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Source Control to Understand AMD Risk Reduction at Closure

However, the risk may lie in the heat generation

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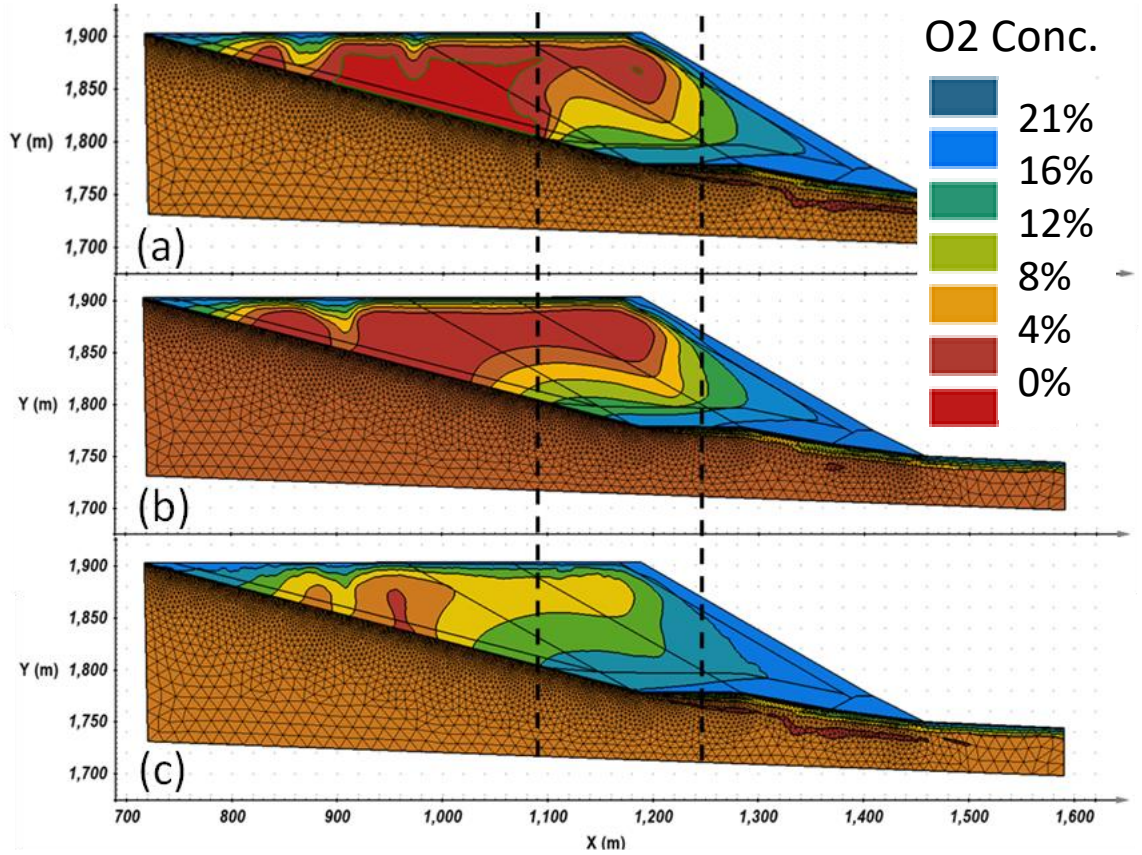
Presentation Outline

- Waste Rock Stockpile (WRS) Source Control
- Sulfide Oxidation and AMD Generation
- WRS Source Control Assessment Method
- Blind Case Study
- Simulated Results
- Concluding Points



SOURCE: Meiers, G. Pernito, M, Bianchin, M. (2022) . An Optimized Approach to Progressive Reclamation – Development of a MRSF Numerical Assessment Simulation Model. Tailings and Mine Waste, Denver

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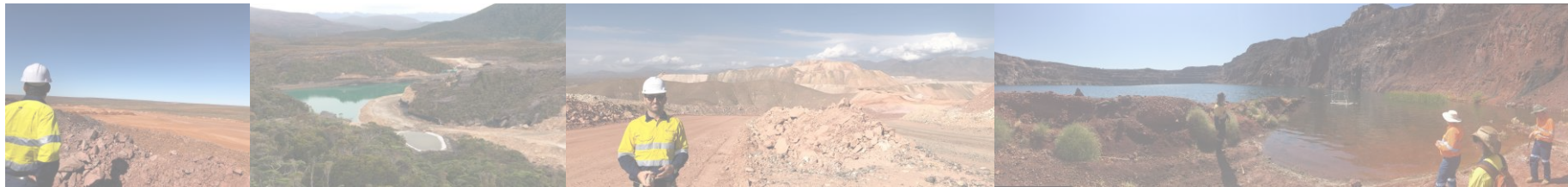
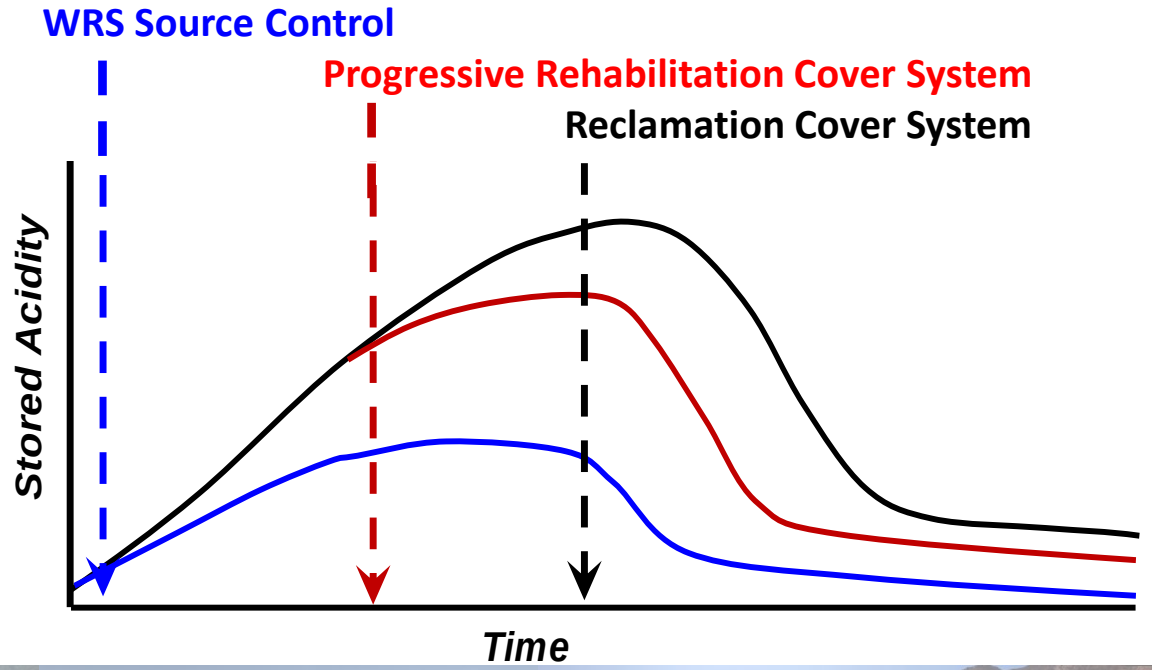


