Tailings storage facility

Issues & perspective of filtered tailings in an arctic environment

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Agenda

- Raglan Mine context
- Tailings & reclamation concept at Raglan Mine
- Response to climate change challenges
- Raglan Mine tailings management : research & studies



Context: current activities in Nunavik

Nickel transport and supply chain

Facts about Raglan Mine

- Initial ore production 1997
- 14.3Mt ore processed at
  - 2.8% Ni + 0.8% Cu (1997-2011)
- Annual production rate 1.3Mt
  - 27,000 tonnes Nickel
  - 7,000 tonnes Copper
  - 140ktpa concentrate
- 4 underground mines +1 in development
- Solid pipeline of projects

Physiographic environment

Characteristics of the Katinniq plateau

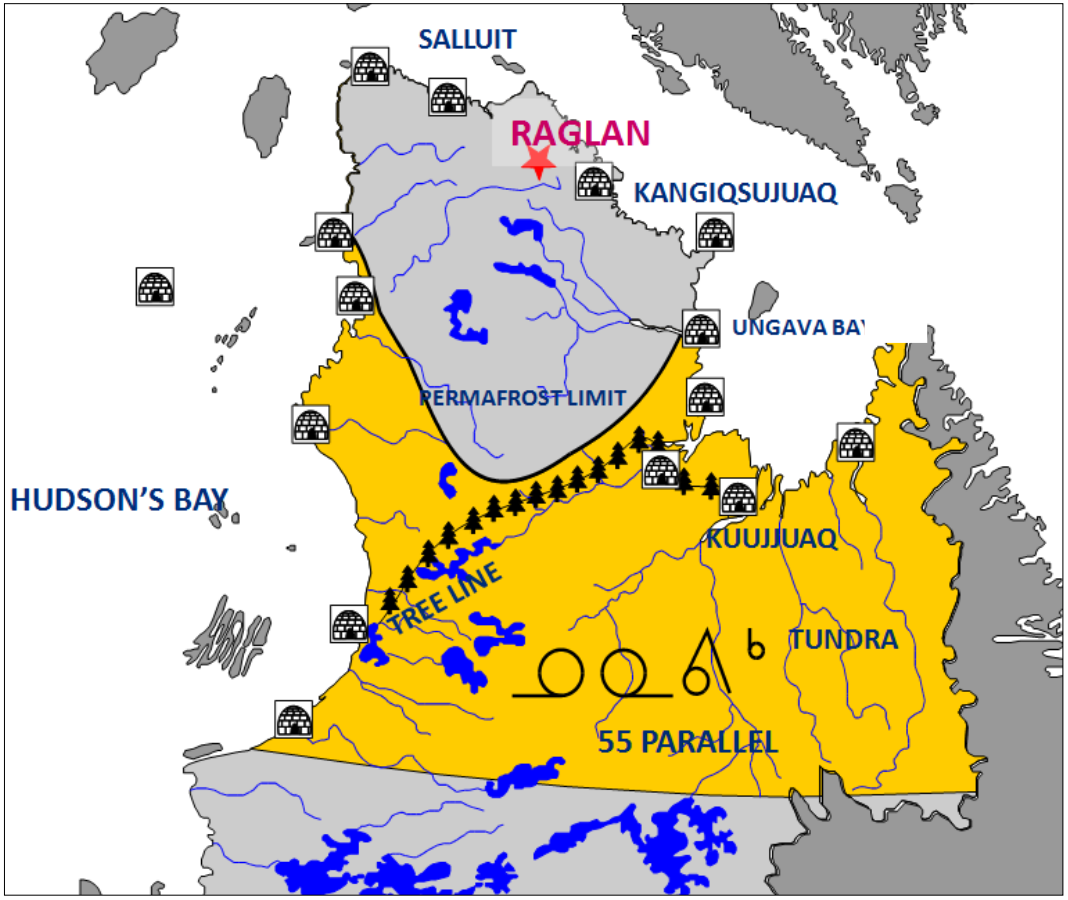
Permafrost
± 550 m deep

Temperature of the rock
-5 °C

Annual precipitations
650 mm (75% snow)
Subarctic desert

Average annual temperature
-10 °C

Limit of the tree line
400 km South of the mine site



Tailings storage facility (TSF)

Operations & deposition

- 1.2 million tonne of tailings produced annually
- Tailings are filtered (83% to 86% solids), transported by truck and placed in lifts with a dozer in the TSF
- The TSF is constructed directly on frozen natural ground
- The collecting basin and ditches meet the requirements of a1:100 year rainfall event

Tailings storage facility (TSF)

