

# CLASH OF THE TITANS

## Clash of the Titans – Father Time, Mother Nature and the Mine Waste Cover

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# What this Talk is About

- Are closure covers a viable closure strategy?
- Why do closure covers continue to “fail”
- What are we doing about it?
- What should we be doing about it?



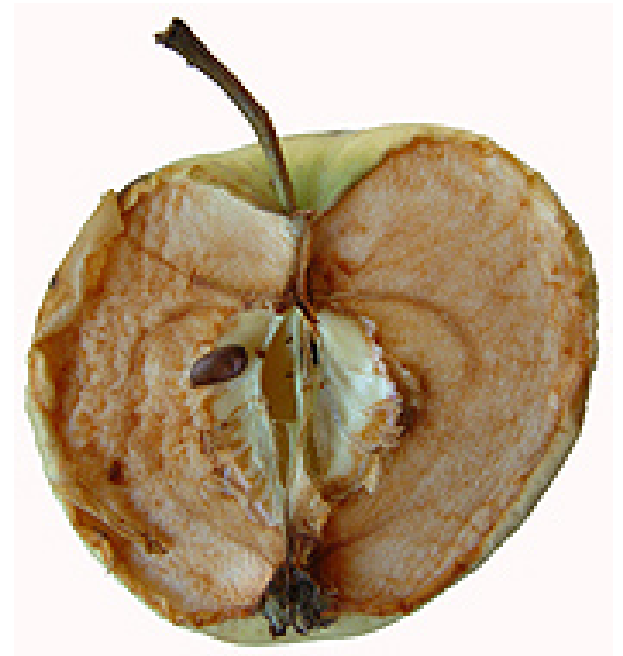
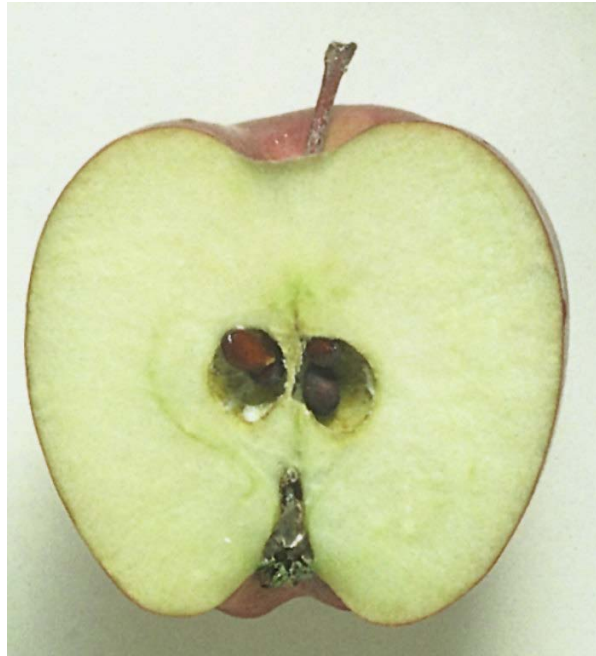
Confidential Site, USA

# The Cover Engineer's Conundrum



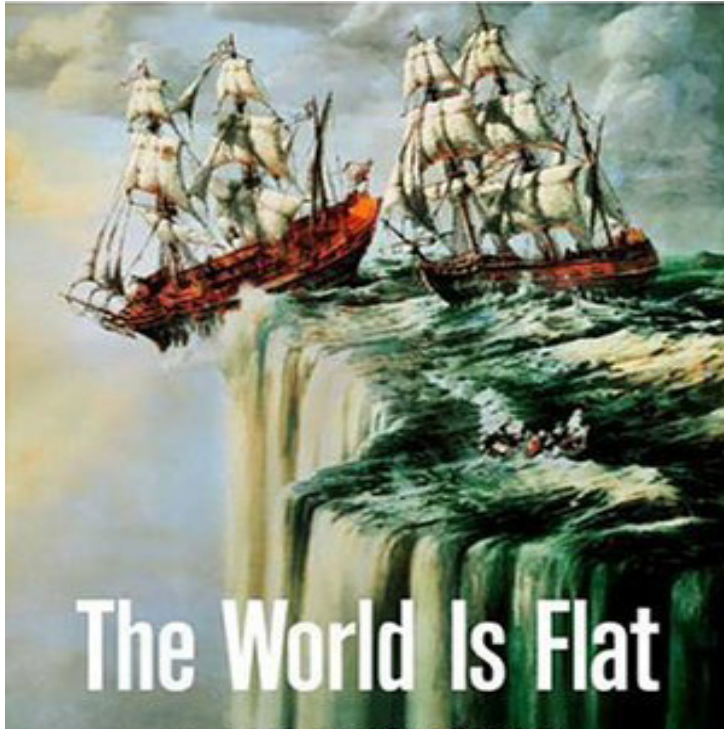
- General consensus
  - Closure mitigation is needed
  - Closure measures must stand up to Mother Nature and Father Time
- No consensus
  - How much of Mother nature to withstand
  - How long are we responsible to Father time