WRS Source Control

- Industry track record is to defer managing AMD risk to the end of mine life (decisions and design are based on NPV and KPI)…. When there is greater uncertainty and risk, BUT this practice is approach is changing
- AMD management strategies should be proactive, start early, and be based on best available technology
- WRS Source Control is reducing sulfide oxidation during operations and post closure:
  - Less reliance on final cover system for management of oxygen and water ingress
  - Shorter time frame for AMD management
  - Reduction in financial security / bond reduction
  - Social License to Operate and stakeholder reputation



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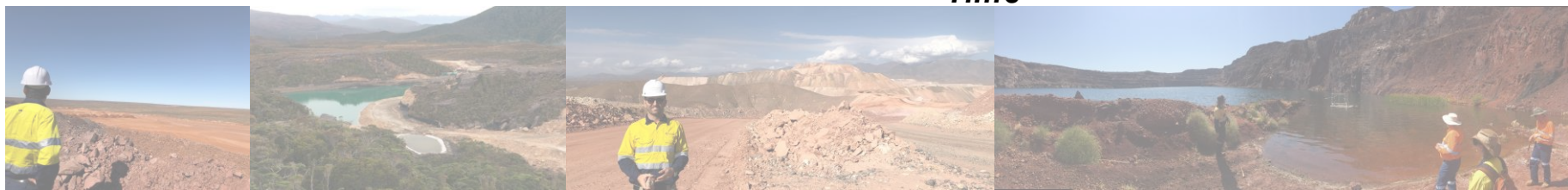
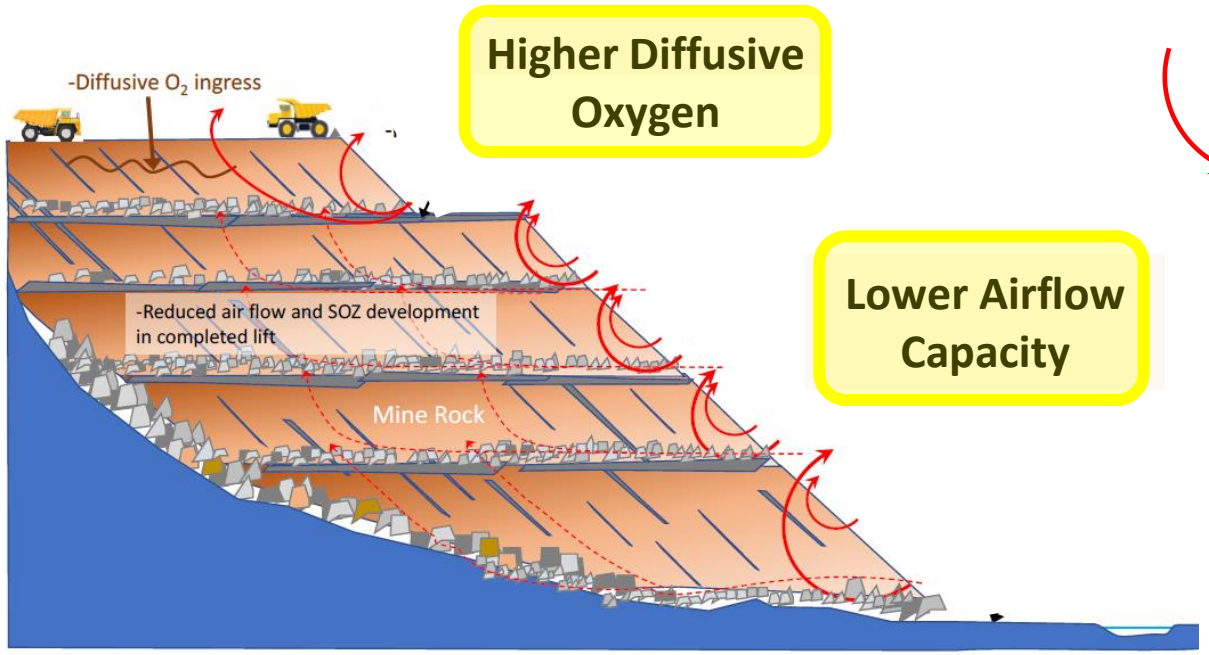
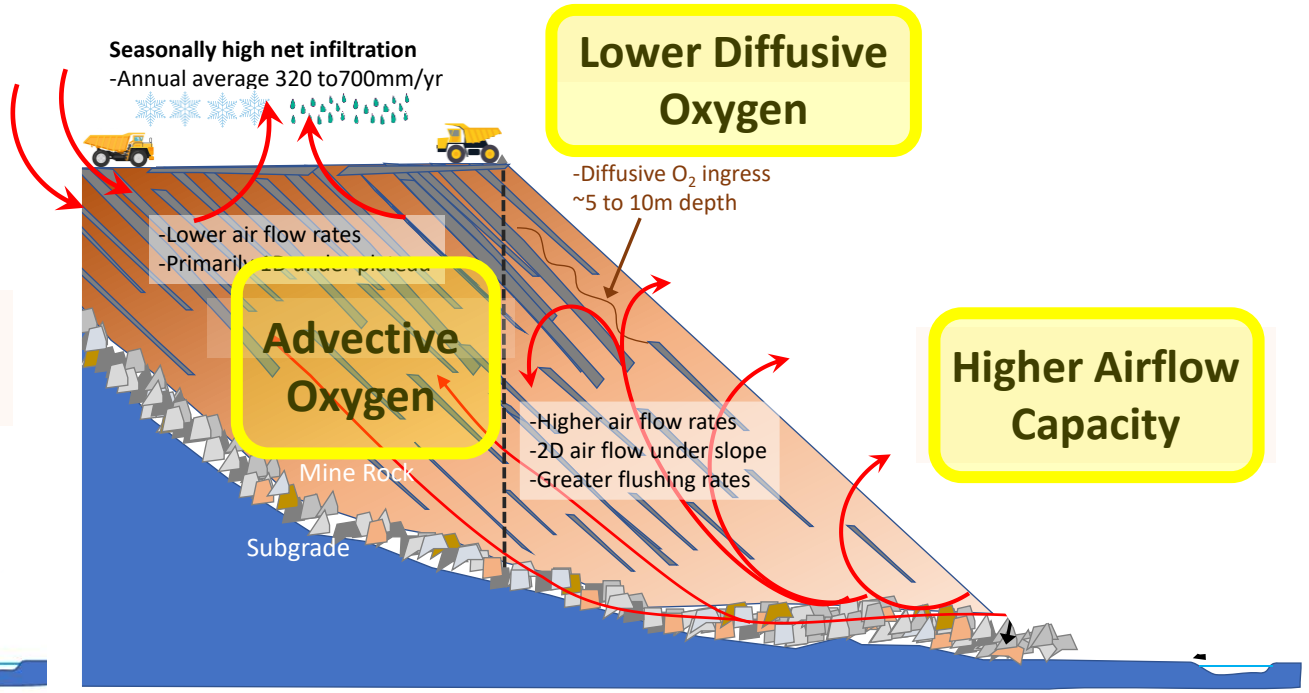


