

What is mine site rehabilitation and what does it require in 2018?

Applying Deswik.CAD and Deswik.LHS for Environmental Evaluation at Mount Isa Mine

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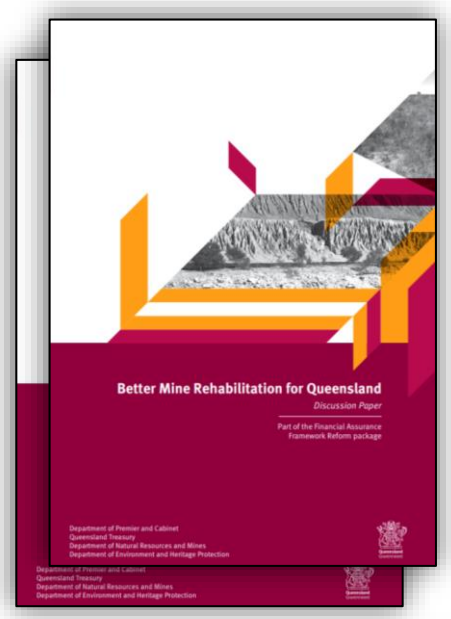
Introduction

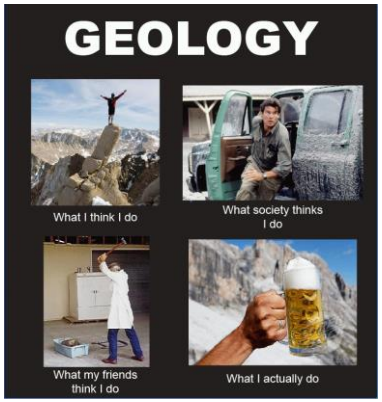
Part 1:
Summarises changes in the mining sector relating to rehabilitation, financial assurance and the implications of the changes to mine sites

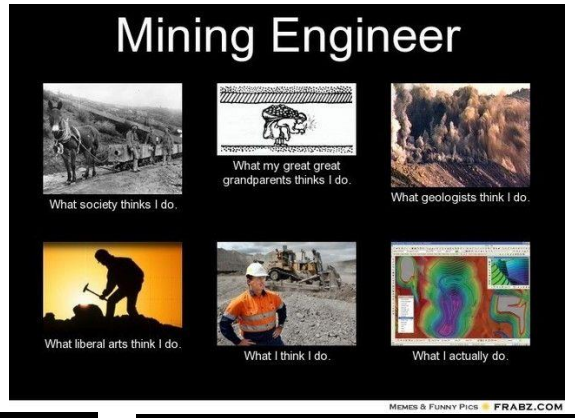


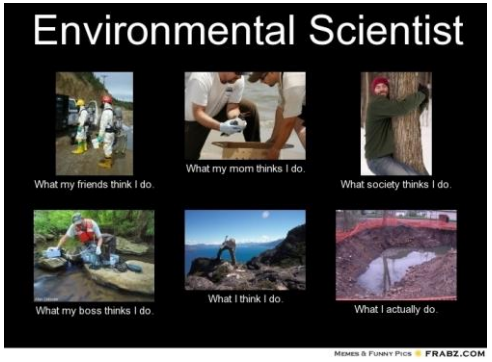
Part 2:
Presents a case study showing the type of work that may be included in a Progressive Rehabilitation and Closure Plan

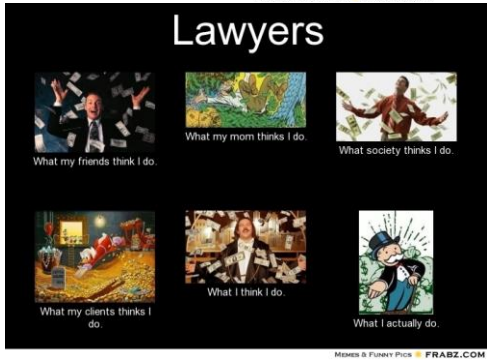

Mount Isa Mine

Mine rehabilitation requires conversations to get people on the same page!









