Rio Tinto

Acid/Alkaline Rock Drainage

Concepts and Research at Diavik

December 14, 2010

About me – Lianna Smith

- At Diavik since May 2005
- Sr. Specialist, Mineral Waste
- Previous experience in consulting and government
- Geology and geochemistry background
- Enjoy field work and learning from other people

Outline

- What is ARD?
- ARD generation
- ARD management
- Diavik waste rock
- Diavik research
- Questions

What is ARD?

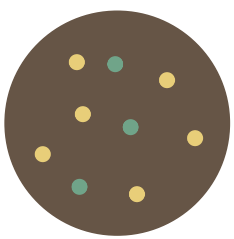
ARD: water that has elevated concentrations of dissolved constituents, which may include trace metals, and may or may not be acidic

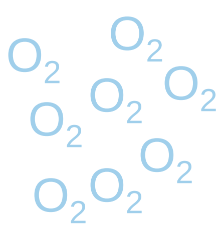
Ingredients

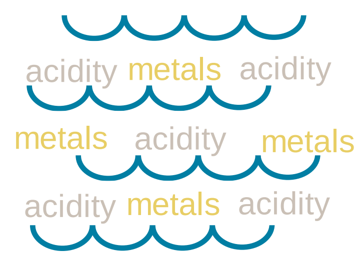
- Sulfide minerals in rocks
- Oxygen
- Sulfide oxidation reactions
- Neutralizing minerals in rocks
- Water to flush reaction products

Products

- Water with elevated acidity (low pH) or neutral/alkaline pH
- Elevated concentrations of dissolved constituents (sulfate)
- Elevated concentrations of dissolved trace metals







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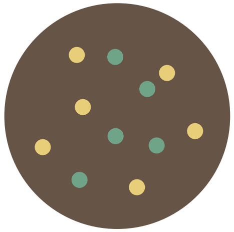
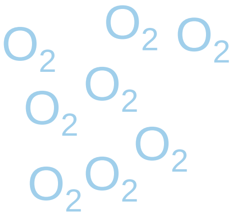
Factors that influence ARD generation

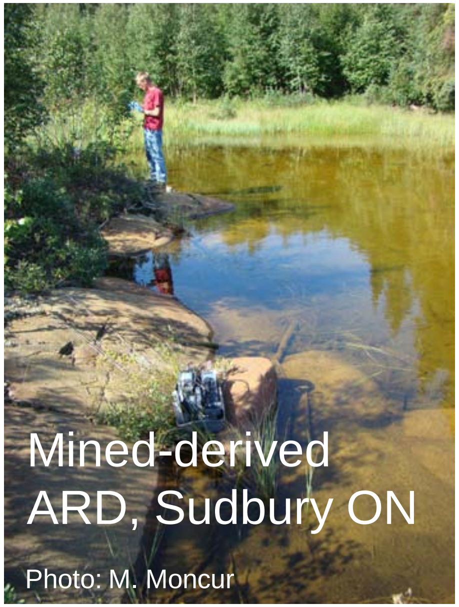
- Mineralogy
  - Type and abundance of sulfide minerals
  - Type and abundance of neutralizing minerals
- Source rock characteristics
  - Grain size distribution (surface area)
  - Permeability to air and water
  - Source rock volume
- Environment
  - Temperature
  - Rainfall/snowmelt

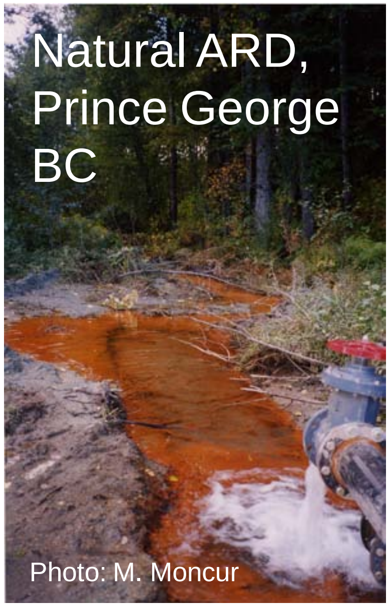




Acid/Alkaline Rock Drainage (ARD)