WRS Source Control

WRS Conceptual Model

- WRSs are generally responsible for a high percentage of a sites AMD risk, because of the physical environment (airflow and temperature)





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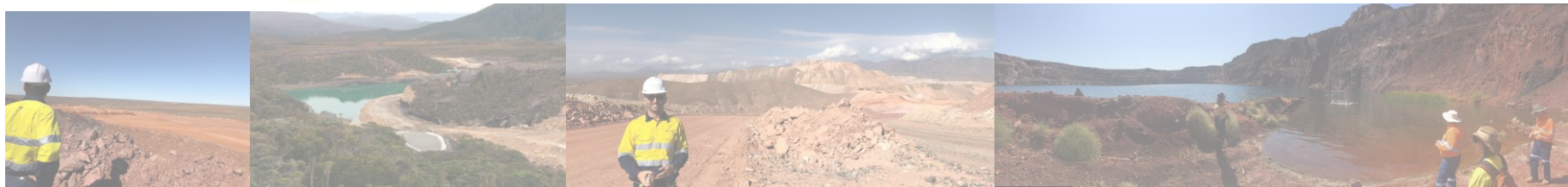
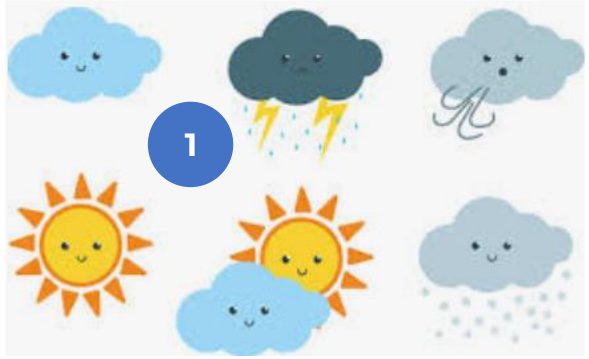


