Research sponsoring: tailings & permafrost

Université Laval & UQAT

- **Marie-Eve Larouche**, Ph.D. candidate & Michel Allard, Director (Université Laval, Centre d'études nordiques):
  - Permafrost and climate change in a mining context : the case of Raglan Mine, Nunavik

- **Véronique Coulombe**, Master candidate & Bruno Bussières, Director (URSTM, UQAT):
  - Performance of an insulation cover to control acid drainage in cold region

- **Marie-Pier Éthier**, M. Sc. & Bruno Bussières, Director (URSTM, UQAT) :
  - Geochemical behaviour of normal and cold conditions on different waste piles from Raglan Mine

Performance of partial insulation covers for AMD control at the Raglan TSF

BY VÉRONIQUE COULOMBE, MASTER CANDIDATE, UQAT

Supervision

Bruno Bussière, UQAT

Jean Côté, Université Laval

Field Investigation : Oxygen consumption test

Used to assess the insulation cover performance:

⇒ *in situ* tailings reactivity measurements with the oxygen consumption (OC) test

This method allows to:

- compare tailings reactivity with and without insulation cover
- evaluate the effect of different configurations of insulation cover on tailings reactivity
- measure tailings reactivity at different periods of the year
- measure tailings reactivity below freezing temperature

Conclusion and preliminary results

Véronique Coulombe, UQAT

- Effect of different cover configurations built on Raglan TSF was assessed *in situ* (0.4 m, 1.2 m and 2.4 m) using OC tests
- Temperature to limit sulphide oxidation
    - > 0 °C; probably between -2 °C and -5 °C
- The 1.2 m and 0.4 m partial covers seem to have a similar impact on tailings reactivity – oxygen flux reduced by ≈ 50%, except for Station S4
- The partial cover delays the freezing period
- Volumetric water content and suction measurements are presently analysed and thermal numerical modelling (TEMP/W) will be performed to compared measurements and theoretical results

Studies for tailings storage facility (TSF)

Consultants studies

Previous studies

- Tailings Stack Reclamation Cover Design (AMEC, 2002)
- Impact of Global Warming on Tailings Stack Cover Design (AMEC, 2006)
- 2006 Geothermal Evaluation for the Tailings Stack Cover Design (AMEC, 2007a)
- Pre-conceptual Evaluation of Options for Tailings Stack Cover Design for Global Warming Scenario (AMEC, 2007b)
- Tailings storage facility geochemical characterization (SNC-Lavalin, 2009)
- Scoping Study : Final Cover of Tailings Storage Facility (Golder, 2010)
- Waste Rock Column Kinetic Tests (URSTM, 2012)
- Hydrology studies (SNC, 2008 & 2012)

Ongoing studies

- Scoping Study, Waste and Pits Reclamation (Golder)
- Deformation Study (SNC-Lavalin Inc)
- Dust Control Study (Amec)
- Prefeasibility Study (SNC-Lavalin Inc)

Geotechnical investigation of TSF – deformation Study

SNC-Lavalin Inc

xstrata nickel

Identify & understand deformation origin

- Irregularities in the tailings surface before placement of the cover material
- Placement method of the TSF cover material
- Consolidation phenomena in unfrozen tailings
- Wetting-induced collapse behaviour of unsaturated tailings
- Surface freeze thaw cycles
- Creep in the frozen TSF slopes
- Water flowing through the TSF cover material
- Tailings mass movement or slipping over the natural ground