# What is a Mine Waste Cover





# Common Cover Myths



- Closure design = cover design
- Cover = no more AMD/metal leaching
- Cover design = geotechnical design
- Cover design = numerical modeling
- Cover design = instrumented field trials
- Cover performance = exact and measurable
- Covers last forever

# Why Mine Waste Closure Covers

- Need definitive site specific answer to this question
- Disconnect remain between **site closure goals** and reason for using covers
- Should define separate terms
  - Closure **OBJECTIVES**
  - Cover **FUNCTIONS**



Johannesburg, South Africa

# Defining Closure Objectives

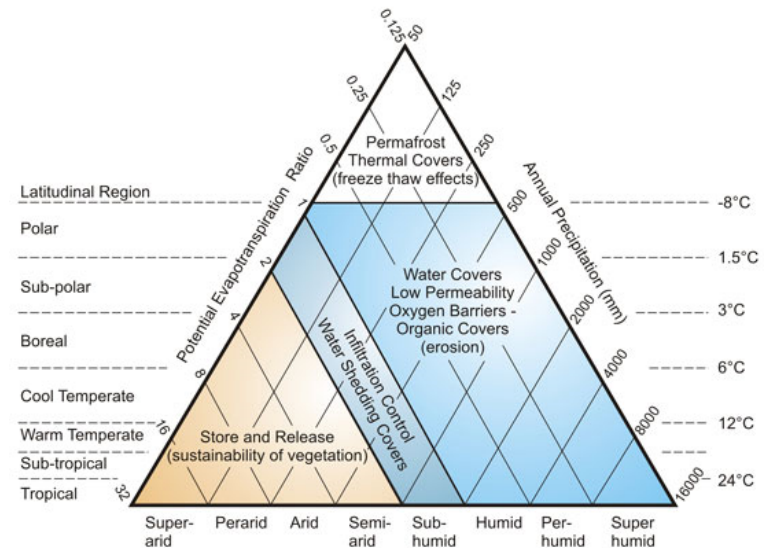
- Closure **Objectives** = fundamental reason/motivation for doing closure work
- Typical reasons include
  - Remove health & safety risks
  - Prevent/remove/minimize environmental impacts
  - Reclaim social/economic land value
  - Regulatory compliance
  - Release bonds



Wismut, Germany

# Defining Cover Function

- A cover is one **Tool** that can be used to achieve a Closure Objective
- Cover **Function** is the “work” that the cover must perform to achieve the Closure Objective
- Typical cover functions include
  - Radiation control
  - Waste stabilization
  - Seepage/leachate management
  - Physical stabilization
  - Thermal control
  - Promote vegetation



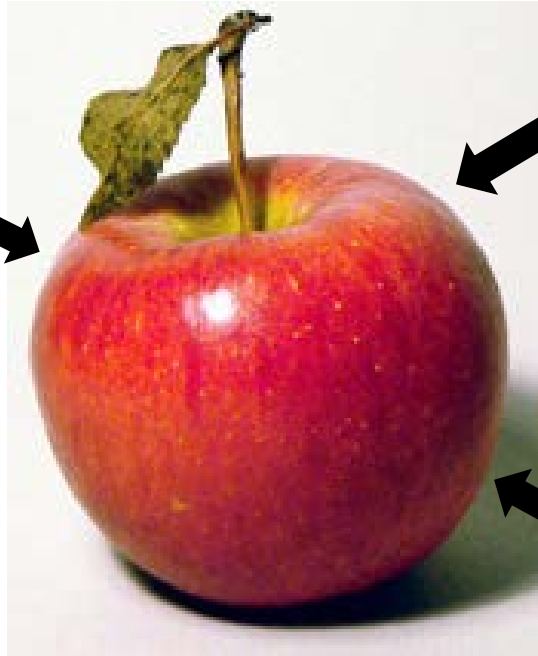
GARD Guide (INAP 2014)



