



MANAGING GEOMECHANICAL RISK AT MINES

MALCOLM BRIDGES

20 April 2017

A few key points:

- * Clear communications
- * Rock and soil inherently variable
- * Risks can be severe
- * Understand geo-mechanisms
- * Mine plan is the basis - expectations
- * Comprehensive monitoring
- * Identify unexpected responses

Clear communications are crucial

❑ Non-technical people

- ⌘ Managers

❑ Non-mining people

- ⌘ Lawyers, accountants, financiers, insurers

❑ Technical experts

- ⌘ competitive

❑ Beyond OZ and non-English-speaking

❑ Legalistic environment of risk event

Clear communications are crucial

- ❑ Everyone's familiar with "Geotechnical" ?!?!?
- ❑ Formally means 'technical geology'
 - ⌘ Geoscientific discipline
 - ⌘ Restricted to civil engineering?
- ❑ Informally from ~1990? I dunno!
 - ⌘ Stability? Ground control? Geomechanics?
- ❑ "Geotech" not a proper word

Clear communications are crucial

- “Geomechanics” is the relationship between forces and displacements in earthen materials
 - ⌘ Geoscientific discipline – geology, physics, maths

- Applied for management of the response of earthen materials to mining and disposal
 - ⌘ Rock, soil, waste rock, stockpiles, tailings, support
 - ⌘ Open pit, underground
 - ⌘ Hard-rock, coal, soft-rock, granular

Earthen materials are naturally variable

□ “Rock” is a solid material

- ⌘ Multiple rock types
- ⌘ Geologic structures
- ⌘ Alteration
- ⌘ Critical mineralogy
- ⌘ Stress (energy)
- ⌘ Porewater
- ⌘ Intermittent seismicity

Earthen materials are naturally variable

- “Soil” is a granular material
 - ⌘ Deposition, alteration, product of mining
 - ⌘ Porewater
 - ⌘ Mineralogy
 - ⌘ Particle sizing, form
 - ⌘ Consolidation
 - ⌘ Intermittent seismicity

Earthen materials are naturally variable

□ And

- ⌘ No choice for the location of a mine
- ⌘ Resources in a special geologic environment

□ And

- ⌘ Not forgetting that people are involved !
 - Budgets and schedules to squeeze
 - Rushed, inexperienced,

Earthen materials are naturally variable

So, ya gunna operate a mine in this stuff !!!!!!!!

Risk

- Vague definition
 - ⌘ But everyone knows what it means

- Low probability
- Adverse consequences
- Uncertain future
- Unexpected outcome
- *Opposite of reliability*

*Not in a
mine plan*

Geomechanical risk

□ Unexpected adverse events

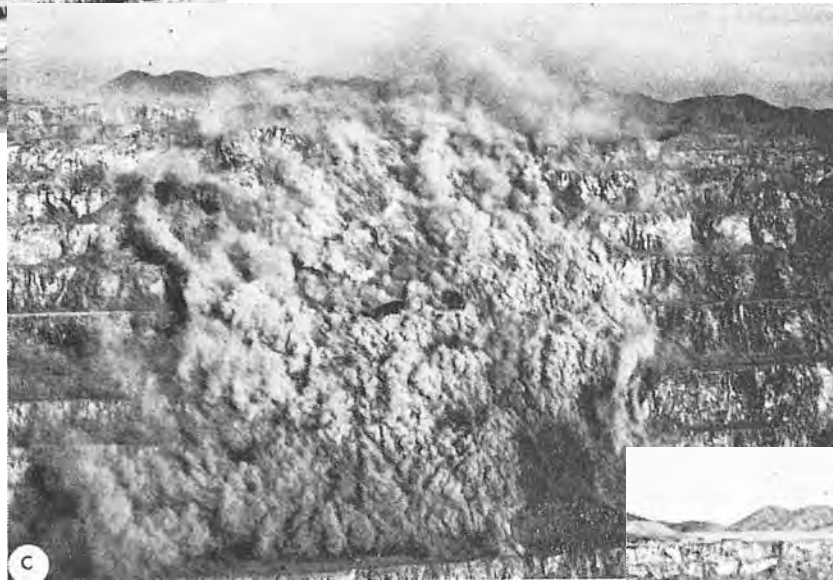
- ⌘ Caused by forces and displacements
- ⌘ In earthen materials

□ Such as:

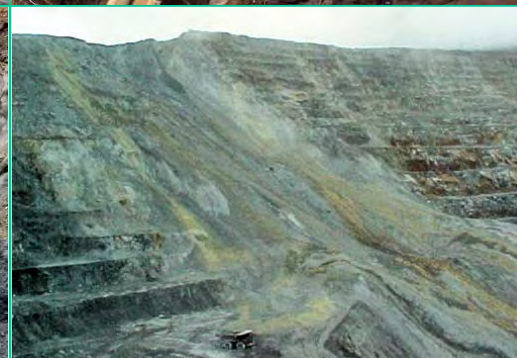
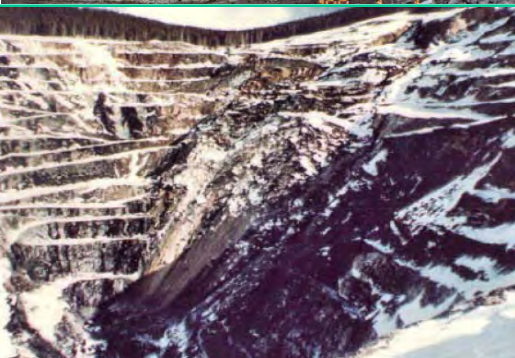
- ⌘ Pit wall
- ⌘ Stopes
- ⌘ Chimney collapse
- ⌘ airblast
- ⌘ Tailings dam
- ⌘ Waste flow

*Not in a
mine plan*

Chuquicamata February 1969













Nifty Mine
March 2014

Subsidence impacts Nifty production

Tuesday, 1 April 2014
Justin Niessner

ADITYA Birla Minerals has adjusted its production guidance for the Nifty copper mine in Western Australia after assessing a perceived subsidence event at the site.

The company said it expected its total production for the full year ended in March 2014 to be about 44,500 tonnes of copper.

This compares to some 69,300t of copper produced in fiscal 2013, with about 49,200t coming from Nifty alone.



April 2014

Nifty to remain in shutdown another month

Wednesday, 4 June 2014
Justin Niessner

ADITYA Birla has confirmed that 350 employees at its Nifty copper mine in Western Australia will remain sidelined until at least July 15 as the company continues to investigate a paralysing sinkhole incident.

The full time-equivalent positions to remain stood down will cross operations in mining, concentrator and paste plant work, maintenance and administration.

The company today said it was unable to provide a definitive date when



June 2014

Huge loss for Aditya

Monday, 1 December 2014
Kristie Batten

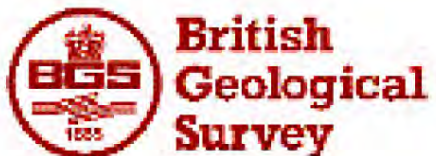
ADITYA Birla Minerals has posted a \$A170 million half-year loss, largely due to the impacts of a sinkhole at the Nifty copper operation in Western Australia.

Revenue for the six months to September 30 dropped 94% to \$9.3 million due to only 2714 tonnes of copper being produced, down 88% on the same time last year.

The company reviewed the carrying value of its assets and impaired the cash generating unity by \$117.2 million due to a reduction in reserves and change



December 2014



[BGS News](#) [Press Archive](#) [BGS Diary](#) [New on the Site](#)

HOLE IN THE GROUND - GEOLOGISTS ARE LOOKING INTO IT

Press announcements are compiled and issued by Hilary Heason, BGS Press Officer, Keyworth.

British Geological Survey

A massive hole has appeared in the ground in Ripon, south Yorkshire. Five homes have been evacuated and, naturally, people are frightened. What's going on?

During Wednesday 22nd and Thursday 24th April a large subsidence crater opened up in front of the

Four miners killed in underground air 'piston'

By MALCOLM BROWN

Four miners were killed at the Northparkes copper and gold mine near Parkes, in the State's central west, yesterday when a rockfall unleashed a lethal blast of air.

Two of the dead are understood to have been in a vehicle caught by the blast in the main decline shaft and tossed about, hitting the wall.

Rescue crews, including mine teams from Lithgow and Newcastle, rushed to the site, on the Bogan Road, 27 kilometres north of Parkes, as engineers assessed the safety of the mine and the possibility of another cave-in.

The names of the dead had not been released last night but it was confirmed that two were drillers and two supervisors.

Their bodies were expected to be left at the site until today, when investigators from Singleton declare the area safe for recovery operations.

The four died when the mass of air blasted through an access

working underground. Usually, the mining party would have comprised only half a dozen.

"We will conduct a full and thorough investigation with relevant authorities into the accident," he said.