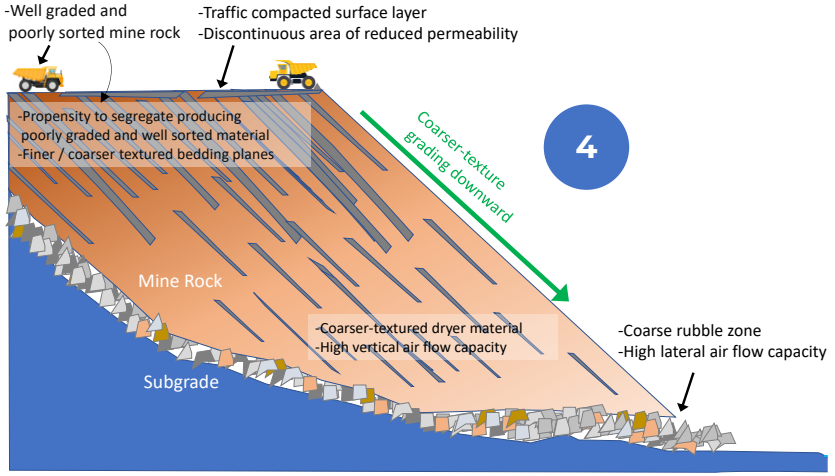
Sulfide Oxidation and AMD Generation

Factors Affecting AMD Generation and Risk

Pyrite + Water + Air (oxygen) = acid + metals + salinity

1. Climate
2. Geochemical Characteristics
3. Physical Properties
4. Physical Environment
5. Closure Cover System





Source: Slide adopted from Meiers, G. and O'Kane, M 2018. Progressive Mine Reclamation ...Can We Enhance this Practice to Include Waste Rock Dump Design. Presented at 2nd International Congress on Planning for Closure of Mining Operations.

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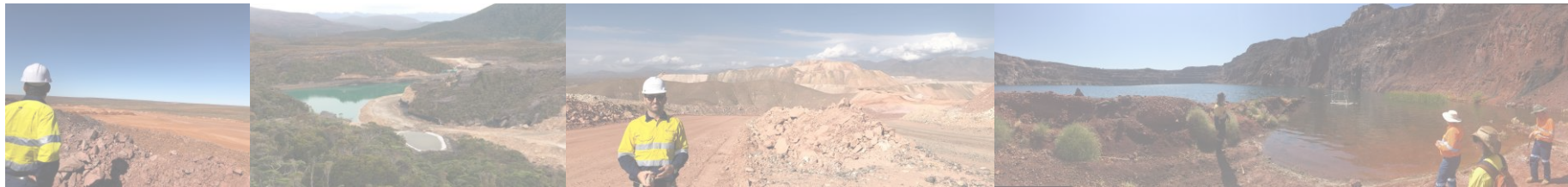

WRS Assessment Method

Numerical Simulation Method

1. Net infiltration – Establish diffusion coefficient (De) and air permeability.
2. Oxygen consumption rate (OCR) provides internal heating and advective airflow
3. OCR and heat generation semi-coupling of internal temperature and pore-oxygen conc.
4. Advective heat loss
5. Output: Oxygen flux (diffusive and advective).
6. Output: Oxygen consumption semi-coupling with internal temperature and pore-oxygen conc.

Supported By FlexPDE Backend Solver

SEEPAGE ANALYSES (SVFlux)

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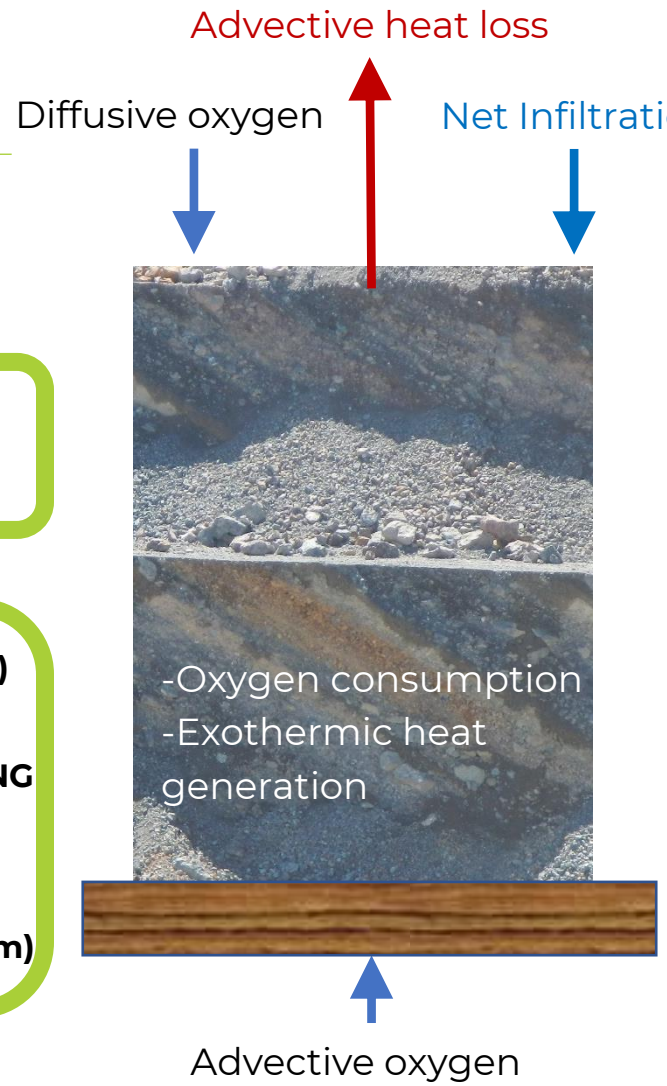
HEAT and AIR FLOW COUPLING (SVHeat / SVAir)

⇩

OXYGEN TRANSPORT (SVChem)



