

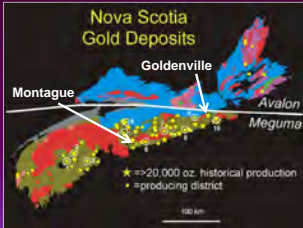
## Using Hydrogeochemical Data to Improve Remediation of Historical Gold Mine Tailings in Nova Scotia

IMWA 2010

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## Historical Setting



- Gold in NS discovered 1858
- 64 operational districts within Meguma slates & graywackes
- Unregulated mining activities
  - > 3,000,000 tonnes of tailings generated
  - Slurried into local waterways
- Arsenic 9 ppm to >300,000 ppm
- Expanding residential development

## Tailings & Water Characteristics

- Nova Scotia gold mine tailings: As-rich (mean 1 wt. %), mineralogically complex, and variable redox conditions
- Surface waters pH-neutral, variable pore water pH
- Arsenopyrite-oxidation has altered to various As-hosting secondary phases
  - Iron arsenates
  - Ca-Fe arsenates





Scorodite

## Study Purpose

- **Focus:** Processes controlling arsenic release and attenuation
- Characterization is essential for:
  - Choosing appropriate strategies for remediation – do multiple phases require multiple approaches?
  - Assessing the potential for remediation-induced geochemical changes on As-bearing phases and pore waters


## Study Location - Montague

- Located within Halifax Regional Municipality
- Tailings slurried into Mitchell Brook (1860s – 1940s)
- Posted signs warning of high As concentrations by Province of NS, 2006
- Continued recreational activity

## Study Location - Goldenville

- 50 km south of Antigonish
- Tailings continue for at least 6 km out to the Atlantic Ocean
- Annual 4x4 rally cancelled in 2006
- Posted signs
- Continued recreational activity



## Methods

To assess stability pre- and post-remediation: water-mineral interactions

### Water Sampling

- Vadose zone
- Saturated zone
- Surface waters

### Water Analyses

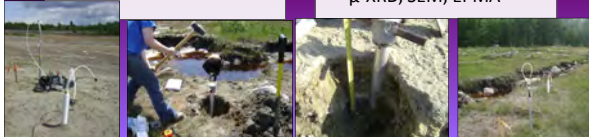
- Digestion, ICP-OES
- IC

### Coring

- Vadose through saturated zones

### Solid Analyses





- Bulk chemistry
- Petrography
- μ-XRD, SEM, EPMA



## Results

### Visual Distinctions in Tailings Types

- Heterogeneous tailings: Grain size, saturation, colour, composition

Fine grained,  
always gray

Hardpan,  
near surface

"Typical", coarse grained,  
oxidized near surface

## Chemistry Results

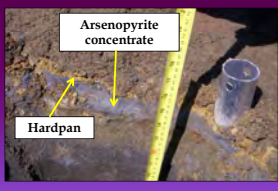
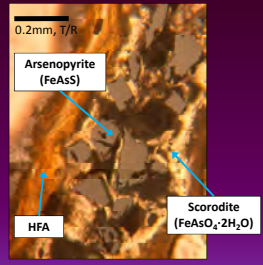
Tailings Types	PORE WATERS (ppm)				SOLIDS (ppm)			
	pH	As	Ca	Fe	As	Ca	Fe	Ca/As
<b>Vadose Zone</b>								
Coarse grained	5.42	5.25	18.4	1.19	6131	2616	31,833	0.77
HP-bearing	2.4	<b>24.8</b>	16.1	<b>45.1</b>	<b>12,808</b>	500	<b>32,512</b>	0.15
Fine grained	6.79	15.2	<b>197</b>	12.9	1237	<b>11,000</b>	23,650	<b>9.20</b>
<b>Saturated Zone</b>								
Coarse grained	8.05	1.19	29.6	0.71	2138	3833	27,567	2.10
Below HP-bearing	6.7	<b>24.4</b>	48	20.5	2854	3100	29,300	1.30
Fine grained	6.85	2	<b>92.7</b>	<b>63.4</b>	872	<b>11,225</b>	28,225	<b>14.5</b>

*For Comparison...*  
**Arsenic guidelines:**  
 Metal Mine Effluent Regulation = 0.5 ppm  
 Drinking Water Quality Guideline = 0.01 ppm

*Soil Quality Criteria* = 12 ppm

## Controls on Arsenic Mobility

- Arsenopyrite oxidation
- Scorodite and hydrous ferric arsenate (HFA) precipitation

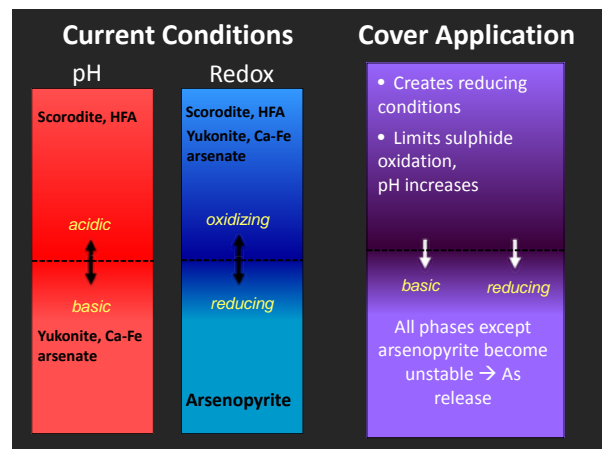



Other secondary phases:

- Yukonite and Ca-Fe arsenate precipitation (Walker et al. 2009)

## Remediation Challenges

- Heterogeneous tailings composition
  - Variable degrees of weathering have produced wide-ranging As-bearing phases
- Phase stability
  - Scorodite & HFA → acidic pH, oxidizing environments
  - Yukonite & Ca-Fe arsenates → neutral pH, oxidizing environments
  - Arsenopyrite → reducing environments
- Remediation
  - A traditional cover can create reducing conditions



## Conclusions

- A complex mix of secondary As minerals provide a temporary form of natural attenuation
  - These may not be stable under changing geochemical conditions
- Mineral stability must be considered in developing an appropriate remediation strategy
- On-going work:
  - More detailed hydrogeology
  - Investigating altered redox conditions in column experiments

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