Failed conversations over the past 30 years or so has led to the government stepping in!

Mining reform is coming (has arrived) in Queensland

- The Queensland government is seeking better mine rehabilitation and improvement in Financial Assurance.

- The mining rehabilitation reforms include:
  - Financial assurance reform
  - Mining rehabilitation reforms
  - Mineral and Energy Resources (Financial Provisioning) Bill 2018
  - Financial Assurance under the Environmental Protection Act 1994 Guideline

- The reforms are being developed to reduce environmental harm and ensure that there is adequate financial provisioning

- Failure to achieve the intent of the mining rehabilitation reforms will adversely affect the bottom line of mining companies

Financial liability drives reform

- The potential financial liability in Queensland associated with incomplete rehabilitation at mine sites is in the order of $3B at Queensland coal mines[1]
- Total actual liability remains unknown!
- Vast tracts of land have not been rehabilitated
- Most mined land that has been rehabilitated will not meet rehabilitation objectives and may not be able to be relinquished

Mount Oxide Mine Rehabilitation Project2

Failed rehabilitation equates to:

- **perpetual management of the land**
- **perpetual and increasing financial liability**
- **potential adverse impact on value and perception of the company to investors**

1 http://www.abc.net.au/news/2016-08-04/taxpayers-exposed-to-multi-billion-clean-up-of-coal-mines-report/7685760; 2 https://www.qld.gov.au/environment/land/abandoned-mines/projects/mt-oxide

Law, legislation and regulation enact and enforce reform

The need to develop a robust and defensible life of mine plan is being driven by:

- amendments to the Queensland Government Mineral and Energy Resources (Financial Provisioning) Bill 2018 (the Bill)

- amendments to the Environmental Protection Act 1994 (EP Act) that will require a progressive rehabilitation and closure plan schedule to be documented in a **Progressive Rehabilitation and Closure Plan (PRC Plan)**

Target Gully tailings dam: before remediation work1

Target Gully tailings dam: redesigned spillway1

1 https://www.qld.gov.au/environment/land/abandoned-mines/projects/mt-oxide

What is (will be) required in a PRC Plan in Queensland

The **PRC Plan** will have mandatory content:

- A rehabilitation **planning component** which documents the:
  - consultation processes undertaken to develop the plan,
  - the proposed design of the mine,
  - the final landform including encapsulation and cover design requirements,
  - different post-mining land uses or non-use management areas for the site,
  - methodologies and trials for rehabilitation,
  - and any post-closure management requirements for the site.

- A progressive rehabilitation and closure plan **schedule component** (PRCP schedule) which includes:
  - all mined units (not just waste)
  - maps of final rehabilitation outcomes for each area,
  - tables of time-based milestones for achieving each post-mining land use or non-use management areas, and,
  - any conditions imposed on the schedule by the administering authority.

