### Evaluation of Multi-Omics Technology in the Mining Industry BCMEND

Celine Michiels, Lais Pereira, Chris Kennedy



### **Presentation Overview**

- 1. Microbiology and Multi-omic tools in mining
- 2. Case study
  - a) Bio exploration
  - b) Pilot-scale bioreactor mine-influenced water treatment of Se and NO<sub>3</sub>
  - c) Other examples
- 3. Opportunities, limitations and concluding thoughts



### Role of micro-organisms in the environment



### **Microbiology in Mining**



## **Microbiology in Mining**



#### Case study Bio exploration

# Use of microbial community fingerprinting to discover concealed kimberlites

- Objective: develop robust, efficient, and cost-effective tool to identify and locate buried mineral deposits
- Techniques: 16S rRNA sequencing MCP compared to standard suite of geochemical analyses





Source: https://www.mdru.ubc.ca/projects/kimberlite-discovery-with-microbes/

#### Results case study Bio exploration



#### 

Source: https://www.mdru.ubc.ca/projects/kimberlite-discovery-with-microbes/

# Case study

#### **Bio exploration**

# Use of microbial community fingerprinting to discover concealed kimberlites

- **Objectives:** develop robust, efficient, and cost-effective tool to identify and locate buried mineral deposits
- **Techniques:** 16S rRNA sequencing MCP compared to standard suite of geochemical analyses

#### Opportunity of case study and limitations:

- One type of analysis low cost of MCP
- Can be applied to variety of buried deposits
- Can be developed into a rapid and cheap screening tool
- Has only been studied for one type of deposit



Source: https://www.mdru.ubc.ca/projects/kimberlite-discovery-with-microbes/

### **Case study**

Bioreactor pilot for treatment of NO<sub>3</sub> and Se in mine-influenced water

- Objectives: Diagnose the cause for poor performance of a pilot bioreactor
- **Technique**: Use of metagenomics, metatranscriptomics, and geochemical analyses

Genome-resolved metagenomics links microbial dynamics to failure and recovery of a bioreactor removing nitrate and selenate from mine-influenced water

Susan A Baldwin<sup>a,\*</sup>, Jon C. Taylor<sup>a</sup>, Ryan Ziels<sup>b</sup>



**- srk** consulting

### **Results case study**

Bioreactor pilot for treatment of NO<sub>3</sub> and Se in mine-influenced water



### **Case study**

#### **Bioreactor pilot for treatment of NO<sub>3</sub> and Se in mine-influenced water**

- **Objectives**: Diagnose cause for poor pilot bioreactor's operation in reducing mine-influenced water containing nitrate and selenium
- **Technique**: Use of metagenomics, metatranscriptomics, and geochemical analyses

#### Opportunity of case study and limitations:

- Showed changes from inoculum to established microbial community, no inoculum was needed
- Identified microbial key-players in failure and recovery of bioreactor
- Related specific metabolic reaction rate to specific gene expression profile
- Pilot-scale study that may not be fully representative of full-scale conditions
- Multi-disciplined approach can be time-consuming and relatively costly
  Srk consulting

#### Other Genomics Applications Environmental DNA (eDNA) Assessment Tool

- **Definition:** Analysis of genetic material shed from organisms into their environment
- Advantages: eDNA can provide non-destructive, rapid, cost-effective and accurate biodiversity information
- Limitations: Variation in data quality and poor understanding of factors affecting eDNA detection
- Opportunity: End-Users calling for methods standardization and accessible eDNA resources to support ecological surveys for species-at-risk monitoring; invasive species management; and granting permits in mining
- iTrackDNA Project:
  - Main objectives:
    - 1. Support the creation of a targeted eDNA detection national standard
    - 2. Generate decision support software for modeling regional biodiversity changes
    - 3. Develop an eDNA training, certification and inter-lab validation framework
  - **Target:** Mainstream assessment tool by 2025



### Other Genomics Applications Biological Water Treatment

#### Saturated Rock Fill technology:

- Semi-passive water treatment: backfilled open pits that have some portion of the waste rock water saturated – supports anaerobic bacteria
- Bacteria used as "catalysts" for removal of nitrate and selenium from mine waste contact waters in British Columbia coal fields by adding organic carbon as electron donor
- Genomics role in biological water treatment technologies:
  - Diagnostic tool
  - Regulatory tool
  - Modelling tool



Source: https://www.teck.com/media/Teck-Water-Quality-Fact-Sheet.pdf



#### Other Genomics Applications ARD Monitoring and Remediation

#### • Problem statement:

- Oxidative dissolution of metal sulfides can be accelerated by indigenous microorganisms
- ARD bacteria use multiple metabolic processes to survive these environments
- Varied responses of microbial communities to different geochemical characteristics
- **Opportunity:** Use genomics for monitoring new stockpile designs or even current piles to help with adaptive management.
  - Study site-specific microbial communities and identify their biogeochemical role
  - Monitor the activity of microorganisms potentially involved in ARD, and use them as early indicators of drainage issues



Rock Placement Strategies to Enhance Operational and Closure Performance of Mine Rock Stockpiles Phase 1 Work Program – Review, Assessment & Summary of Improved Construction Methods



Source: https://www.inap.com.au/wp-content/uploads/2020-Jan-INAPmproving-Stockpile-Construction-Phase-1-Final-Report.pdf



## **Other Genomics Applications**

#### **ARD Monitoring and Remediation**

- Long-term monitoring of waste-rock weathering at the Antamina mine, Peru
- Could genomics provide more time = better risk management and planning?



### Limitations of current advances

- Individual case studies are not always applicable to other systems
  - There is no standardized workflow existing yet for genomic work, preventing direct comparison between sites (bioinformatic tools, databases used, etc.)
  - Pilot-scale studies do not always reflect on-site conditions
- Only a few types of analysis are currently common practice: microbial community profiling
  - Information gathered from MCP dataset is very limited
  - Multi-disciplined approach can be time-consuming/costly and requires expertise to interrogate the data



## **Concluding thoughts**

- Mining microbiome is a huge "mine" of information that can inform us on cheaper and/or best practices, prevention and diagnostic tools for problematic conditions at all stage of a mine
- Field is still in its infancy and went through a huge amount of research and growth in a small amount of time
  - Cost of sequencing has exponentially decreased while...
  - Sequencing capacity and data management has increased through new technologies
- Initiatives are under development to achieve standardized methods across the field and will simplify the use of genomics as tools in the industry

## Acknowledgements

- Genome BC and OGI funding and connections
- Industry survey participants