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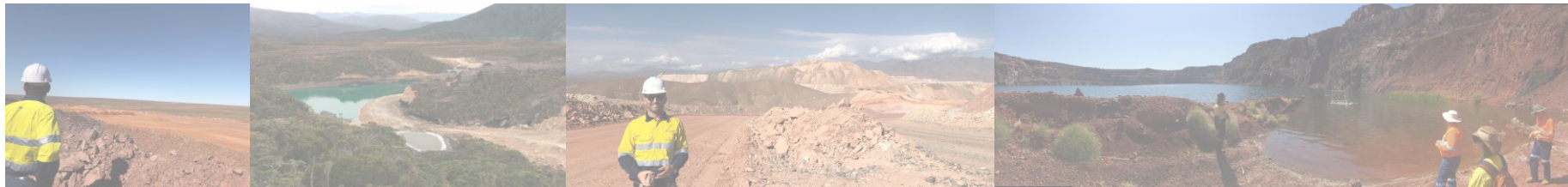
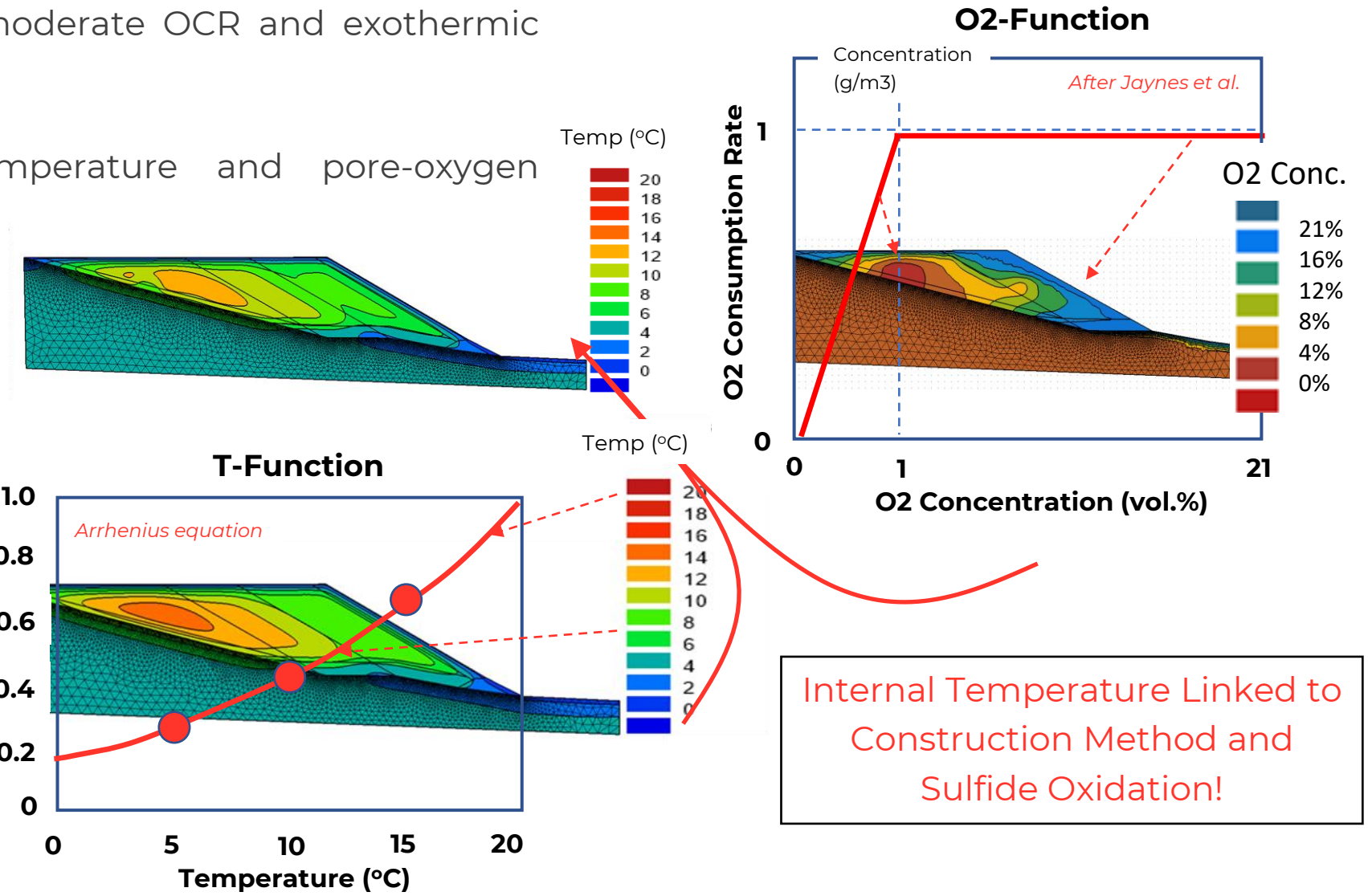


WRS Assessment Method – Heat Generation

- T-Function and O2-Function moderate OCR and exothermic heat generation.
- OCR linked to internal temperature and pore-oxygen concentration.
- Temperature / pressure gradient drives airflow and oxygen supply
- The model then allows for the construction method to influence temperature



Internal Temperature Linked to Construction Method and Sulfide Oxidation!