- ARD occurs when sulfide minerals react with oxygen in the atmosphere
- Sulfide minerals exist in many types of rock, including rocks that are mined
- ARD can occur as a result of human impacts, including mining
- ARD can occur naturally



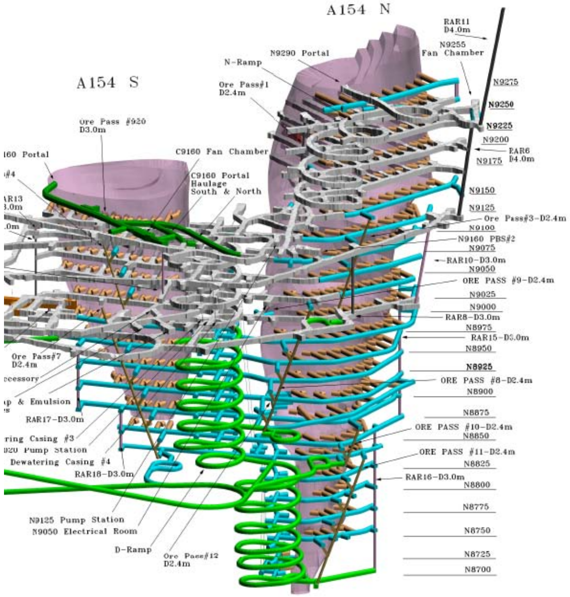


Factors that affect ARD risk

- Type and volume of waste rock
- Short-term and long-term storage design
- Sensitivity of receiving environment

ARD Sources at an Operating Mine

- Underground workings
- Open pit wall exposures
- Tailings impoundments
- Waste rock stockpiles
- Ore stockpiles
- Sludge ponds
- Heap leach piles

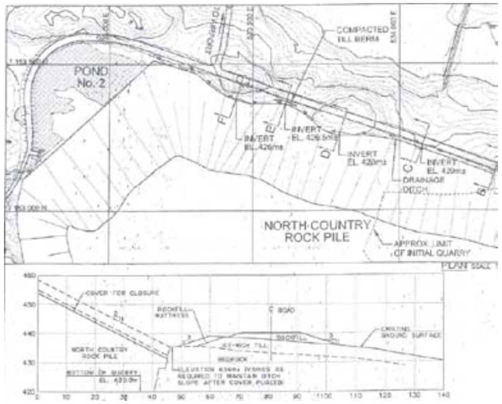


ARD Management

- Characterize the source and the receiving environment

- Laboratory experiments
  - Measure amount of sulfide minerals
  - Measure amount of neutralizing minerals
  - Run column experiments (accelerated weathering)

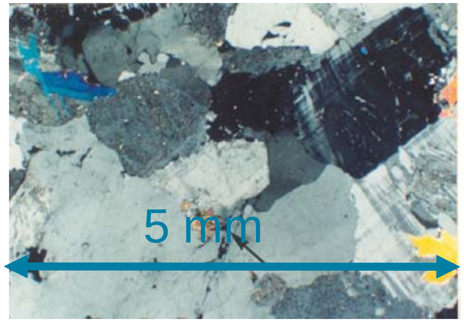
- Appropriate storage design
  - Storage configuration
  - Secondary containment
  - Treatment options

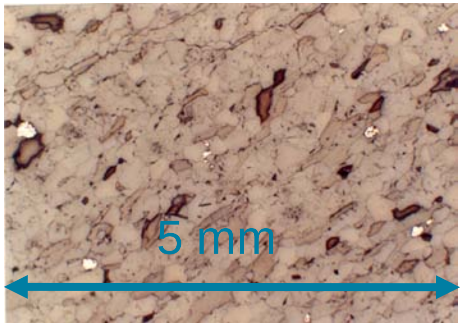


Diavik Waste Rock Management

Diavik Waste Rock

- Granite with metasediment (biotite schist) lenses and rafts
- Granite contains only trace of sulfide minerals
- Biotite schist contains < 0.42 wt. % S





