NATURAL RESOURCES CANADA - INVENTIVE BY NATURE

Impact of climate change on mine waste management by water and saturated covers

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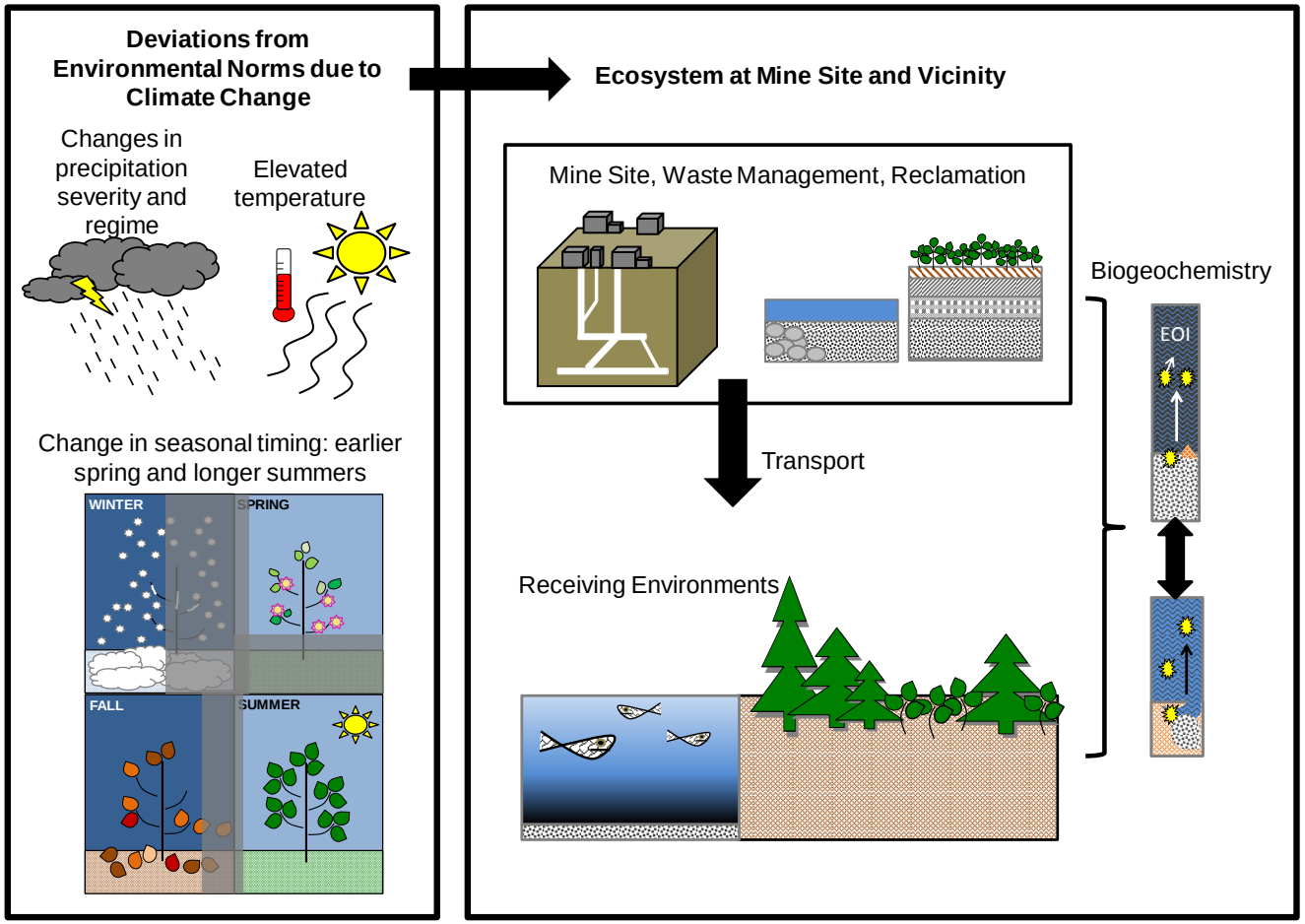
1. What are the current thoughts in the mining community regarding climate change?