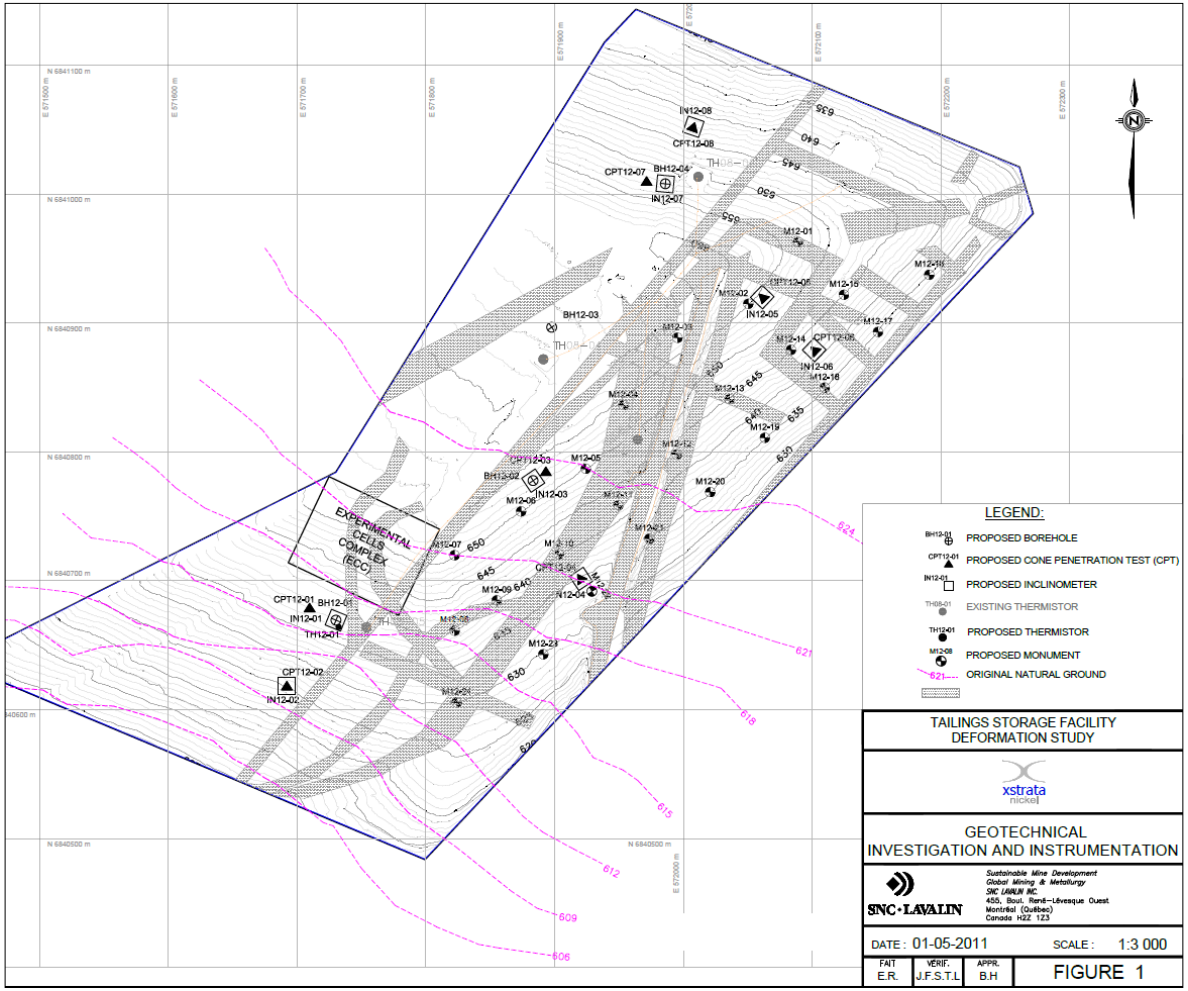


Geotechnical investigation of TSF – deformation study

Field investigation

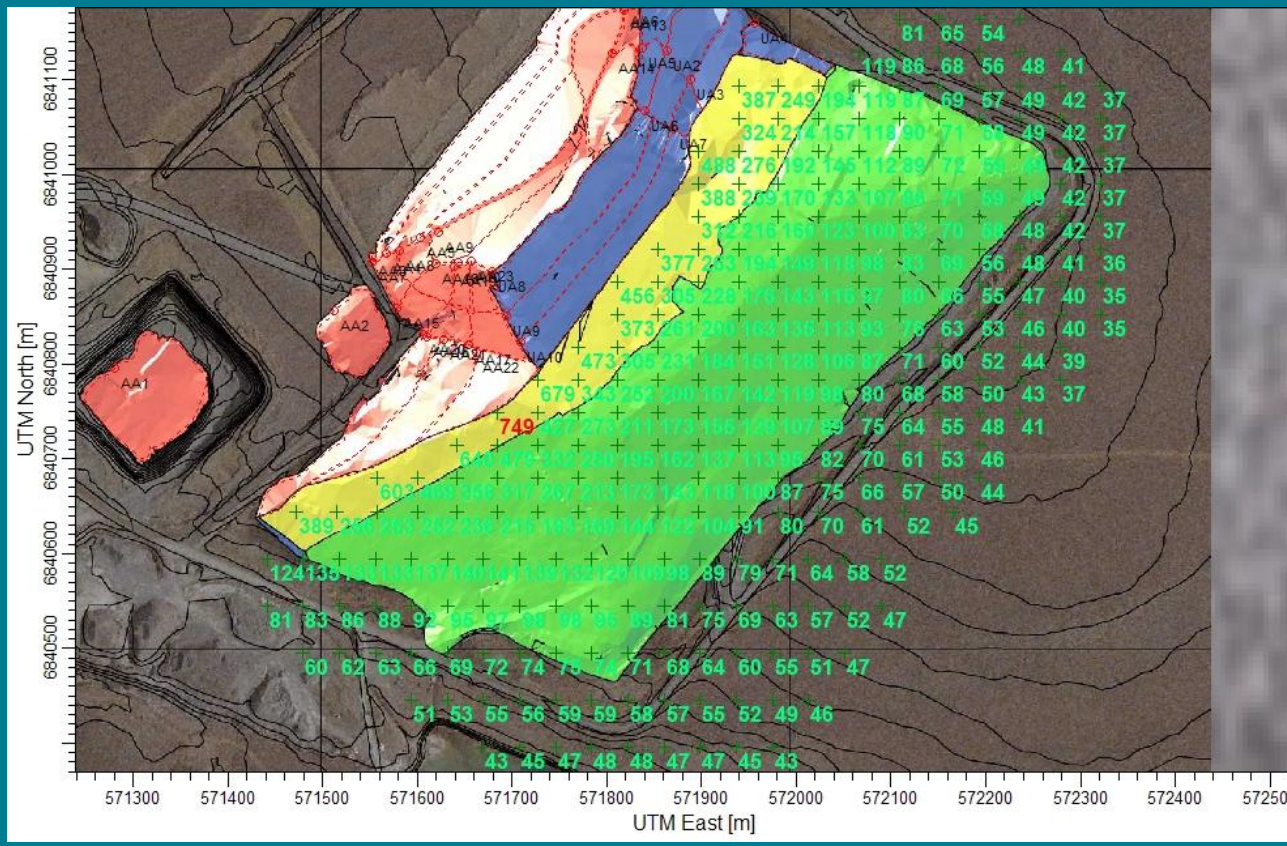
Objectives

- Describe the current tailings
- Obtain field geotechnical properties
- Sample tailings from different time periods
- Field investigation with respect to different slopes



Modeling tailings dust emissions from TSF

Sources, measurement and modeling



Tailings dust study

Amec 2012

xstrata nickel

This Study :

- Understand the dust source at the tailings storage facility
- Composition of the dust (particle size, chemical composition and mineralogy)
- Dust modeling (AERMOD dispersion model)
- Evaluate operational causes of dust emissions
- Investigate correlation between location and dust production
- Compare options and find an optimal solution for the tailings dust control

Next steps: Integrated approach

- Dust abatement cover (0-20 mm) at final elevation
- Continued reorientation of the direction of deposition to reduce exposure to wind forces
- Strategic placement of cover material stockpiles to reduce effect of wind
- Identify solutions to stabilize the inactive slopes and minimize the generation of airborne material
- Implement operations manual to address solutions and integrate with the new deposition plan in development.