"Our thoughts are with the families and friends of the men who were killed. This is a tragic situation for all in North Limited and for the Parkes community."

The accident happened two kilometres inside the mine and hundreds of metres below ground level. There were 35 people underground at the time.

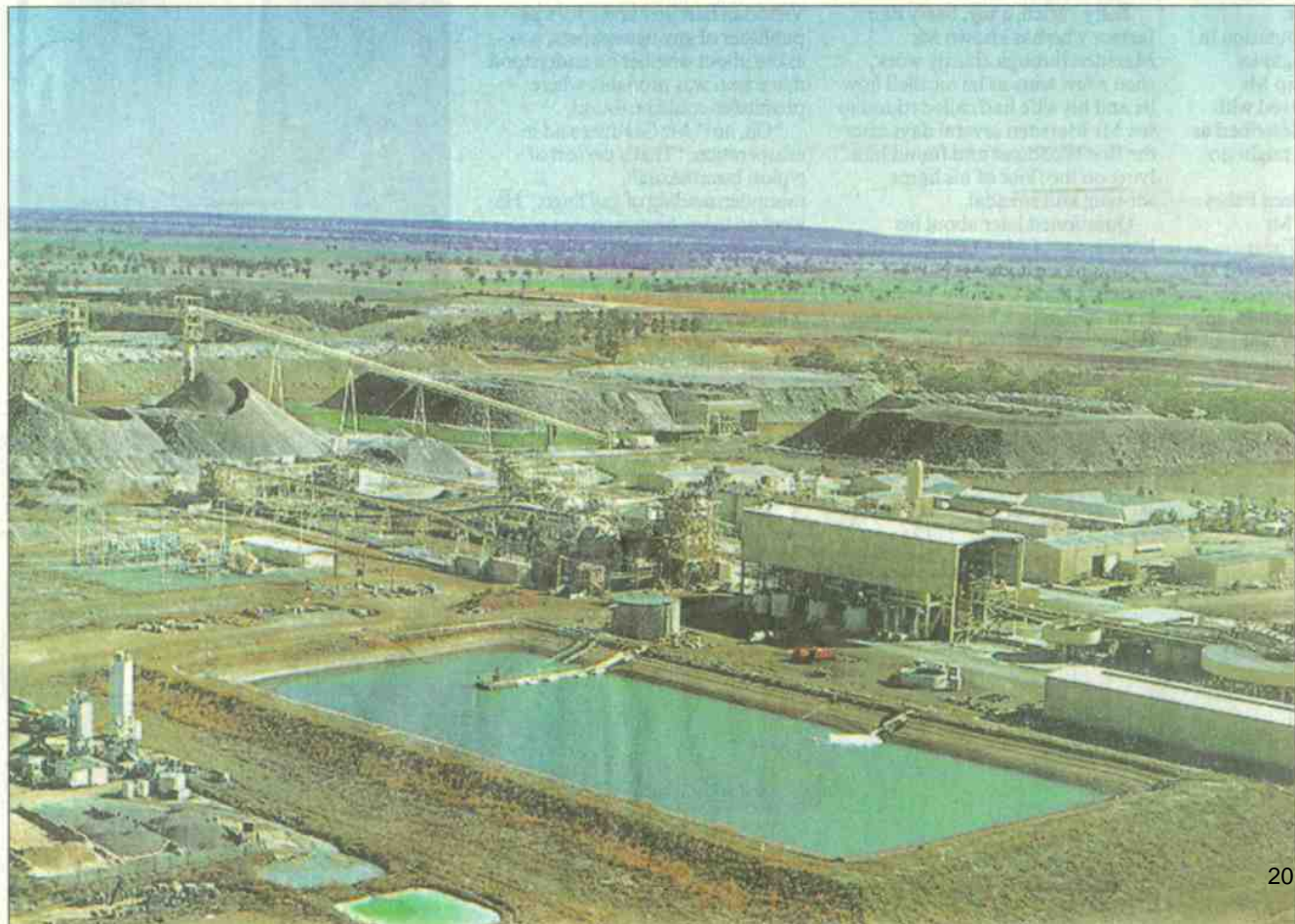
The State Minister for Mines, Mr Obeid, said last night it had been quickly established that there were no safety concerns for any other miners who were underground at the time.

About 30 remained in the mine for several hours after the accident, but it was understood last night that all of them had got out safely. Some were treated for minor injuries.

Counsellors were at the site giving help to survivors and families.