What is the intent of a PRC Plan schedule


Mount Isa Mine

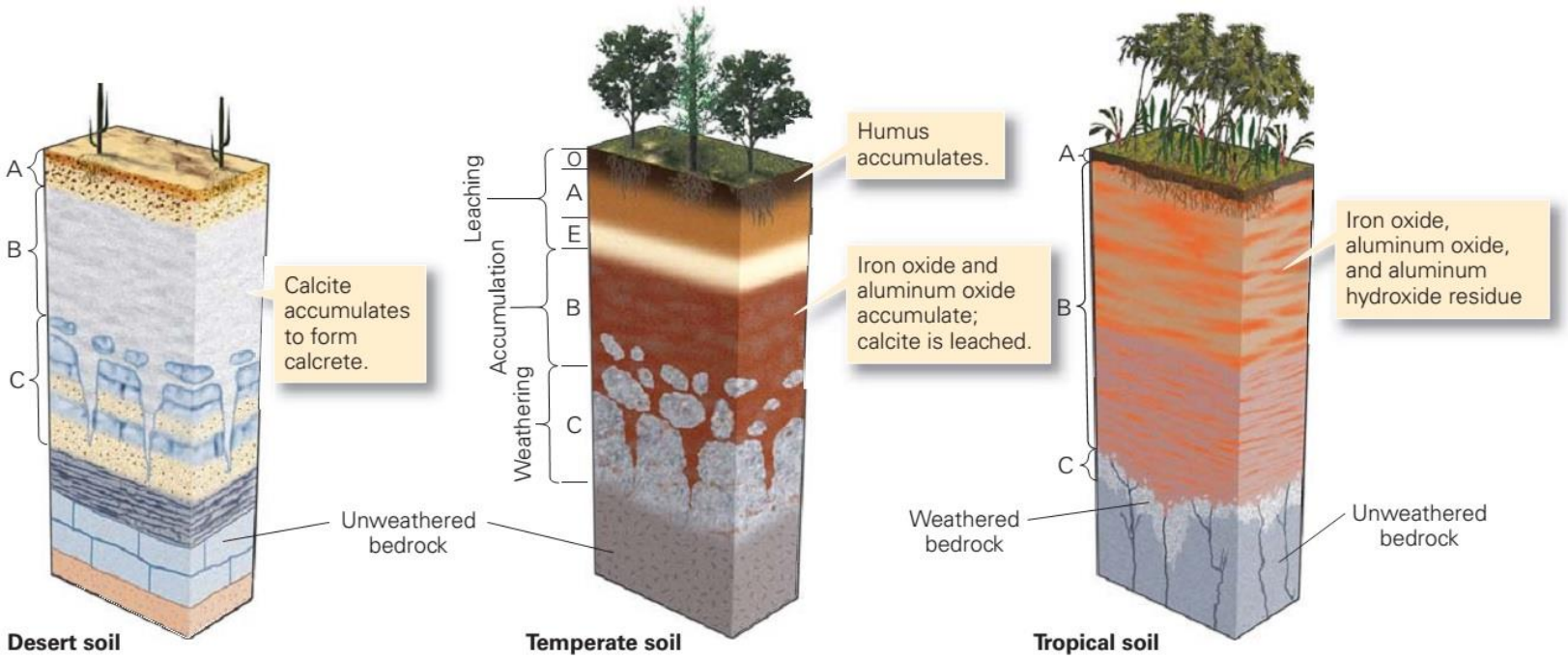
The primary aims of a PRC Plan will be:

- to develop and implement a mine waste schedule that will enable miners to mine and place the mine waste in the right place the first time to ensure the potential for adverse environmental impacts on the receiving environment is minimised
- ensure the rehabilitation of the mined land is fit for purpose (safe and stable and non-polluting)
- rehabilitate all areas of a mine (e.g. tailings, waste rock, low grade ore stockpiles, underground voids and open pits.

What is mine waste

- To most planners, engineers and geologists on a mine the mine waste is everything other than the commodity coming out of the ground
- Based on the previous assumption mine waste includes topsoil, subsoil and the other units in the regolith above the pre-mine standing water level in the vadose zone and the transitional units and fresh rock below the water table
- Mine waste therefore includes **beneficial** and **deleterious** material types
- Beneficial material types may include topsoil subsoil, weathered regolith, non acid forming or acid consuming (AC) waste rock
- Beneficial material types have geochemical and physical properties
- Deleterious material types may include potentially acid forming (PAF), saline or sodic material

Regolith science



(a) Aridisol forms in deserts. Rainfall is so low that no O-horizon forms, and soluble minerals accumulate in the B-horizon.