Physical and chemical proprieties of tailings

- Silty Sand

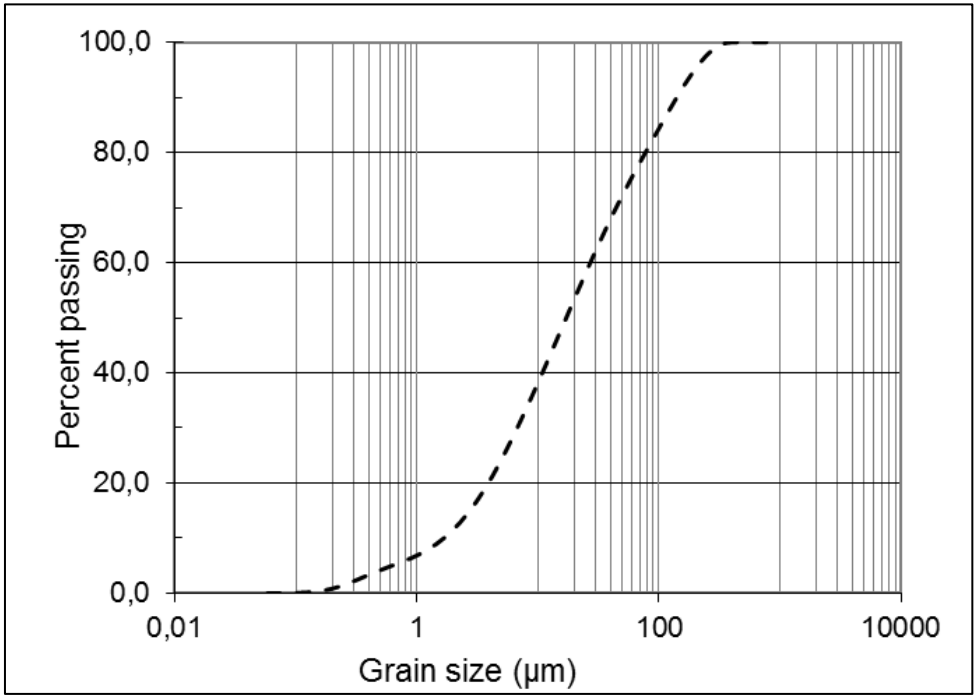
  ⇒ 80% passing 80 µm

  ⇒ Silt with low plasticity (ML) (USCS)

- Sulphur percentage : 6 to 8% (mainly pyrrhotite)

- Net neutralisation potential (NNP) of -118 kgCaCO3 eq/t. Tailings are potentially acid generating based on acid-base accounting test.

- 85-90 % saturation



- Saturated hydraulic conductivity: 3.5 X 10-5 (cm/s)

Approved closure concept at Raglan Mine

Closure strategy & cover design criteria

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Approved closure concept at Raglan Mine

Cover Layer

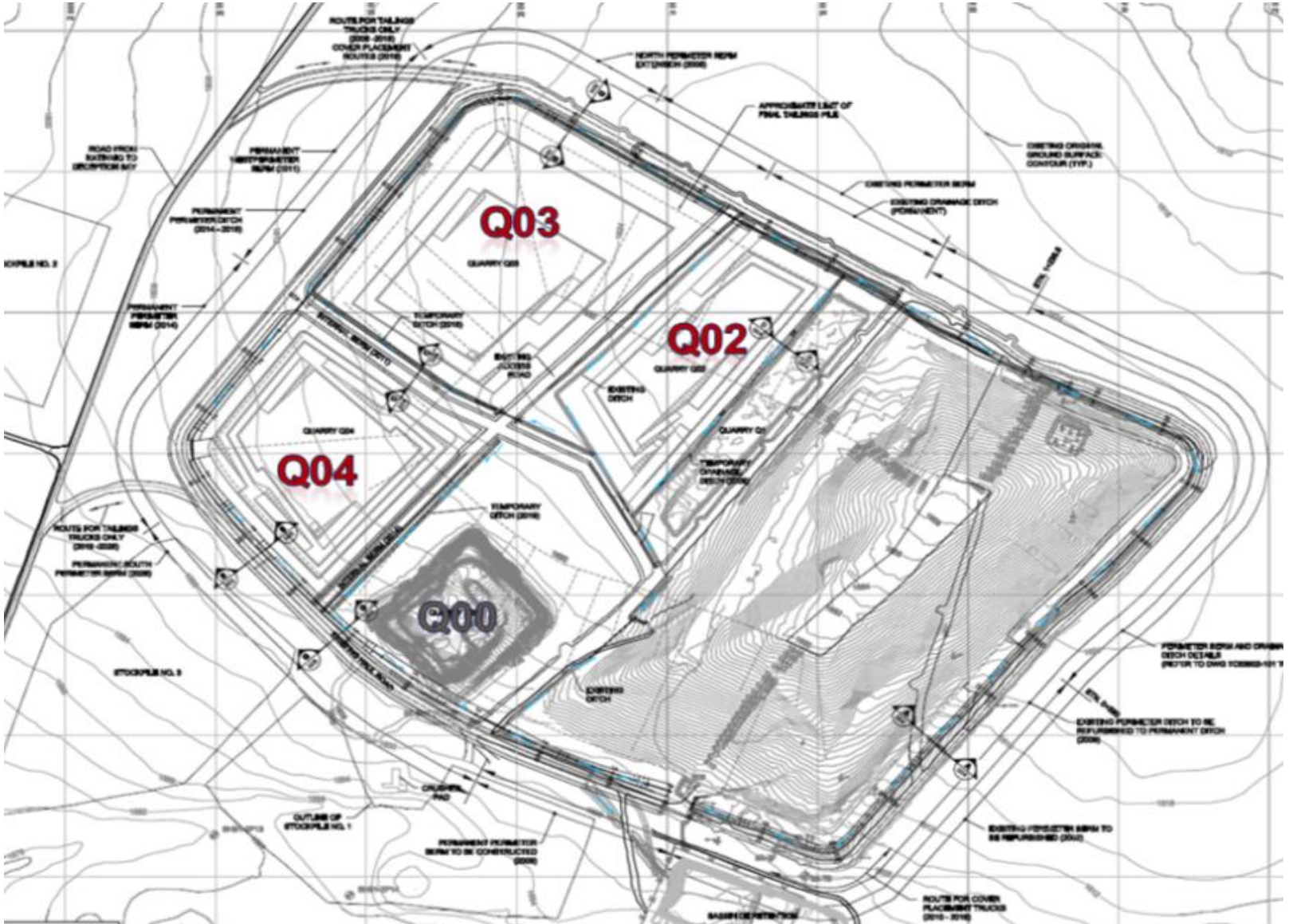
The 2 layers for the cover are comprised of:

- A lower layer consisting of 1.2 m of 0-20 mm crushed esker or crushed rock placed in lifts with a thickness of ±0.4 m each, compacted by a minimum of four passes of a 10-tonne vibratory roller. This layer is essentially a ***thermal cap.***

- An upper layer consisting of 1.2 m of minus 600 mm rockfill that can be obtained by either quarrying sound rock (e.g., gabbro) or "harvesting" ablation till. This upper rockfill layer is also placed in lifts with a thickness of ±0.6 m each, with both lifts compacted by a minimum of six passes of a 10-tonne vibratory roller.

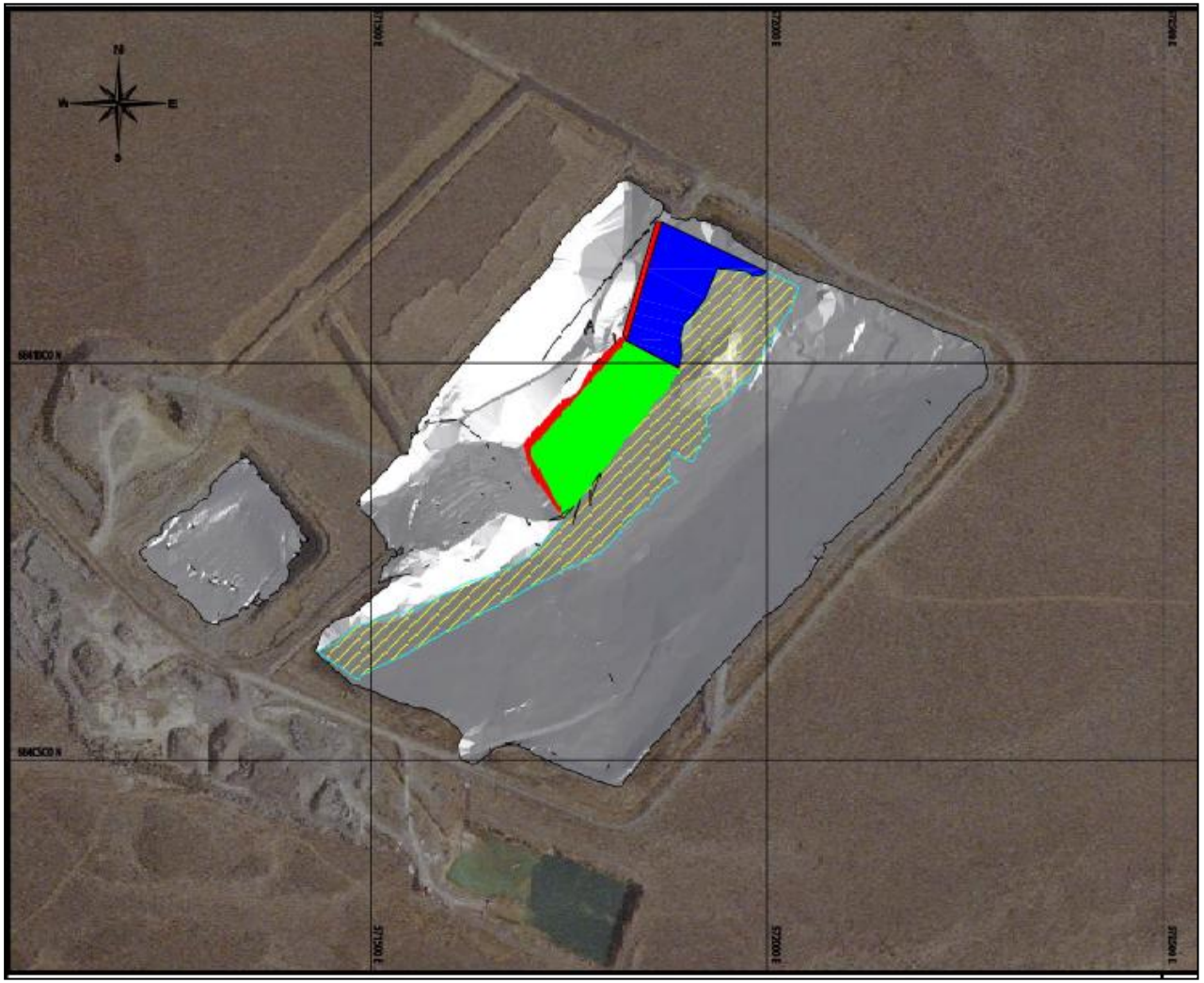
Tailings storage facility (TSF)