A mining engineer told the Herald last night that the "block caving" method being used in the mine was new in Australia, but was regarded as safe and was a lot cheaper than the traditional "drill and blast" method.

The method involved creating



Six feared dead

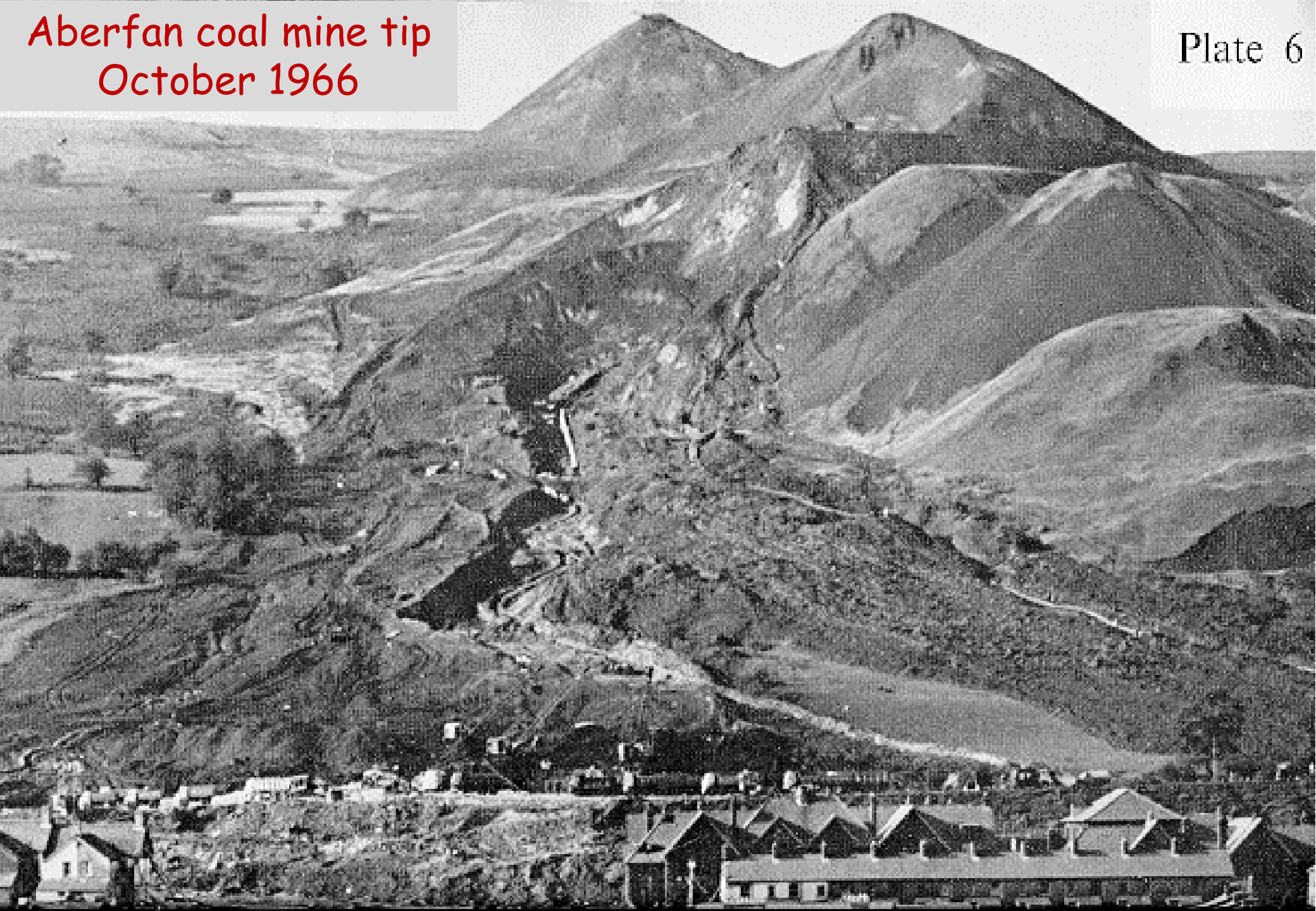
A pilot and five members of an Aboriginal land council are missing, feared dead, in a light plane crash near the Gulf of Carpentaria yesterday. Nothing

Gretley Colliery
November 1996



Aberfan coal mine tip
October 1966

Plate 6





Mt Polley tailings dam August 2014





Newcrest forecasts at risk after quake shakes Cadia mine

Cadia Mine
14 April 2017



A loader works underground at Cadia

The Australian | 12:48PM April 18, 2017



DANIEL PALMER
Business journalist @Danielbpalmer

Newcrest's full-year guidance is under pressure after an earthquake on Friday interrupted activity at one of the nation's largest gold mines.