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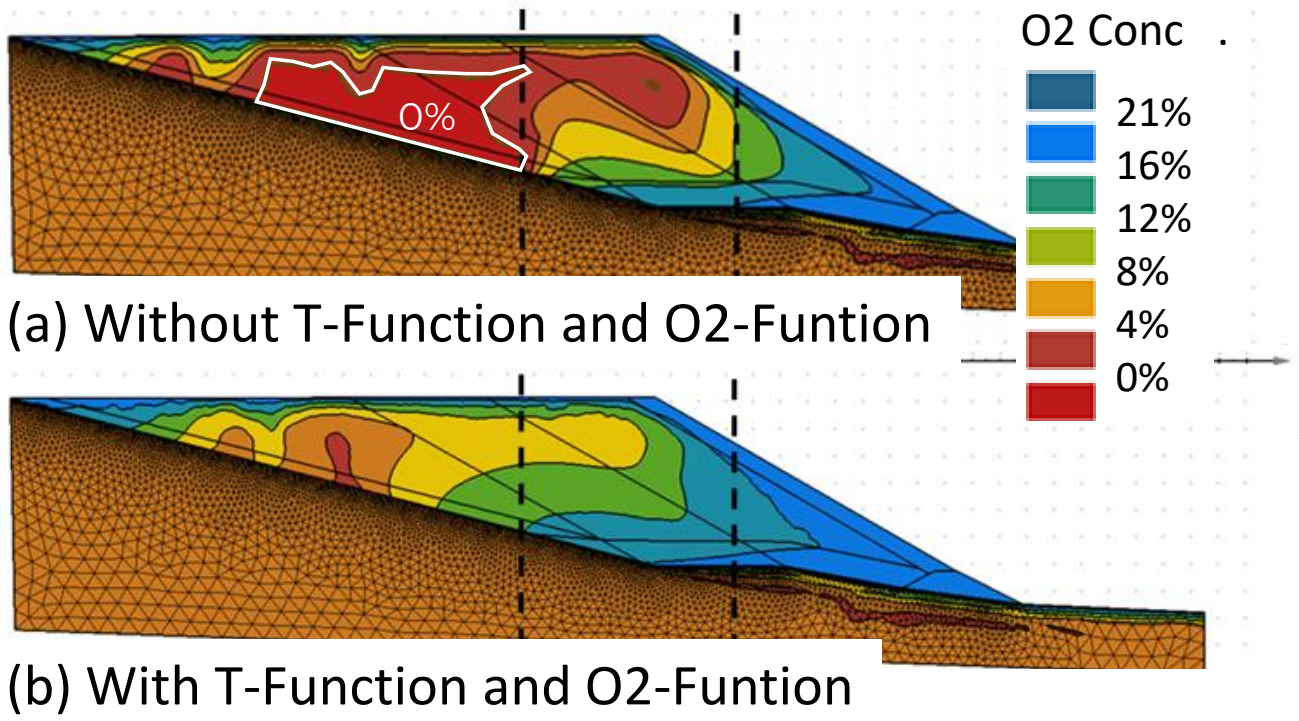
WRS Assessment Method – Pore-Oxygen Conc.

- T-Function and O2-Function:
- Moderate OCR and hence pore-oxygen concentration… Is depleted oxygen important for your assessment?
- OCR is related to sulfide oxidation and stored load.
- Pore-oxygen concentration drives diffusion
- A reduction in advection can increase diffusion



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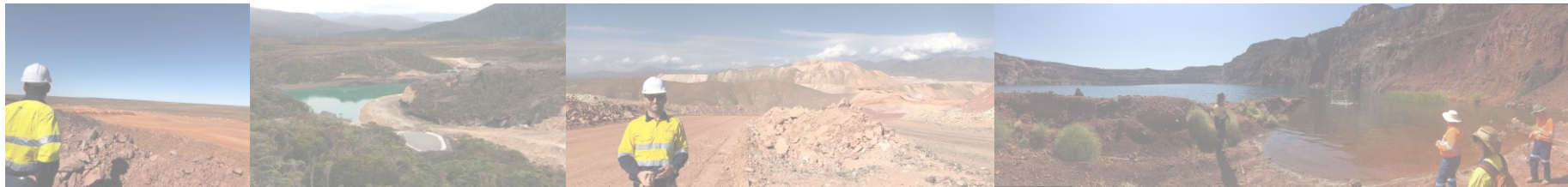
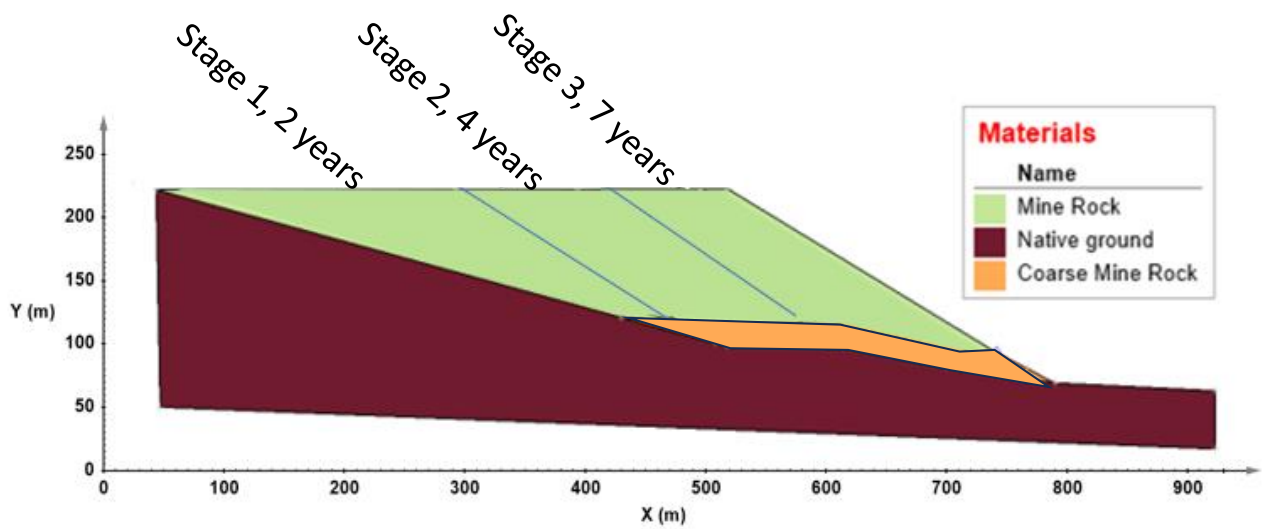