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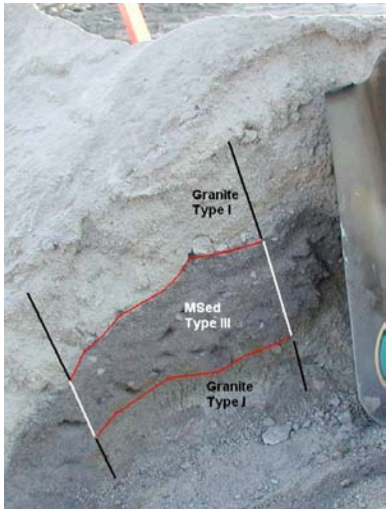
Waste rock - layering

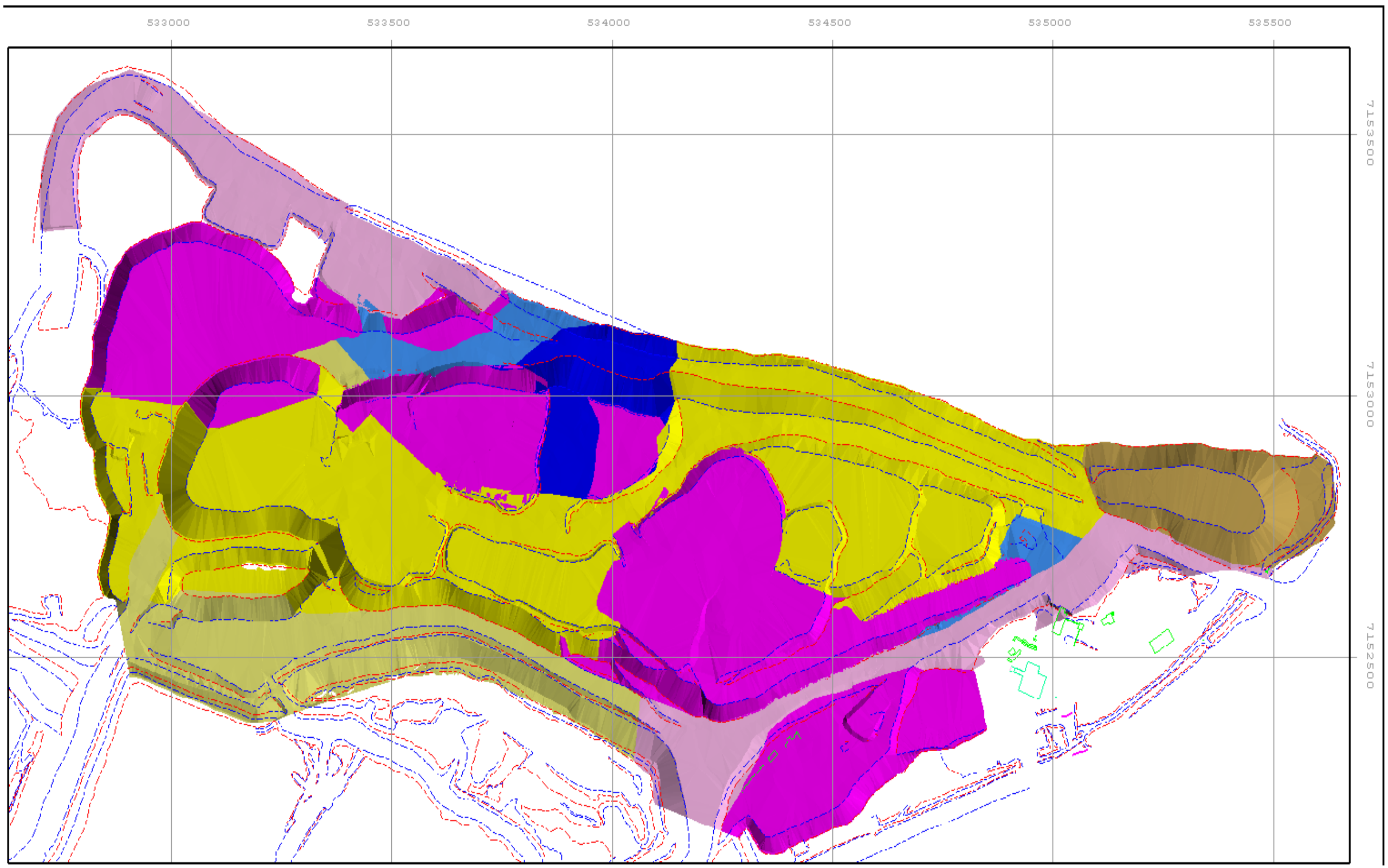
Waste Rock Segregation

- Waste rock segregated based on target sulphur content:

Type I	< 0.04 wt. % S	Predominantly granites
Type II	0.04 – 0.08 wt. % S	Predominantly granites with small amount of biotite schist
Type III	>0.08 wt. % S	Predominantly granites with greater amount of biotite schist

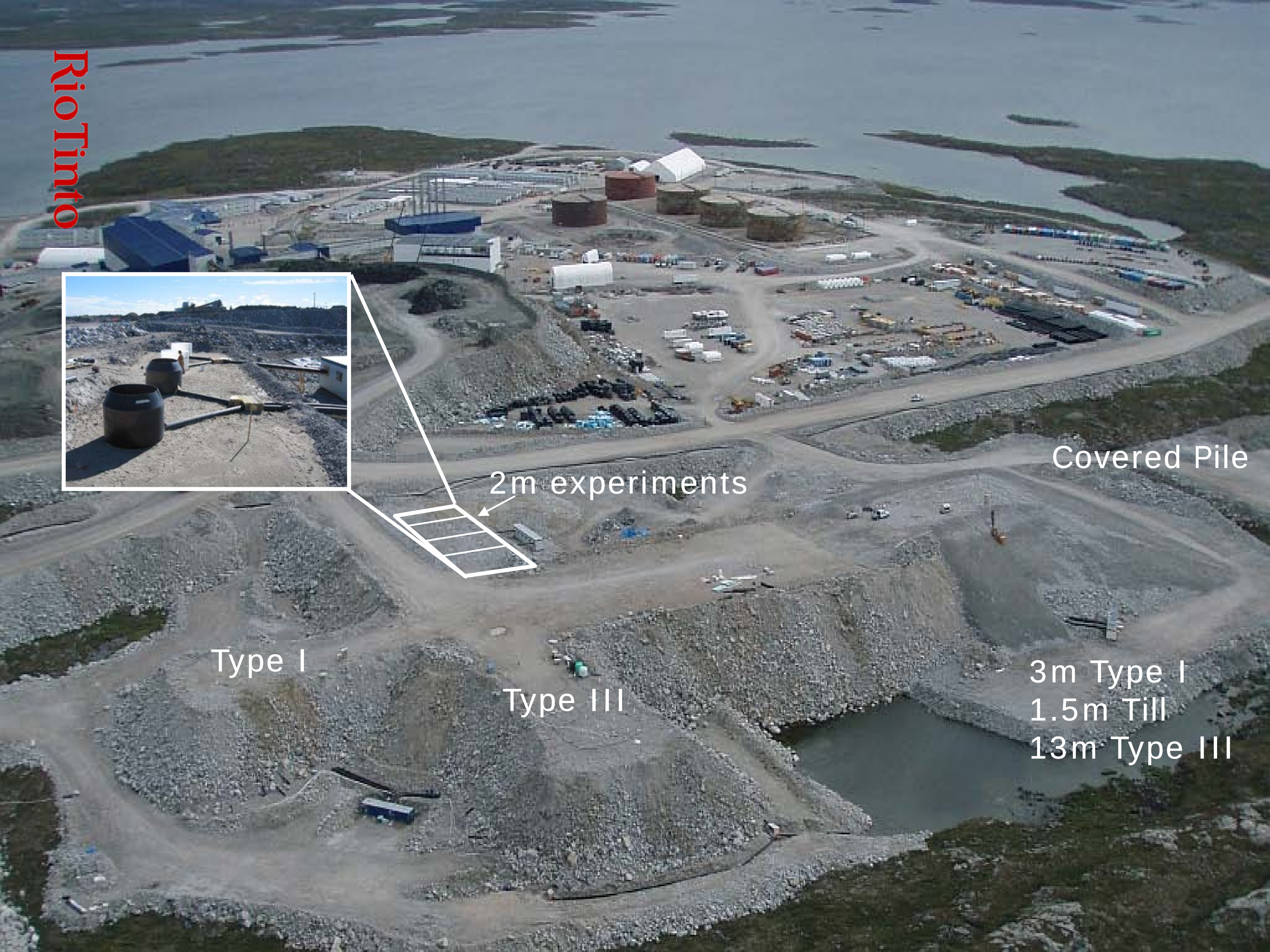


Waste rock management



Waste rock ARD research

- Research directed through Test Piles Project
- University-led, multidisciplinary program 2005 to 2015
- Multimillion dollar investment from Diavik, INAP, NSERC
- Lab experiments
- Six 2 m experiments
- Three 15 m high piles, instrumented