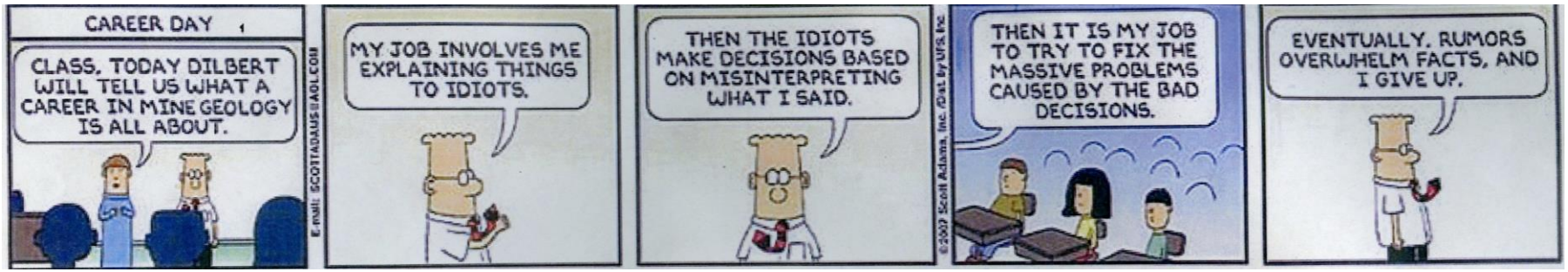
(b) Alfisol forms in temperate climates. An O-horizon forms, and less-soluble materials accumulate in the B-horizon.

(c) Oxisol forms in tropical climates where percolating rainwater leaches all soluble minerals, leaving only iron- and aluminum-rich residues.

Different soils and regolith units have very different purposes for civil construction and rehabilitation including cover design

What is rehabilitation and what does it require?

Rehabilitation requires conversations across multiple disciplines.



Rehabilitation is not (just) putting on a soil cover and adding grass seed to dirt!

What does rehabilitation require

To hit rehabilitation targets there is a need for integrated planning across technical disciplines:

- Drilling and sampling
- Geochemical and physical testing
- Interpretation of the results
- Rehabilitation strategy based on test results
- Geological modelling to develop material balances
- Defining rehabilitation objectives, design criteria, indicators for success and completion criteria
- Development of cover design(s) based on material balances and rehabilitation objectives
- Mine schedule for ore, deleterious and beneficial waste units
- Post placement verification to check things were done correctly
- Rehabilitation verification (monitoring) programs
- Sign off process to transfer title of the land

What about final voids e.g. open pits and underground workings?

What are the rehabilitation options at mine sites

Base case to rehabilitation

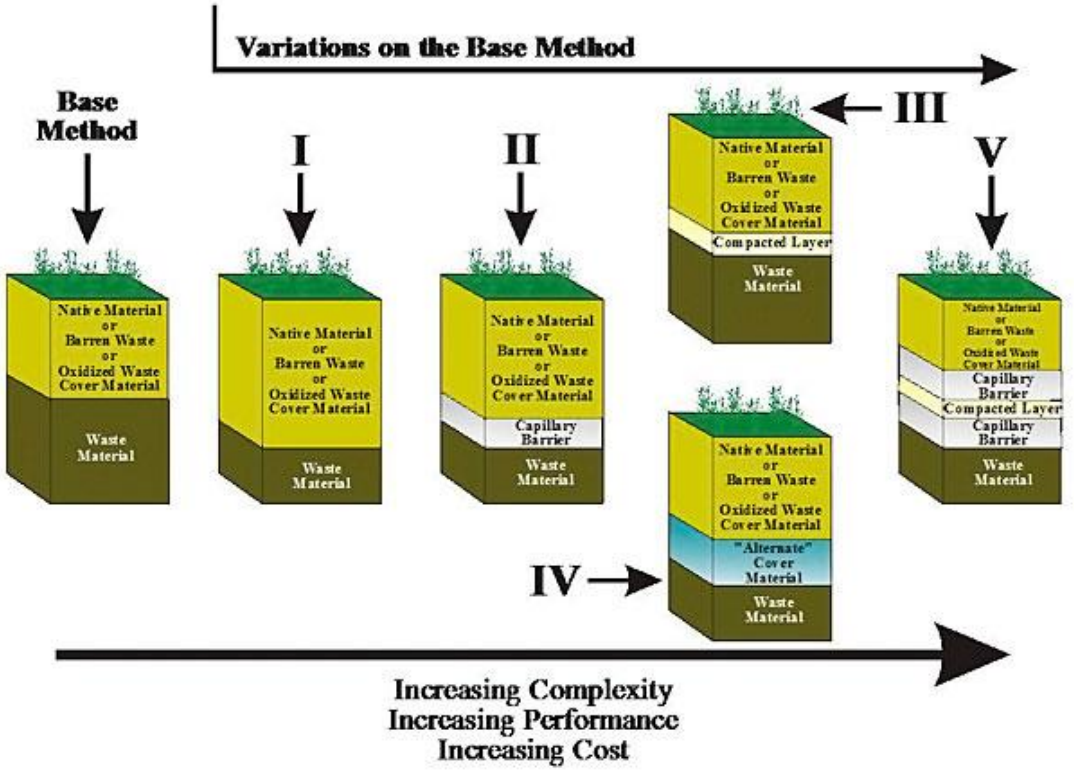
- Cover waste rock and tailings, seed it then return it to bushland
- Some success may enable grazing or return to pasture (maybe)
- Covers might include simple (analogue) soil covers, engineered covers, geo-synthetics, geo-composites
- Pits are made safe with a bund to stop access
- Pit lakes may evolve over time
- Underground workings sealed off and left to groundwater