Climate change and metal mines

Climate Related Factors Relevant to Mines (IPCC 2014, CEAA 2003, ICMM 2013)

- Warming trend
- Permafrost thaw
- Extreme temperature
- Increased precipitation
- Disruptions to operation
- Extreme weather events
- Drying and dust emissions
- Impact to building infrastructures

Relationship between climate change / mine sites



What happens when mine site/waste and receiving environments interact with climate change?

- Release of metals during rainfall (evaporitic salts dissolution)
  - Spring Creek California, Contrary Creek Virginia, Red River New Mexico, Iberian pyrite belt SW Spain
- Metals dilution and pH raises (high water volumes from rain)
  - Spring Creek California, Red River New Mexico, Rum Jungle Australia, Stockton coal mine New Zealand
- Waste exposed to oxygen (drying and lowered water table)
  - Snake River Colorado, Iberian pyrite belt Spain
- Change of baseline concentrations (permafrost thaw)
  - Snake River Colorado

2. Saturated Covers

Knowledge gaps – Saturated covers

The mining industry already proposing saturated covers as water cover alternatives at sites where water covers are not feasible

- Elliot lake, ON
- Snip Lake, BC
- Val d'Or, QC

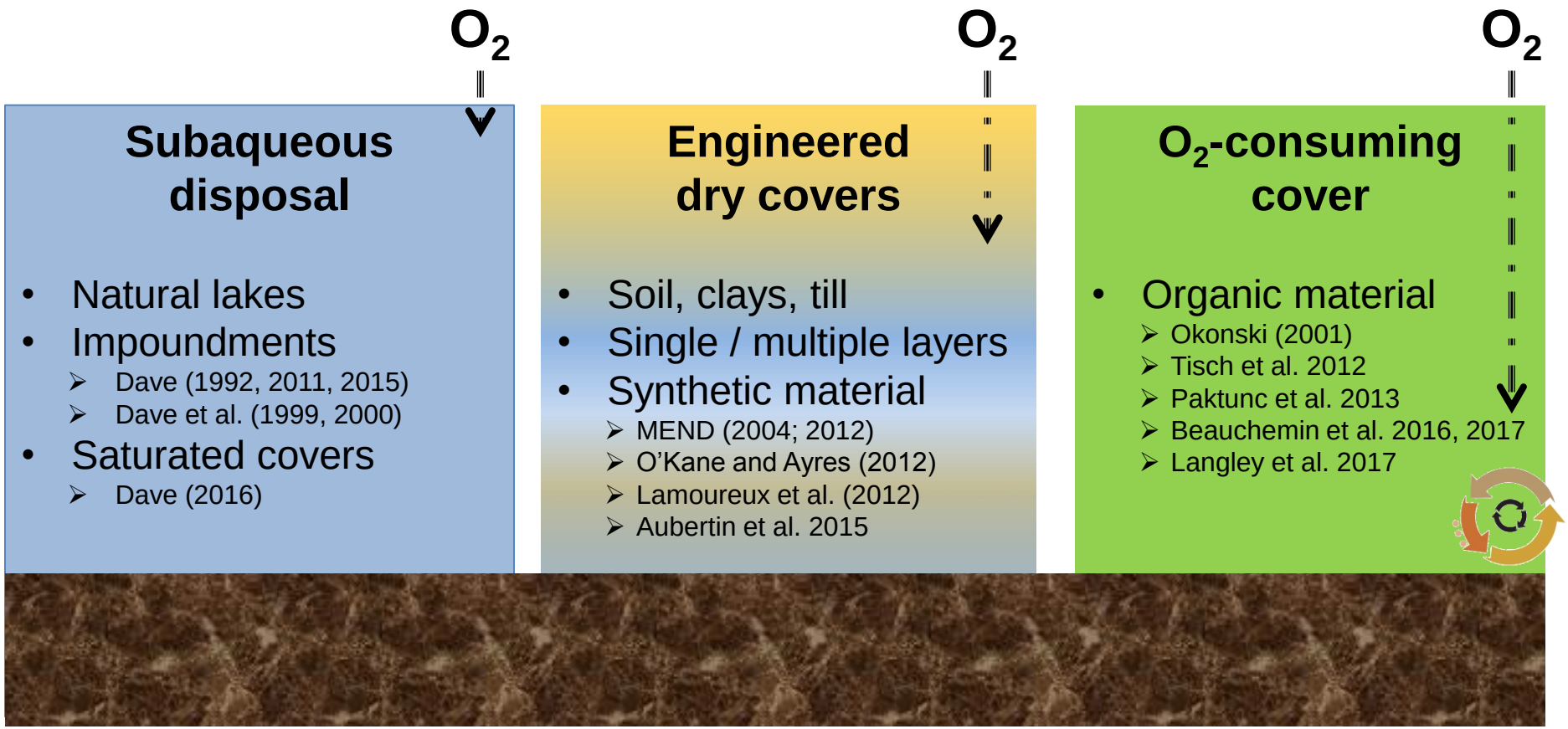
- Long term performance to minimize AMD metal mobilization, long-term recovery of ecosystem
- Adaptation of water covers for northern conditions of limited precipitation and cold winter months
- Fluctuation of water cover heights due to climate change-mediated changes in precipitation patterns