Blind Case Study

Project Objectives:

- Establish a conceptual model to support the numerical simulation program. Input parameters and vet simulated performance (in term of temperature and pore-oxygen conc.)
- Provide quantitative assessment of alternate WRS construction methods for AMD source control
- Identify key parameters that influence performance, what works and what doesn't (Seventeen construction methods were assessed)
- Increase understanding of processes
- ***Blind case study,*** top-down WRS (175m x 750m)
  - Transient analysis built in three stages
  - 7 –year build, 10-year assessment period



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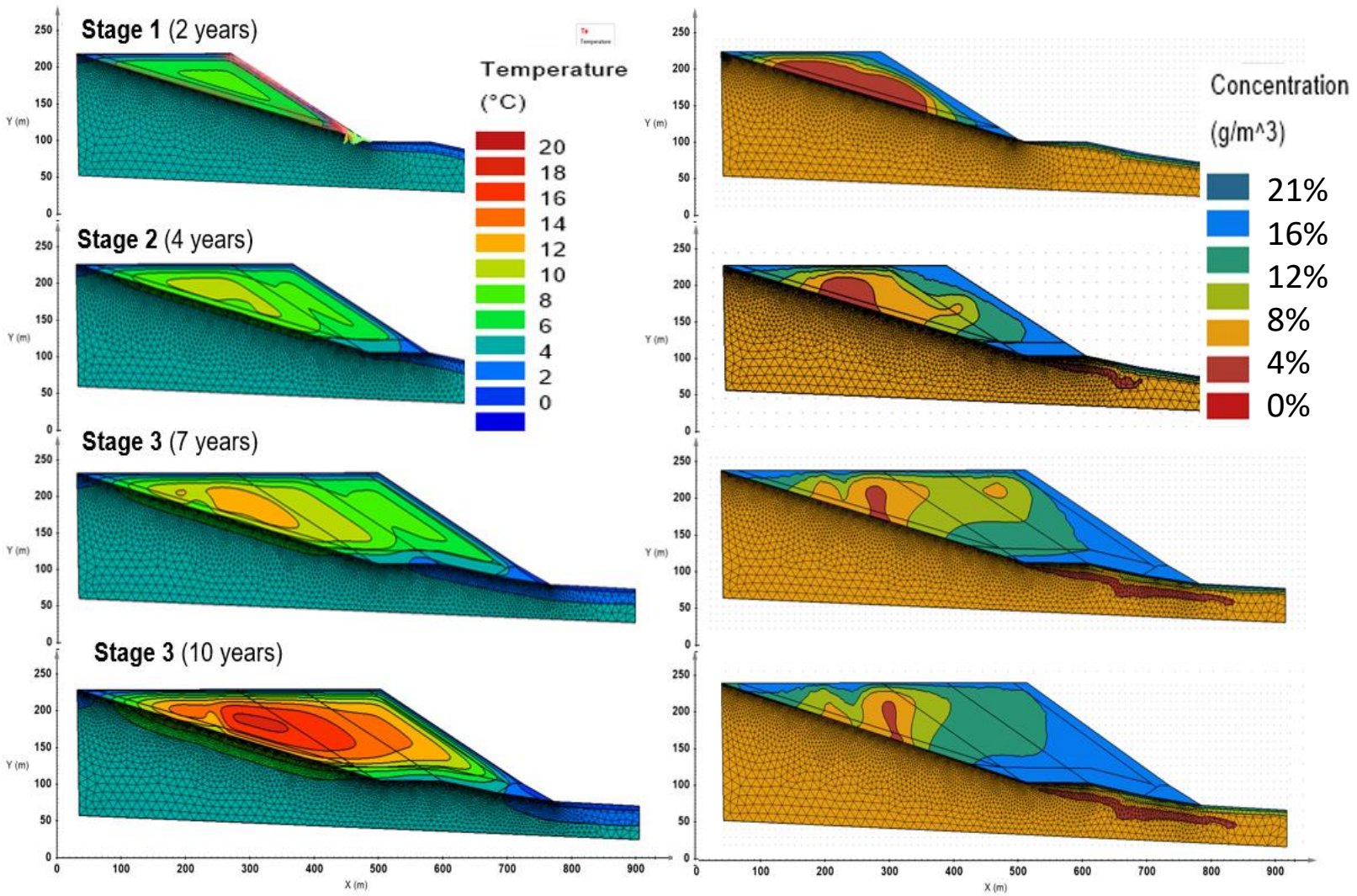
Simulated Performance – Temp & Pore-Oxygen

- Temperature increases beyond the construction stage and then becomes more constant after 10 years
- Peak temperature of ~18°C reached
- While temp and OCR increase so does the advective airflow which suppresses the development of depleted pore-oxygen



