Structural and Hydrologic Characterization of Two Historic Waste Rock Piles at Detour Lake Mine

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Sulfide Oxidation in Waste Rock





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Detour Lake Historic Waste Rock Piles



- Four historic waste rock piles on site:
 - 16 year operating history and 10 year post-closure history
- Two of four stockpiles were selected to analyze physical properties of historic waste rock under site conditions

Study Components

- Oxidation Products
- Gas transport

Waste Rock Excavation Goal and Objectives

Evaluate the geotechnical properties and hydrologic behaviour of Detour historic waste rock under site conditions

Objectives:

- 1. Conduct a field and laboratory program evaluate structural characteristics
- 2. Collect a sample inventory for detailed testing
- 3. Assess unsaturated soil properties of matric material
- 4. Evaluate volume of matric material and available water to assess flow characteristics

Research Program

- Two phase study:
 - Field Investigation
 - Representative sampling
 - Temperature profile
 - Matric suction measurements
 - Rock type identification, sulfides
 - Laboratory and Desktop Study:
 - Particle size distribution
 - Paste pH
 - Munsell soil colour
 - Moisture content
 - Saturated hydraulic conductivity
 - Soil-water characteristic curves (SWCC)
 - Digital Image Processing (DIP) techniques

Test Pit Sampling Program

Profile Sampling Program

-D Waste Rock Characterization Project

Interior Pile Structure

Field Program Results

- Structural features indicate the piles were likely a push or paddock dump with multiple benches of 10 15m
 - Typical features included traffic surfaces, angle of repose layering and coarse rubble zones at the base of benches
- Primarily clast supported structure, indicating pile behaves as a rocklike material
- Weathering was found throughout the waste rock to varying degrees
- Tensiometer matric suction:
 - Cover material 10 to 50 kPa
 - Waste rock fines 1 to 30 kPa
- Gravimetric Moisture contents: Between 3 wt% and 6 wt%

Geochemical Setting

- Samples from WRS 1 and WRS 2:
 - Average carbon/sulfur of waste rock: 0.59/1.2 %
 - 56% of samples classified as PAG (Detour cutoff for PAG 1:1.5)
- Instrumented Piles (WRS 3, WRS 4)
 - Porewater geochemistry near neutral (pH 7-8),
 Eh = 200-400 mV, elevated sulfate
 - Sulfide oxidation is ongoing, acidic drainage has not set in

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Matric Flow Estimation and Residence Time

• Determining matric flow in the waste rock using a basic conceptual model:

Assume water flow only occurs in <4.75 mm material

Utilize a Representative Elemental
 Volume (REV) of 1 m³ to create a
 conceptual model for flow

N DE

Estimate the proportion of matric material present utilizing DIP grain size data

Range of volumetric moisture contents (θ_w) for matric material - SWCC data,

-Tensiometer matric suctions

Determine the volume of water within the (REV) as a height of water

Steady state conditions and plug flow (Δ S=0), and flux equal to the average annual rainfall

Determine the residence time for the REV

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Waste Rock Characterization Project

-P Waste Rock Characterization Project

Digital Image Processing

N DE

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Water Content and Residence Time

	Residence Time for 1D flow in REV for Varying Percent of Total Infiltration (880 mm/yr)			
	100%	50%	25%	10%
1D flow in REV (days)	10	20	40	100
20 m waste rock pile (years)	0.55	1.1	2.2	5.5

• Conceptual model provides an estimate of residence time between 0.5 to 5.5 years for 20 m waste pile

Summary and Conclusions (1/2)

- After a 26 year history, evidence of oxidation throughout the entirety of the stockpiles
 - The degree of weathering and oxidation is varied
 - The cover has not prevented oxidation, but may limit advective gas transport into the waste pile
 - Sulfide oxidation is ongoing, acid drainage has not set in more geochemical results to come
- Evidence of segregation of material and structure consistent with push dump construction techniques

Summary and Conclusions (2/2)

 Detailed laboratory testing determined SWCCs and full grain size curve using DIP techniques

- Developed framework for understanding matric flow
 - Fluid flow occurs in matric fines <4.75 mm in unsaturated conditions
- Residence times ranged from 0.6 to 5.5 years for 20 m pile, expected in the range of 1.1 to 2.2 years

Questions and Discussion

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