Tailings reclamation cover- prefeasibility study

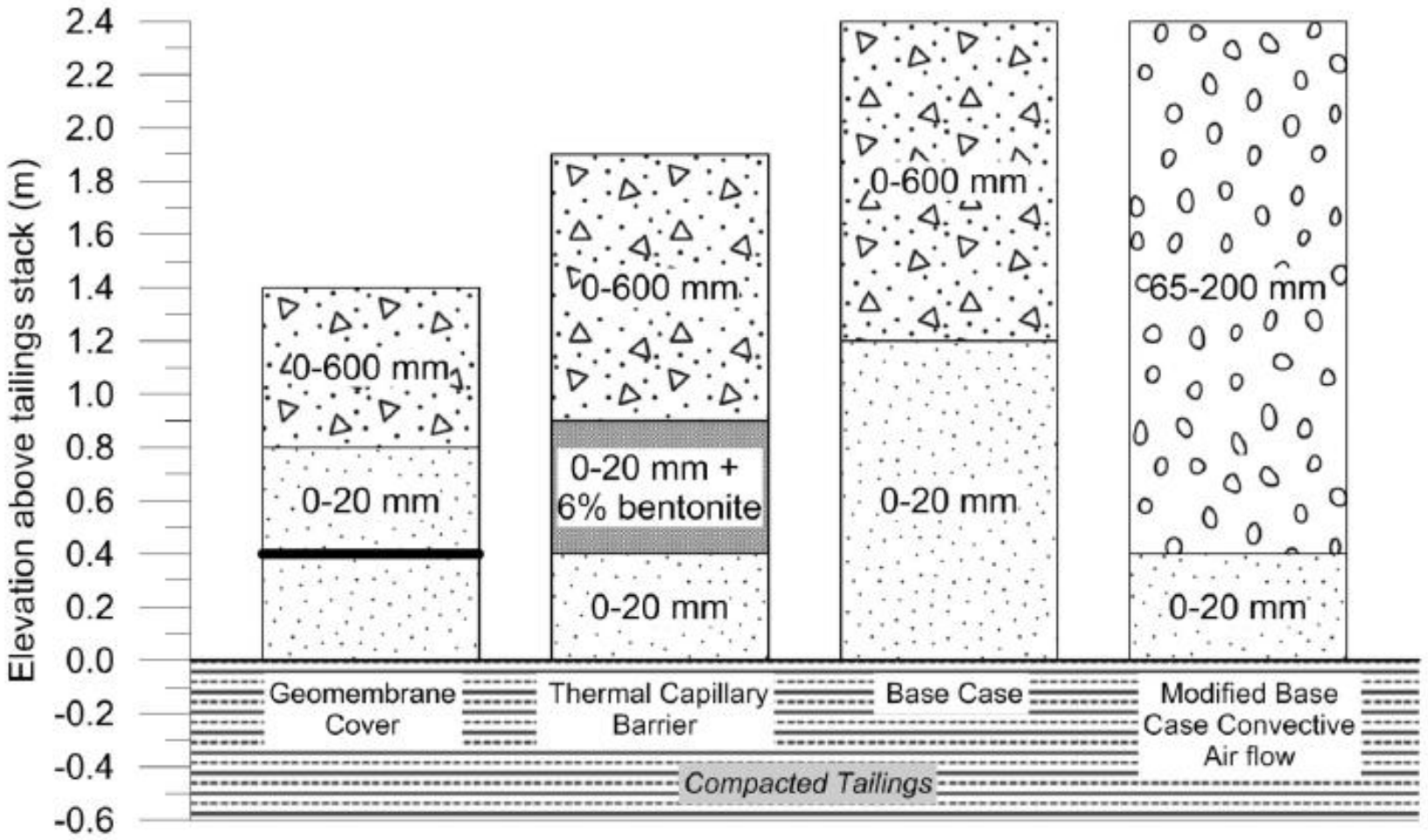
SNC-Lavalin Inc

Reclamation concepts reviewed to be « climate-change proof »

- TSF reclamation concept at the prefeasibility stage
- Construction of four test cells to evaluate performance and reliability of concepts
- Chosen concept not to rely on permafrost but remain compatible
- Chosen concept to be effective in an arctic environment

Tailings reclamation cover– prefeasibility study

4 concepts (test cells)