# Conditions Imposed on Covers

## Physical Processes

- Erosion
- Slope Instability
- Wet/Dry Cycles
- Freeze/Thaw Cycles
- Consolidation/Settlement
- Extreme Climate Events
- Brush Fires
- Construction



## Chemical Processes

- Osmotic Consolidation
- Dispersion/Erosion
- Dissolution/Precipitation
- Acidic Hydrolysis
- Mineralogical Consolidation
- Sorption
- Salinization
- Oxidation

## Biological Processes

- Root Penetration
- Burrowing Animals
- Bioturbation
- Human Intervention
- Bacteriological Clogging
- Vegetation Establishment

# Covers are “Failing”

Confidential Site, USA



Confidential Site, USA



Engineering/Design Failures



# Covers are “Failing”

Colomac Mine, Canada



Patterned Ground, Canada



State of Practice Limitations

# Covers are “Failing”

Union Bay, Canada



Union Bay, Canada



Unreasonable Expectations



# Covers are “Failing”

Confidential Site, Europe



Confidential Site, Canada



Mother Nature is in Charge

# Mother Nature

Expect to see more emergencies like Oroville Dam in a hotter world

Roads closed, tourists stranded as record-breaking rains flood Pilbara region of WA

**Massive Winter Weather System Brings 'Epic' Snowfall to Sierra Nevada**

**Monster storm breaks rain records at several Southern California locations**

**First Week of 2017: Record Cold, 48 States Going Below Freezing**

**Qld, NSW outback towns to reach high 40s as heatwave sweeps across eastern Australia**

India crippled by extreme weather as 100 million exposed to floods

# Covers will “Fail”...in the future

Bryce Canyon National Park, USA



Pyramid of Khafre, Egypt



Father Time outlasts all...



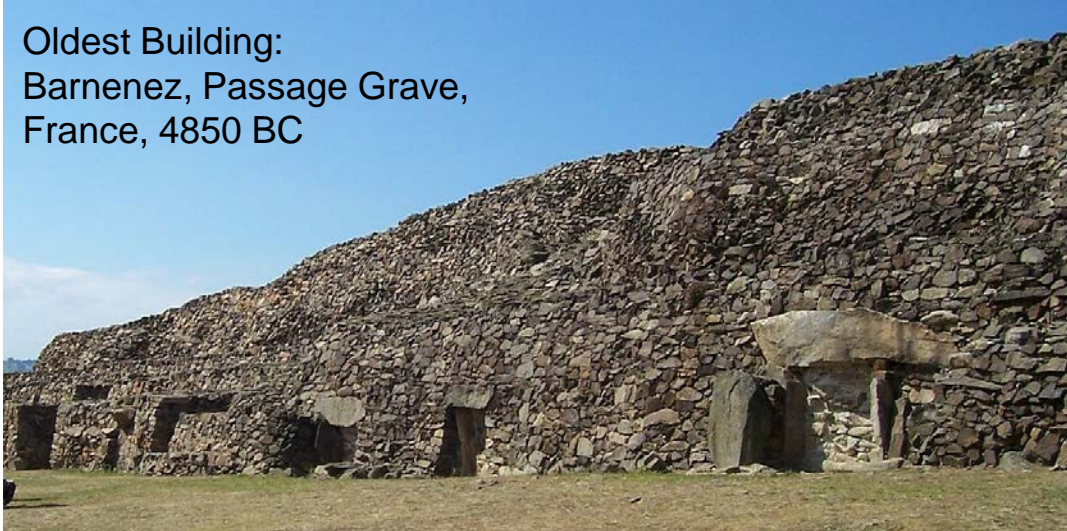
# Father Time

Oldest Man-Made Structure:  
Theopetra Cave, Stone Wall,  
Greece, 21000 BC



All of these has undergone extensive remedial work and require ongoing maintenance