Why should water covers and permafrost be considered in terms of climate change?

- Dam stability for man-made impoundments remains a long-term concern, especially in the context of climate change
- Extreme weather can mix and transport sediments (O_2 exposure)
  - Heath Steele, New Brunswick (Mian and Yanful 2004)
- With 1 m water cover, high winds along the cover surface disturbs the water and increase dissolved O_2, particularly at low temperatures
  - Don Rouyn Quebec, lab experiment (Awoh et al. 2013, 2014)
- North of 60^o latitude, tailings are stored under permafrost
  - Increased temperature is compromising the stability of this waste

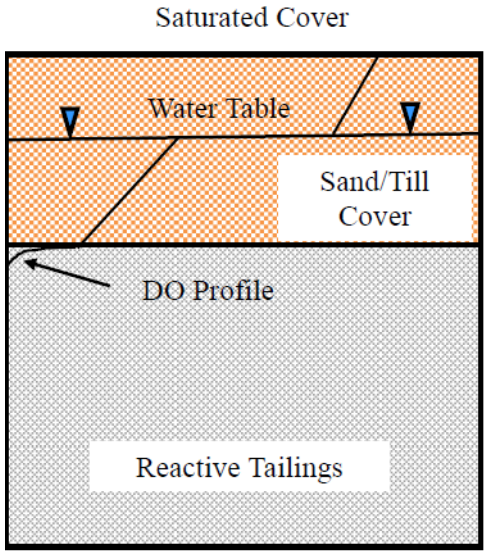
Reclamation of sulfidic tailings

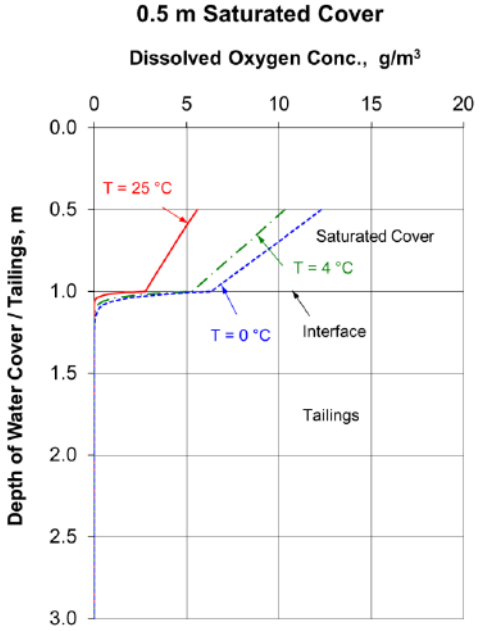
- The need to limit O_2 diffusion
- Common reclamation strategies: physical barriers to isolate tailings