Cells construction

Field preparation

4 cells (10 m X 40 m) side by side

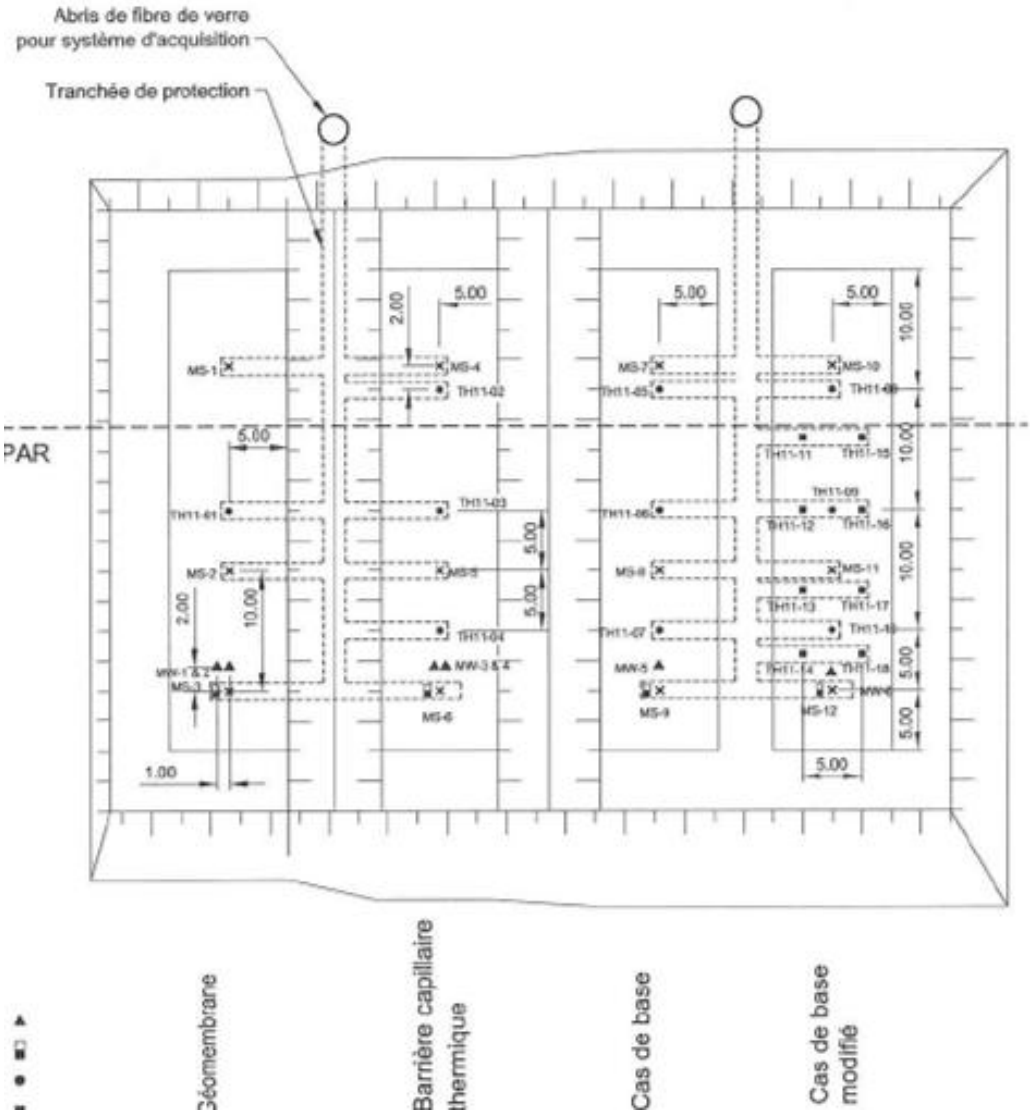
TOP OF TSF

Geomembrane cell

5 : 1 slope

Tailings reclamation cover– prefeasibility study

Instrumentation



- 10 long thermistors (10m)
- 8 short thermistors (2.4m)
- 6 monitoring wells
- 6 water collection system
- 12 monitoring stations
- 12 O_2 consumption test (Apogee)
- 43 Capillary pressure (Watermark 200SS)
- 43 Water content (EC-5, Decagon)
- 10 O_2 sensors
- 1 weather station
- Pyranometer
- Wind sensor
- Barometer
- Pluviometer
- Temperature & humidity sensor

Tailings reclamation cover– prefeasibility study

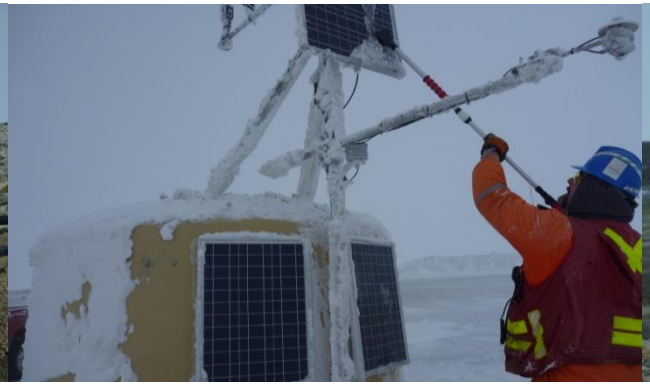
Instrumentation

Water collection system

Tailings reclamation cover– prefeasibility study

On-site data collection

- Data logger (1/month)
- Oxygen consumption tests (1/month)
- Water collection in monitoring wells (4 times/year)
- General maintenance


Prefeasibility study

Material characterization

- Grain size distribution
- Specific gravity
- Water hydraulic conductivity
- Water retention curve
- Leaching tests (TCLP1311, SPLP1312, CTEU9, Shake Flask)
- Static tests
- Thermal conductivity tests
- Freeze and thaw cycling tests

Tailings reclamation cover– prefeasibility study

Next steps

- Thermal numerical model (Temp/W coupled with Seep/W and Air/W) :
  - Develop a numerical tool that will allow to gain a better understanding of the existing condition and predict the behaviour of each reclamation cover options
  - Predict the long term reclamation cover behaviour
  - Optimize the reclamation cover design
- Estimate TSF cover capital cost for the four covers
- Proceed to trade-off study and produce final prefeasibility report (2-years data)

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TAIMA!
Questions?

Tailings storage facility

Issues & perspective of filtered tailings in an arctic environment

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