Oldest Building:  
Barnenez, Passage Grave,  
France, 4850 BC



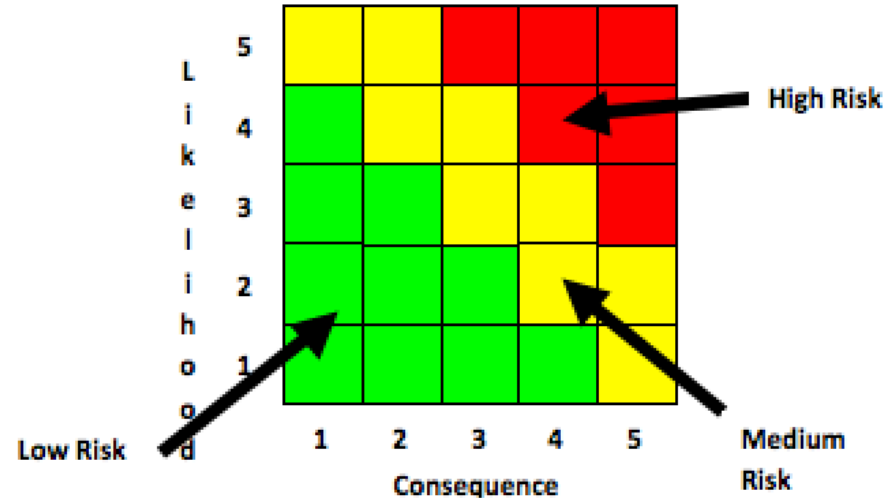
Pyramid of Khafre, Egypt, 2500 BC





# How are we mitigating these challenges

- Learn from our failures
- Develop Best Practice guidelines
- Make risk based decisions
- Apply best available technology to manage uncertainty such as climate change
- Demand “walk-away” closure
- Design for “indefinite” timelines



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There is only one thing more painful than learning from experience, and that is not learning from experience. **Laurence J. Peter**

# Best Practice Guideline Documents



**DESIGN, CONSTRUCTION AND PERFORMANCE MONITORING OF COVER SYSTEMS FOR WASTE ROCK AND TAILINGS**

**VOLUME 1 – SUMMARY**

**MEND 2.21.4a**



**DESIGN, CONSTRUCTION AND PERFORMANCE MONITORING OF COVER SYSTEMS FOR WASTE ROCK AND TAILINGS**

**VOLUME 2 – THEORY AND BACKGROUND**

**MEND 2.21.4b**



**DESIGN, CONSTRUCTION AND PERFORMANCE MONITORING OF COVER SYSTEMS FOR WASTE ROCK AND TAILINGS**

**VOLUME 3 – SITE CHARACTERIZATION AND NUMERICAL ANALYSES OF COVER PERFORMANCE**

**MEND 2.21.4c**



**DESIGN, CONSTRUCTION AND PERFORMANCE MONITORING OF COVER SYSTEMS FOR WASTE ROCK AND TAILINGS**

**VOLUME 4 – FIELD PERFORMANCE MONITORING AND SUSTAINABLE PERFORMANCE OF COVER SYSTEMS**

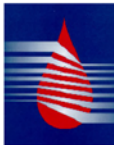
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**DESIGN, CONSTRUCTION AND PERFORMANCE MONITORING OF COVER SYSTEMS FOR WASTE ROCK AND TAILINGS**

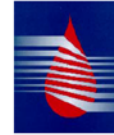
**VOLUME 5 – CASE STUDIES**

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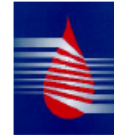
**Macro-Scale Cover Design and Performance Monitoring Manual**

**MEND Report 2.21.5**



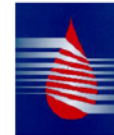
**Modelling the Critical Interactions between Cover Systems and Vegetation**

**MEND Report 2.21.6**



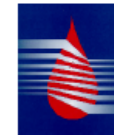
**Mine Waste Covers in Cold Regions**

**MEND Report 1.61.5a**



**Cold Regions Cover Research – Phase 2**

**MEND Report 1.61.5b**



**Cold Regions Cover System Design Technical Guidance Document**

**MEND Report 1.61.5c**

# Prescriptive Guidance Documents





# What should we be doing

- Recognize we cant outwit Mother Nature and Father time
  - Design with finite timeline in mind
- Work towards a paradigm shift
  - Put measures in place to manage the future
- Really do what we say
  - “Design for closure”



2011 Japan Tsunami

# Conclusion

- Covers remain appropriate closure tool
- Be realistic and explicit about expectations
- Be cautious of prescriptive designs
- Think proactive not reactive
  - Cover practitioners should work towards putting themselves out of a job!



Machu Picchu, Peru