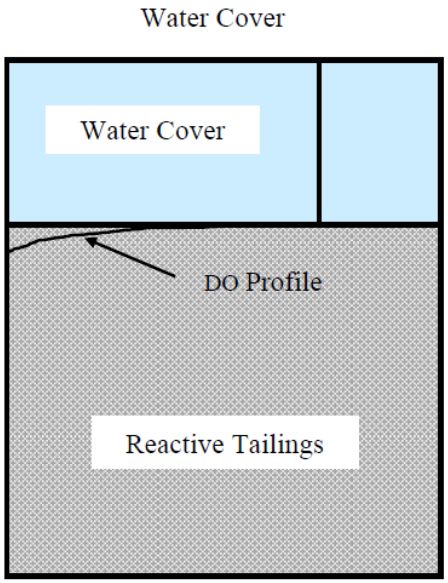


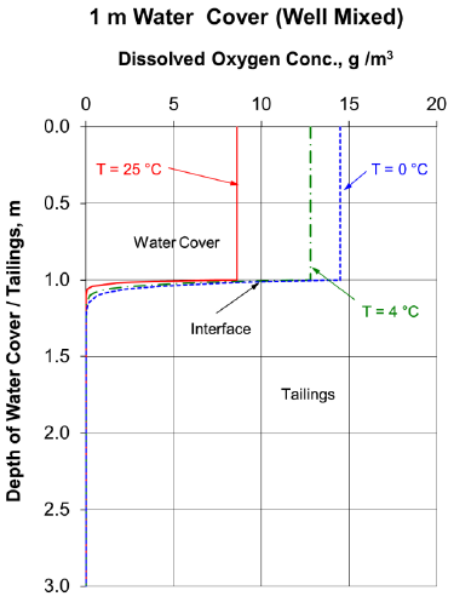
Saturated cover vs. water cover

- long-term dam stability concerns for man-made impoundments
- negative perception of use of natural water bodies for mine waste disposal









How do we evaluate the efficacy of saturated covers?

- How effective are saturated covers compared to water covers?
  - Investigate in terms of acid generation and metal mobility.
- How resilient are saturated covers against climate change-mediated changes in precipitation patterns?
- How will cold climatic conditions affect oxidation and metal mobility?

Saturated covers – Approach

- Comparison of site implemented water & saturated covers in Ontario
  - radionuclides speciation, physical and chemical properties of tailings
  - potential release of contaminants into the water cover
- Development of methods for performance evaluation of saturated covers
  - column testing in laboratory
  - field testing in Yukon
- Evaluation of the role of cold climatic conditions on oxidation and metal mobility under saturated covers
  - contaminant transport behavior
  - mineral characterization
  - microbial enumerations

Proposed study sites (South of 60º)

Mine Panel – Rio Algom, Elliot Lake (Ontario)

- Pyritic U tailings, vegetation contains high concentration of ^{226}Ra
- Site still requires treatment to control ^{226}Ra leaching from the mine tailings
- Both water & saturated cover conditions are field implemented and monitored

- Tailings characterization from both sites was completed at CanmetMINING
- Column testing is in progress…

Proposed study sites (North of 60º)

Mount Nansen mine site

- Abandoned gold mine, high concentration of As and CN
- Located in the Dawson range like Casino Mine

Faro mine site

- Abandoned Pb and Zn open pit mine
- Dam holds back 70 million tonnes of tailings

Wolverine mine site

- Pyritic Zn-Ag-Cu-Pb-Au underground mine
- On care & maintenance by Yukon Zinc
- Closed in 2014, looking to re-open

Expected benefits

- Evaluation of chemical, mineralogical, and microbiological controls on tailings stability under saturated covers
- Evaluation of the impact of cold climatic conditions on oxidation & metal mobility under water and saturated covers
- Evaluation of performance of saturated covers as an adaptation measure to climate change

Expected outcomes

- Provide optimized tailings reclamation strategies to:
  - Decrease operational costs and future liabilities
  - Enhance the environmental performance of rehabilitated mine sites in Canada
- Propose mitigation measures to adapt for climate change
  - Saturated covers as 2nd generation water cover technology

Actual team and partners

CanmetMINING

- Nicolas Reynier, Bill Price, Cheryl Laviolette, Roselyne Gagné-Turcotte

INRS University

- Jean-Francois Blais, Audrey Le Pioufle

Yukon Research Center

- Guillaume Nielsen

Mining industry

- Casino mining

Yukon Government

- Amelie Janin

3. Final Comments

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- Bio-geochemical reactions in tailings are affected by environmental parameters
  - Evidence of water level as a controlling factor
  - Understanding the mechanisms involved will lead to better adaptive measures

- Working towards an alternative to deep water cover
  - Saturated water cover is a promising option
  - Ensuring resilience against rapid environmental fluctuations involves understanding microbial and geochemical processes

QUESTIONS

Thank you