The news has helped wiped 5 per cent from the group's (NCM) valuation.

The "large seismic event" in New South Wales hampered the gold miner's Cadia operation, near Orange, with work underway to assess the damage.

No injuries were sustained by employees as a result of the event, despite damage to the project.

"The safety of our people involved in the assessment of damage and remediation

Geomechanical risk events

□ Characteristics:

- ⌘ Low probability – unexpected
- ⌘ Some occur suddenly
- ⌘ Not in mine plan (obviously)
- ⌘ Failure of earthen materials (collapse or flow)
- ⌘ Or, misjudged ground conditions (latent)
- ⌘ Different mechanism than customary
 - Partly reason for unexpected

Geomechanical risk events

□ Potentially serious consequences

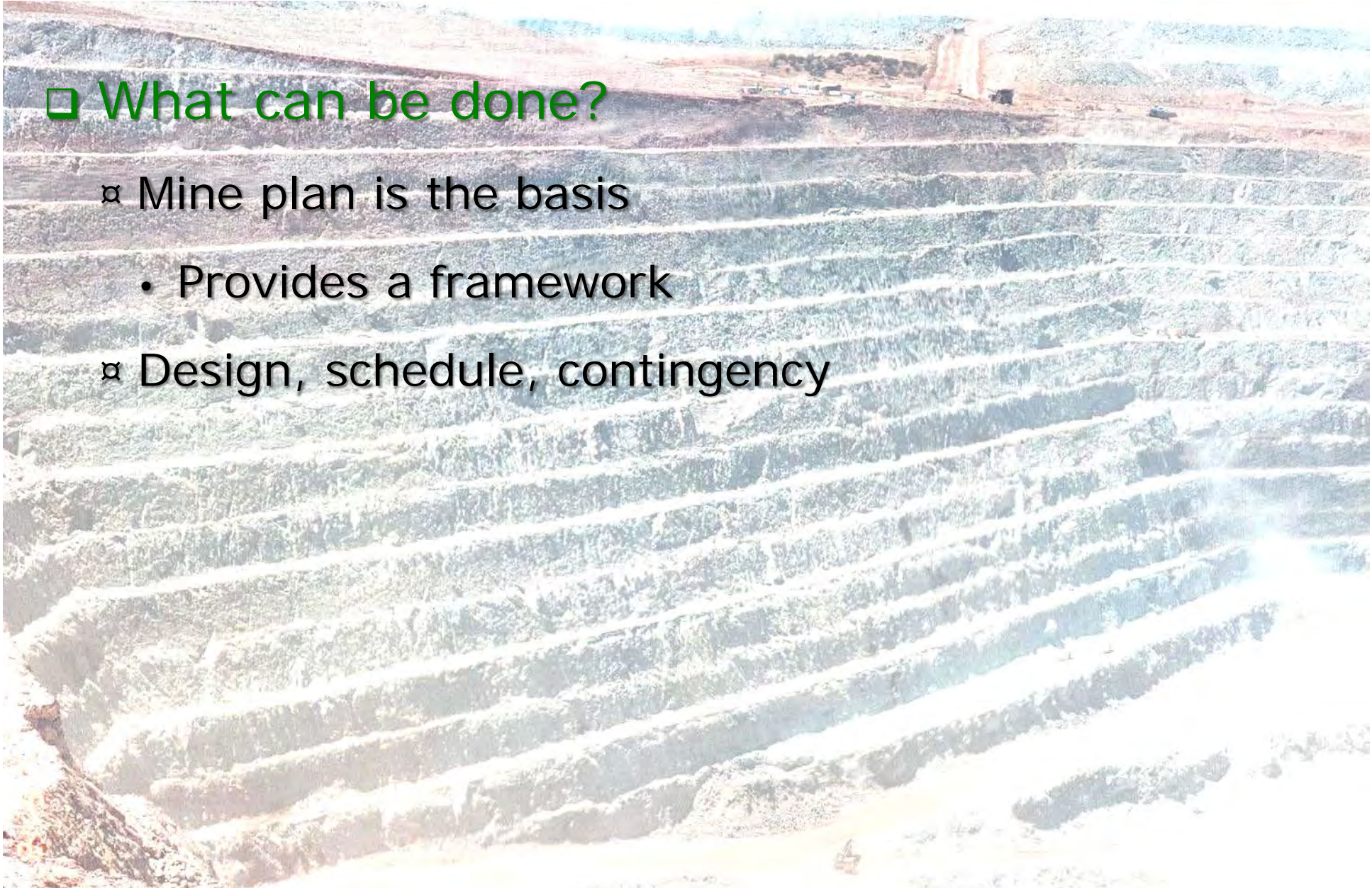
- ⌘ Many low-consequence – millions \$
- ⌘ High consequence – tens to hundreds millions \$
- ⌘ Single to multiple fatalities
- ⌘ Loss of ore reserves
- ⌘ Premature closure of a mine
- ⌘ Reputational damage

