of contrary field or mineralogical evidence, the Sobek NP should be used to derive NPR**

71

NP Assessments should consider:

- Contribution of low pH
- Iron and manganese carbonate
- Clay mineral buffering
- Low sulphur and carbonate levels

72

Carbonate NP

- Required as a check of Sobek NP
- Required to provide greater understanding of the mineralogical basis

73

NP:AP Ratio (NPR)

- Operationally identifying and separating PAG materials
- Screening criteria in the early stages of the prediction program

74

More Refined Geological Characterization

- using microscopic and submicroscopic techniques
- mineralogical information

75

Mineralogical Information

- Acidity and metal sources
- NP sources
- Oxidation, readily soluble constituents
- Amount and spatial distribution
- Physical features that will influence weathering

76

Petrographic Examination

- Representative subset of samples
- Samples with ABA and elemental data

77

- Petrographic examinations: coarse to medium grain mineralogy
- XRD: phyllosilicate minerals
  grains < 100 um
- Sub-microscopic techniques:
  -mineral alteration features
  -elemental composition of specific minerals

78

Screening Criteria

79

- Screening criteria
- Avoid unnecessary work
- Focus effort on materials of greatest concern or uncertainty
- NOT intended to serve as final prediction criteria

80

- ignorance regarding rock and mineral activity
- lack of detailed historic site characterization and monitoring
- criteria are coarse and conservative
- kinetic information is required to develop more refined and precise site specific estimates

81

Acid Base Accounting (ABA) Screening Criteria

82

- If sulphide content is greater than 0.3% an ABA assessment is required
- Due to greater solubility of metals at low pH, if the pH is less than 5.5, a 24 hour shake flask extraction is required

83

Potential for ARD	Initial Screening Criteria	Comments
Likely	NPR < 1	likely ARD generating unless sulphide minerals are non-reactive
Possibly	1 < NPR < 2	possibly ARD generating if carbonates are either non-reactive or are depleted at a faster rate than sulphides
Low	NPR 2 - 4	non-ARD generating unless significant preferential exposure of sulphides or extremely reactive sulphides in combination with low reactive cabonates
None	NPR > 4	

84

- **ARD Guidelines**

85

- Identify all different geological materials potentially affected by the mine
- Predict the metal leaching / ARD potential of each different geological material in the form(s) and environmental condition(s) in which it will be exposed
- Based on the metal leaching potential and the environmental protection needs, create management units and determine their monitoring, mitigation, and materials handling requirements

86

AVOIDING ERRORS

87

- Metal leaching / ARD program must be compatible with the mine plan.

88

- Focus on the questions critical to the particular waste handling and remediation options

89

- Determine the applicability of the testwork, samples and analysis to the questions being asked
- Metal leaching tests, which are often misused or misinterpreted, provide very specific information

90

- Large number of factors to consider
- Long duration of some testwork
- Onerous undertaking in time and resources
- Expertise necessary for interpretation
- Iterative process of testwork, analysis and review, similar to that used to determine other geological characteristics such as ore reserves

PHASED APPROACH

91

- Detect all potentially problematic materials
- Avoid unnecessary work on materials for which there is no concern
- Inform decisions regarding materials and methods for more costly, time consuming test procedures (such as kinetic tests), with cheaper, more easily collected ABA and elemental data
- make timely refinements in response to unforseen conditions

92

B.C. MEI ARD GUIDELINES FOR PREDICTION

- Policies
- Questions/Answers Required
- Measurements/Evidence
- Screening Criteria
- Procedures for Data Analysis
- Transparency
  - -communication
  - -criticism