New ideas for rehabilitation

- Use pit lakes for floating solar farms
- Use voids for landfill, hydro power generation recreational lakes, water supply
- Cover waste with HDPE (instead of soil) and use waste dumps and TSFs to generate energy
- Landscape re-hydration processes may be applicable rehabilitation options for coal mines

What are cover systems?

To hit rehabilitation targets there is a need for development of a cover design(s) plan for the mine waste based on the availability of the mined units

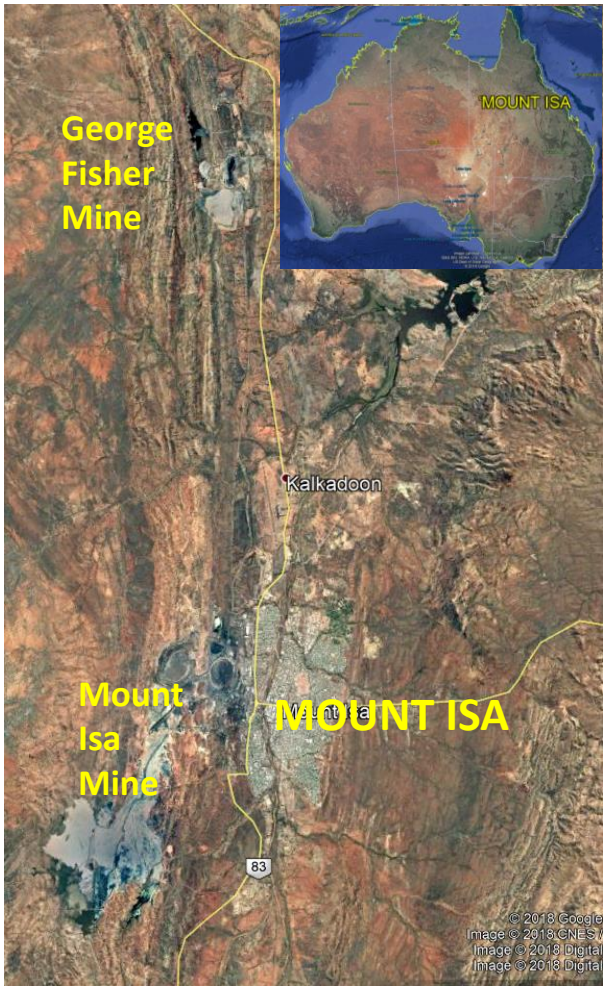


$30,000/ha

> $500,000/ha

Project case study presented at ICARD 2018

- Mount Isa Mines (MIM) is a significant asset within the Glencore global portfolio
- Mineralisation discovered in 1923
- 1931, lead zinc concentrator, lead smelter, milling operation and a power station, were constructed and the operation started the production of lead bullion
- Copper production undertaken between 1943 and 1946
- In 1966, a copper concentrator was constructed to feed the new copper smelter and underground mining of the deep copper deposits within the orebody commenced
- ML8058 commenced on 1 December 1986 for a term of 50 years and covers a surface area of 31,026 hectares (ha).