- Instrumentation installed in the waste dump
- Academic and Diavik-specific questions addressed through test piles project
  - Hydrology and thermal regime in unsaturated waste rock piles
  - Sulfide oxidation in low-sulfide waste rock in cold climates
  - Scaling from laboratory experiments through full-size waste dumps
  - Performance of till and Type I layers for closure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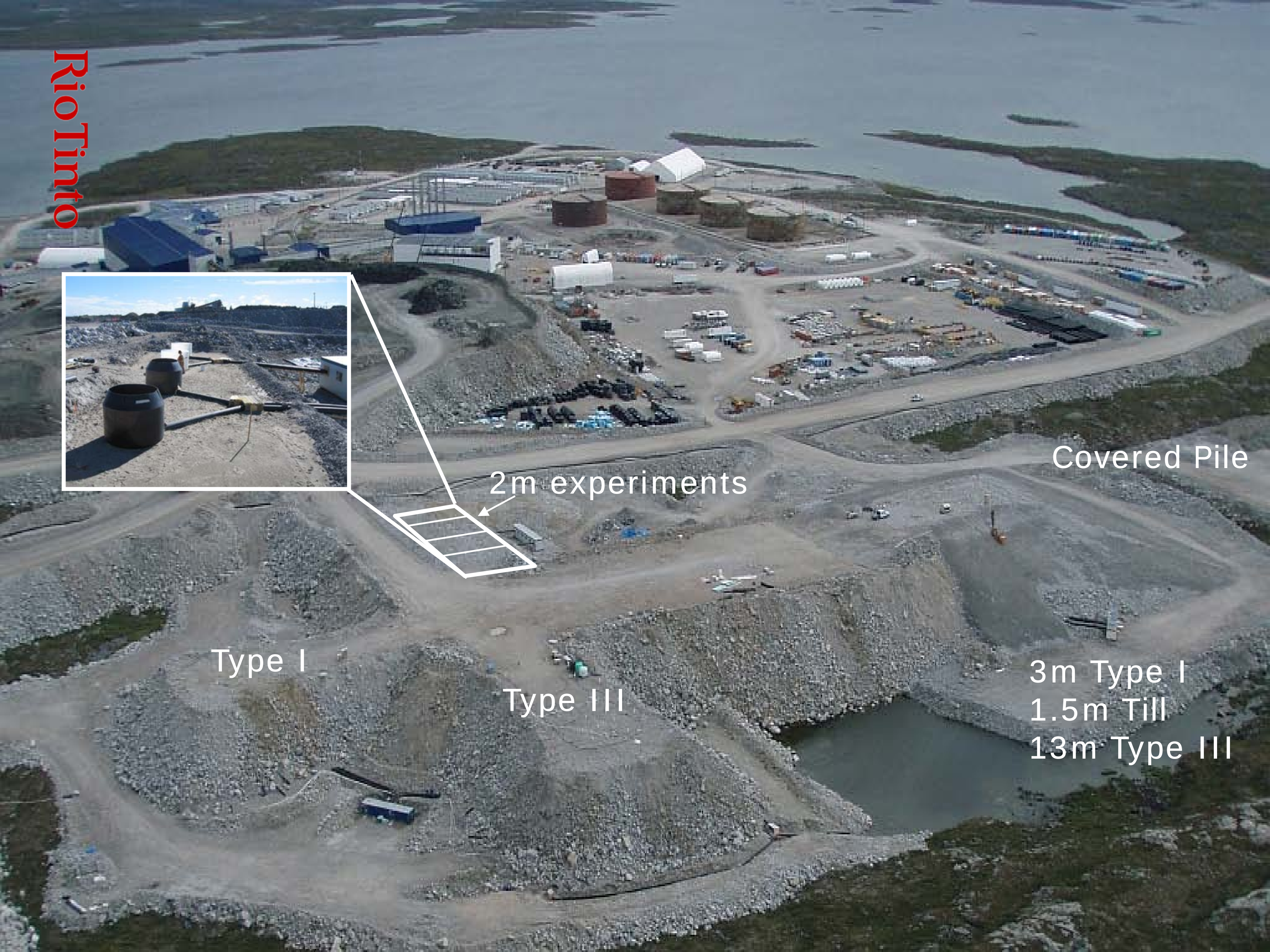
2m experiments
Covered Pile
Type I
Type III
3m Type I
1.5m Till
13m Type III