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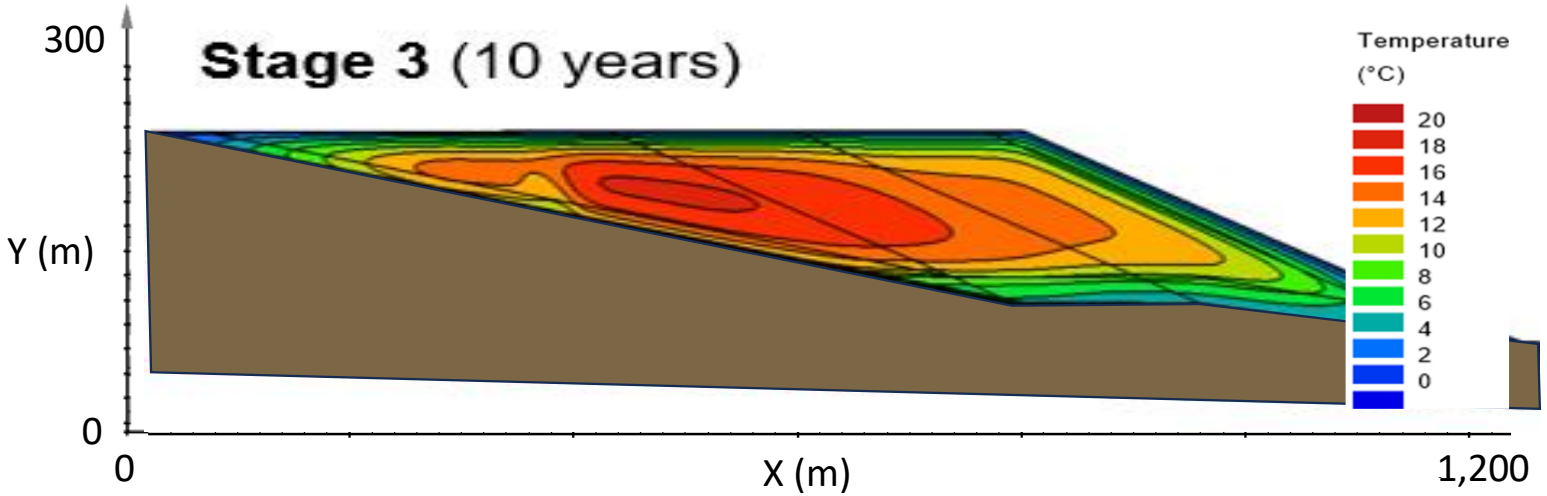
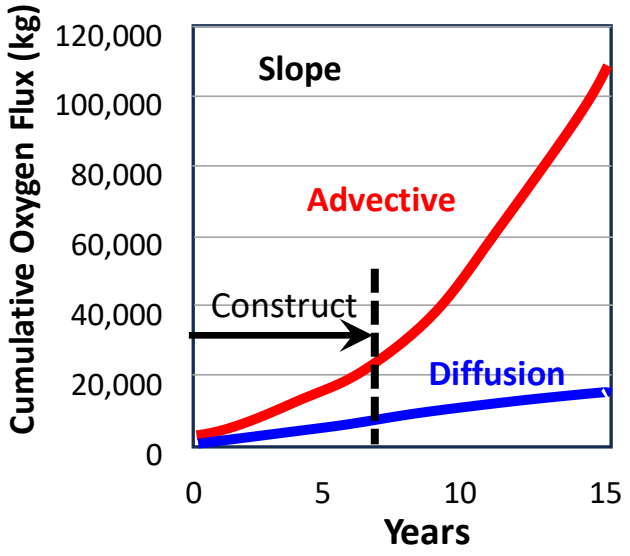
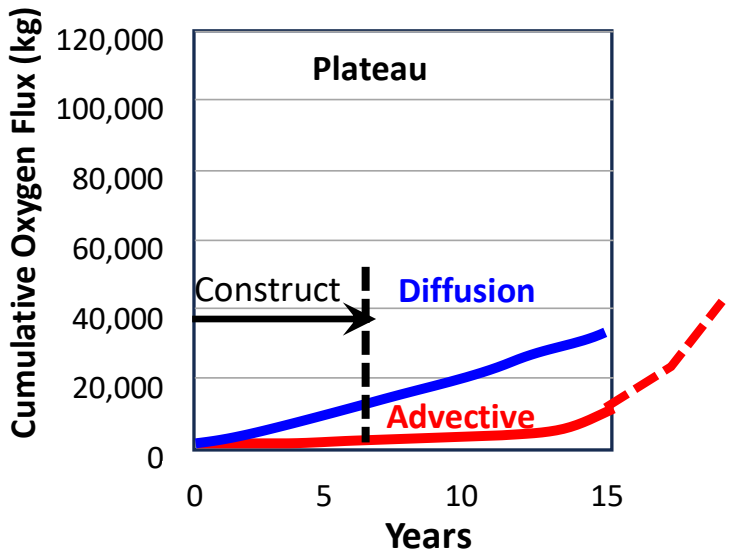
Simulated Performance – Diffusion & Advection

- Diffusion increases proportional to mine rock placement
  - The concentration gradient
- Diffusion ~40% of oxygen ingress
- Advective airflow increases beyond the 7-year construction period, linked to temperature
- Delay in plateau advective airflow observed
  - Increase in year 13.
  - Rethink the conceptual model?







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Concluding Points

- OCR, exothermic heat generation, and AMD risk is driven by the physical environment of which in-situ temperature and pore-oxygen concentration are key parameters.
- Assessment of WRS construction methods should capability to simulate temperature evolution and oxygen consumption (sulfide oxidation) with coupled diffusion and advection.
- The conceptual model for top-down WRSs is that airflow enters the coarse rubble zone and when it warms and becomes light enough it starts to rise establishing advective flow. Completed transient numerical simulations suggest that advective airflow patterns will evolve and may draw airflow through the plateau. Consider monitoring. Consider mitigation.
- Assessment of diffusive oxygen should be coupled with advective airflow given that the concentration gradient drive diffusion. Typically, as advection decreases diffusion increases.
- Diffusion accounts for approximately 40% of the oxygen flux over the construction period.

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