Operations – quarries exploitation



Progressive reclamation

On-site cover (0-20 mm)



Filtered tailings in arctic environment

Raglan Mine case

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TSF Advantages

- Minimal water to manage
- Negligible seepage
- Progressive covering & reclamation
- Minimal footprint impact (including quarries concept)

TSF Issues & Challenges

- Tailings dust from active deposition layer
- High operational cost
- Monitoring of surficial cracks & erosion
- Seasonal operational constraints

Climate change adaptation

- The scientific evidence that the climate is changing is now beyond doubt, and a link to human emissions is well established (IPCC, 2007c, b)

- Primary economic activities, which are the mainstay of local economies in much of Canada, are particularly exposed and sensitive to the consequences of climate change because of their immediate dependency on the natural environment

- The potential vulnerability of many of these economic activities to climate change has considerable regional significance



Current challenges and opportunities

Tailings and waste reclamation in permafrost

- Reclamation concept for tailings storage facility utilises permafrost
  - Filtered-pressed tailings are integrated within permafrost and permanently frozen under a non-reactive granular cover

- Reclamation concept for open pits and waste piles utilises permafrost
  - Waste rock used as backfill for underground openings and open pits
  - Waste rock permanently frozen

- Collection basins for water retention
  - Permafrost prevents contaminated water seepage from collection basins under the active layer
  - Permafrost also considered for water retention in ditches

Climate change challenges

Reduction of permafrost

- TSF, open pits and waste piles reclamation
  - Uncertainty regarding long term performance of reclamation concepts
  - Potential release of contaminants to the environment

- Collection basins water retention
  - Potential decrease in water retention
    - Release of contaminated water

- Models also show an increase in overall precipitations
  - Capacity of water treatment plants may be insufficient
  - Capacity of overall water management systems may be insufficient

Raglan Mine's reclamation prospective

- Current mines and associated infrastructure have been designed assuming current climatic conditions will prevail
- Mines are often designed to cope with climatic events of a certain recurrence interval and within specified climatic parameters
- Reclamation concepts reviewed to be « climate-change proof »
- Upcoming water management systems are designed to handle a 1:100 year annual runoff
- Raglan Steering Committee

Raglan Mine's reclamation

The Raglan Steering Committee (RSC)

The RSC was created by Falconbridge Limited in 2005 to support Raglan Mine's management team in their analysis of short, mid and long term issues associated with tailings management. The members are chosen based on their experience, knowledge and reputation.

TSF management & operations

Xstrata Nickel Raglan Mine commitments

- RSC meetings (1-3 times/year)
- Studies (consultants) based on RSC recommendations and guidance
- Research sponsorship URSTM, UQAT, Université Laval, Centre d'études nordiques, IRME
- Tailings study manager
- Geotechnical annual inspection (consultant)
- Xstrata Nickel Raglan Mine team involvement :
  - Monthly internal environmental inspection for TSF/bi-monthly during summer season
  - Weekly meeting for operations & follow-up on TSF
  - Instrumentation: maintenance, training & follow-up