Scale-up

Test piles project
2 m scale experiments



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2m experiments
Covered Pile
Type I
Type III
3m Type I
1.5m Till
13m Type III

Test piles construction
Build the base

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Install Basal Thermistors

Install Impermeable Liner and Basal Drain

Construct Basal Lysimeters

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Place 2 m run-of-mine lift and fill basal lysimeters

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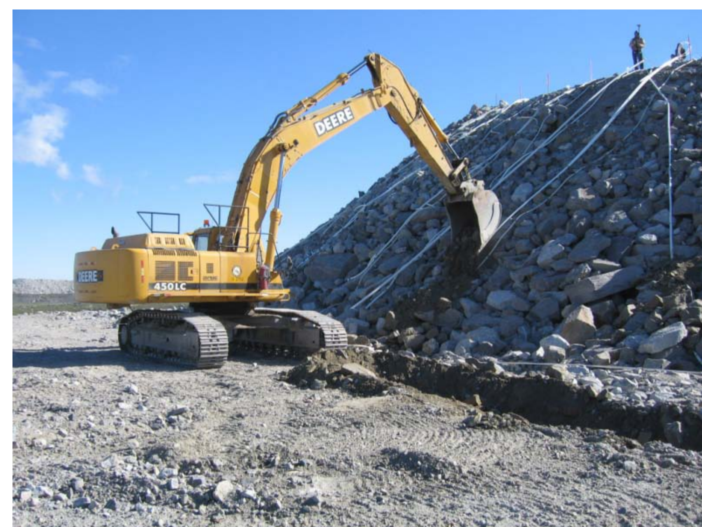
Push run-of-mine from ramp to build pile