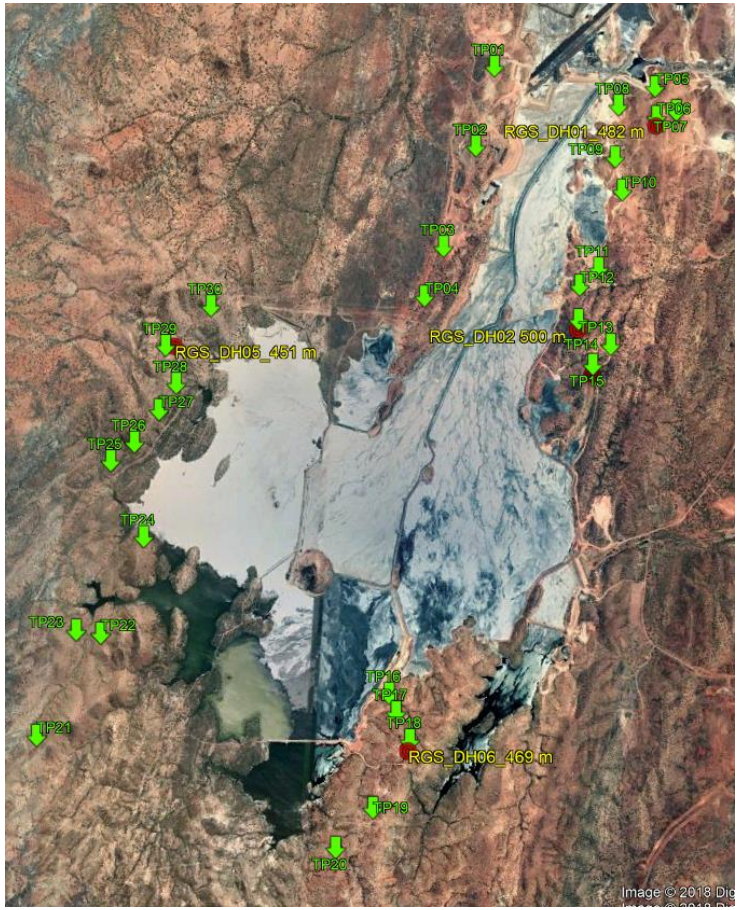


Project aim

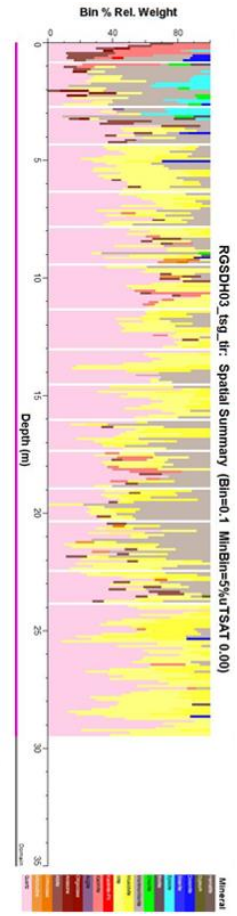
- The overall aim of the work is to verify:
  - what type of material can be obtained from the regolith in the hills around the TSF (e.g. topsoil, subsoil, extremely to weathered regolith and fresh rock)
  - how much material can be obtained for each of the main regolith units
  - evaluate scheduling options to calculate the time it would take to complete the construction of a cover system on the TSF

- The objectives of the study were to:
  - Identify borrow areas and potential borrow pits that would yield material for potential cover systems for rehabilitation of the MIM TSF
  - Obtain samples from test pits and drill holes for static geochemical and physical characterisation to determine if the materials would be suitable for a cover system
  - Use Deswik mine scheduling software to schedule the mining and placement of borrow material onto the MIM TSF
  - Use SEEP/W to evaluate how the conceptual cover system proposed for the MIM TSF might perform under field conditions