□ Most mines have no serious events – which?

Geomechanical risk events

□ What can be done?

- α Mine plan is the basis
 - Provides a framework
- α Design, schedule, contingency



The mine plan

□ Deals with expected outcomes

- ⌘ Strives for optimum – maximise profit
- ⌘ Not unexpected outcomes

□ But, also

- ⌘ Identify potential adverse outcomes
- ⌘ Provide monitoring, analyses, assessments
- ⌘ Requires geomechanics expertise (experience)
- ⌘ Needs to be evolutionary

The mine plan

□ Initially:

- ⌘ Geological & geomechanical investigations (linked)
- ⌘ Geomechanical analyses and assessments
 - Mechanistic model
 - Estimate expected forces & displacements
- ⌘ Programme to monitor

The mine plan

□ Then, operate:

- ⌘ Information on forces and displacements
 - From monitoring
- ⌘ Ongoing analyses and assessments
- ⌘ Identify
 - potential unexpected response
 - including conservatism

The mine plan

□ Operate: with monitoring:

- Measure distances
- Automated prisms
- Laser scans
- radar
- Photogrammetry
- InSar
- Tiltmeters
- Repeated surveys
- Repeated photographs
- Piezometers
- Rainfall
- Run-off water
- Measure stress
- Stressmeters
- Extensometers
- microseismics
- Local GPS
- Observations
- and more



⌘ All in parallel with geological mapping/modelling

The mine plan

□ If – Then - Else:

- ⌘ **If** there is an unexpected development
 - Alerted from monitoring, analyses, assessments
- ⌘ **Then**, revise plan
 - Avoid (engineer-out) or mitigate consequences
- ⌘ **Else**, continue with initial plan
 - Learning from monitoring, analyses, assessments

□ Through the life-of-mine

The mine plan

□ Essentials for success:

- ⌘ Must **understand** mechanics of rock, soil, support
- ⌘ **Experienced, expert** geomechanics specialists
- ⌘ **Ongoing**, progressive, iterative, programme
- ⌘ **Comprehensive** monitoring and analyses
 - Much more than is customary

Some personal observations ...

- Most mines regard themselves as safe
 - ⌘ Learned from experience
 - ⌘ Including those that have a failure-dispute
 - Misjudgements, over-confident

- Most failures-disputes are a surprise
 - ⌘ Not within experience of those involved
 - Don't know about some experiences

Some personal observations ...

□ Learn most from failures

- ⌘ More learned from failure than non-failure
- ⌘ Requires detailed (forensic) investigation
- ⌘ For me, enormous value professionally
 - Changed or reinforced my understanding
 - Customary understanding may be wrong
 - Scope for rigorous scientific process

Some personal observations ...

- People at many mine sites & companies lack geomechanics experience-expertise for risk
 - ⌘ Only 'big' companies may have it
 - ⌘ Small % of geomechanics people have it
 - ⌘ Risk for risk is wrong geomechanical model
 - ⌘ Difficult to overcome
 - people
 - attitudes

Some personal observations ...

□ Confidentiality is 'Achilles Heal' of risk

- ⌘ Only a few know details of events
 - They cannot even discuss – or even mention
 - May include crucial development of understanding
- ⌘ Some events not known by others
- ⌘ No-one knows it all
- ⌘ Good reasons, most instances
- ⌘ For me, very frustrating – as a professional
- ⌘ *Can it be overcome? Despair!*



Some per



Some personal observations ...

□ Some pointers:

- ⌘ Gretley inrush (breakthrough coal pillar)
- ⌘ Northparkes (collapse & airblast)
- ⌘ Mt Polley (tailings dam BC)

□ Each, government (state) promoted

Finally, ... what happened?

Glen Osmond
October 2016



Stay safe