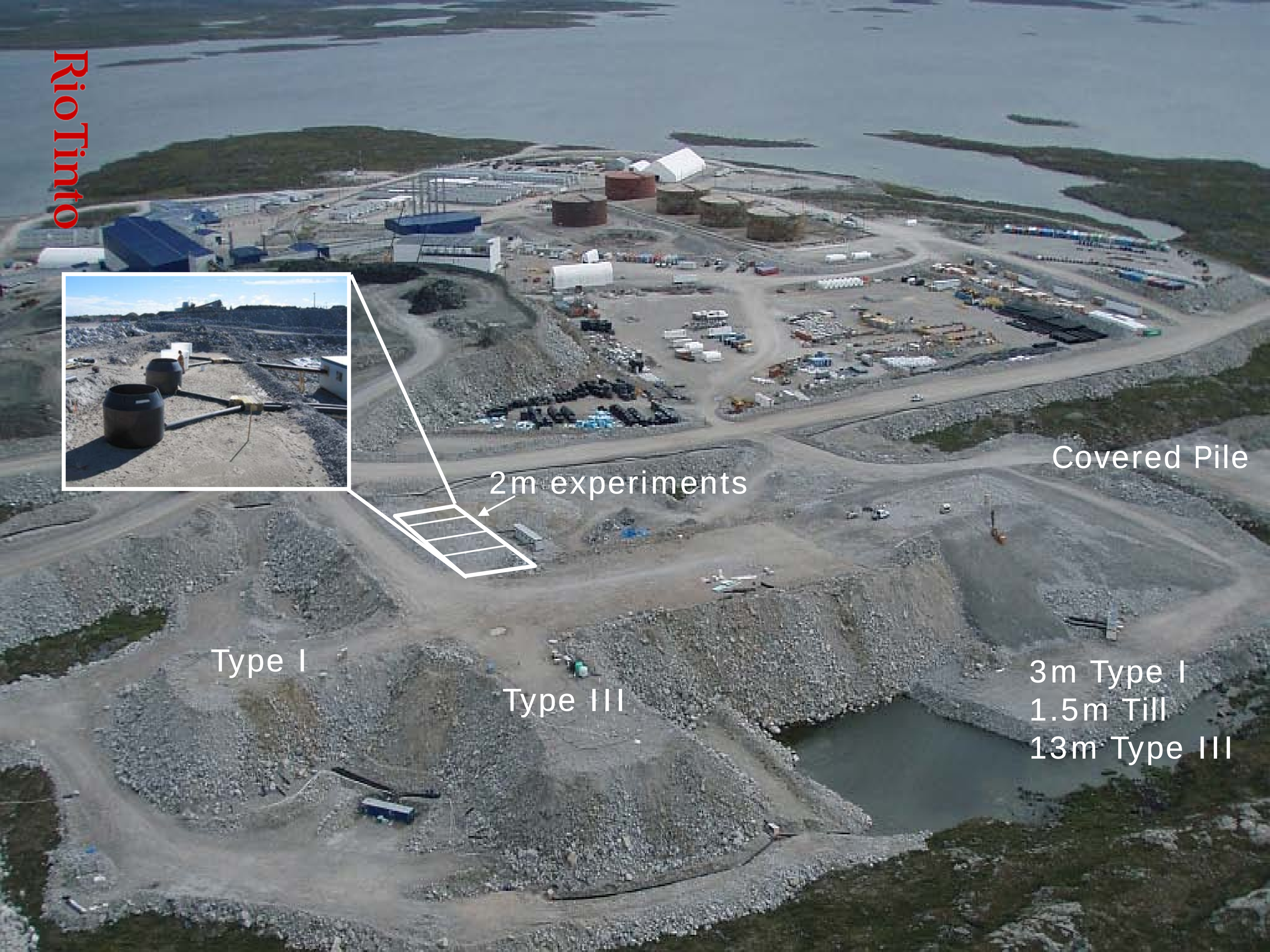
Assembling Instrumentation Lines




Install instruments on tip face



Covered Pile: Re-slope core, place till layer, place Type I thermal layer


Rio Tinto
2m experiments
Covered Pile
Type I
Type III
3m Type I
1.5m Till
13m Type III

Full-scale drill holes

- 3 drill holes
- 32 m
- 31 m
- 40 m deep

Instrumentation

Instrument	Target measurement/purpose
Air permeability probes	Internal test pile permeability to air flow
Thermistors	Bedrock and internal test pile temperatures
Gas sampling lines	Internal test pile gas phase composition
Suction lysimeters	Internal test pile water quality
Basal drain collection lysimeters	Discrete collection of basal water flow (quantity) and quality
Basal drain collection lines	Bulk waster flow (quantity) and quality
Microbiology access ports	Internal test pile microbial populations
TDR probes	Internal test pile moisture content / wetting front movement
Tensiometers	Internal test pile matric water potential (unsaturated rock moisture tension)
Thermal conductivity probe access lines	Internal test pile thermal conductivity characteristics
2 m scale experiments	Active zone (upper 2 m) water flow (quantity) and quality

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Closure Considerations

- Properly characterizing waste rock
- Robust storage designs
  - Stable
  - Secondary storage
- Understand ARD potential
  - Waste rock characteristics
  - Behaviour of waste dumps (controls on ARD?)
  - Can lab experiments predict dump behaviour?
  - What is the best configuration for closure?

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Thank you
Questions?