Sampling and analytical program



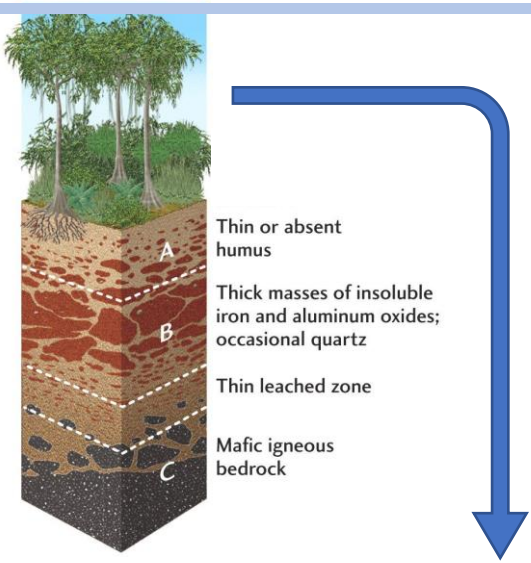
- 5 x PQ holes drilled to 30 m bgl and 30 samples
- 30 x test pits and 83 samples to 2 m bgl
- pH, EC, XRF, texture and dispersion testing (113 samples)
- TS, ANC, CRS, CEC, pH, EC, Soluble and total element analysis (30 samples)
- Porosity, density , LAA testing (14 samples)
- Full suite of geochemical and physical testing on 12 composite samples

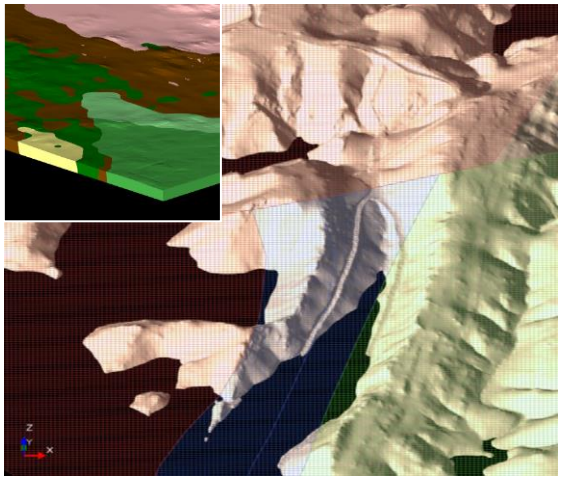


Forward works – 2018 and 2019

- Ongoing drilling and test pits in 2018 and 2019
- High resolution imagery and hyperspectral mineralogy on drill core
- Static geochemical and physical analyses of drill core and test pit samples
- Develop nominal borrow pit shells in Deswik

- Develop 3D regolith model of the nominal borrow pits defining geochemical and physical properties of the following materials to then produce a material balance and mining and rehabilitation schedule for:
  - Topsoil
  - Subsoil
  - Extremely weathered regolith
  - Weathered regolith
  - Transitional regolith
  - Fresh rock





Summary of presentation

- New legislation and regulation will enforce mine sites to do more life of mine planning for rehabilitation
- Rehabilitation is more complex than some mining engineers and mine planners may think
- Rehabilitation is not just spreading some dirt over PAF waste and ripping in some grass seed
- Cover systems form an integral part of the rehabilitation process
- Covering PAF waste (in its own right) does not stop long term AMD issues
- Successful rehabilitation needs long term integrated planning
- Mine planning for operations will need to incorporate long term plans for rehabilitation
- Changes to the PRC Plan should be able to made over the life of mine to accommodate changes to the mine plan, life of asset etc, but the changes must be defendable and auditable
- Life of asset scenario analyses to evaluate a broad range of options at PFS / FS should be done to identify the best overall mine plan before a PCR Plan is submitted that the mine then becomes accountable to.

Acknowledgements

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