It’s all about Water! Mine water and its critical role in mining and mine safety.

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Introduction

When you think about mines and mining operations, often the image of water is not the first that comes to mind. However, this often-forgotten aspect of mining and mine infrastructure design is critical to mine safety, efficient mine operations and production. Improper water management can lead to the collapse of open pit mines, inrush or flooding of underground workings, catastrophic failure of mine waste facilities and negative environmental impacts.

This paper provides a high-level introduction to the critical role of mine water management in mine planning and operations. It covers the basic engineering and environmental considerations of mine water in effective engineering and management of open pit slopes, underground mines, and associated large infrastructure like mine waste facilities.

Focusing on mine water management, this paper presents an introduction to some critical considerations in development and operation of mines and mine infrastructure:

- Pore pressures and basic engineering principles;
- Mine water and open pit slopes;
- Underground mining, with a spotlight on cave mining;
- Mine waste facilities and water related stability considerations; and
- Environmental considerations.

Further detail on each of these topics is provided in Sections 1.0 through 5.0:

1.0 Introduction to Pore Pressures and Basic Engineering Principles

The concepts of pore water pressure, effective stress, and shear strength underpin the reasons why mine water can affect ground control risk to mining operations. An awareness of these basic engineering principles are fundamental to understanding the engineering controls necessary to control the risks of improper water management on mining operations.

Pore water pressure is the pressure of groundwater held within the gaps (‘pores’) between soil and rock particles. Terzaghi’s principle states that an increase in pore water pressure decreases the effective stress supported by the rock mineral frame (Terzaghi, 1925). This leads to a decrease in the shear strength of the soil or rock which can have a detrimental effect on ground stability (Terzaghi, 1925).

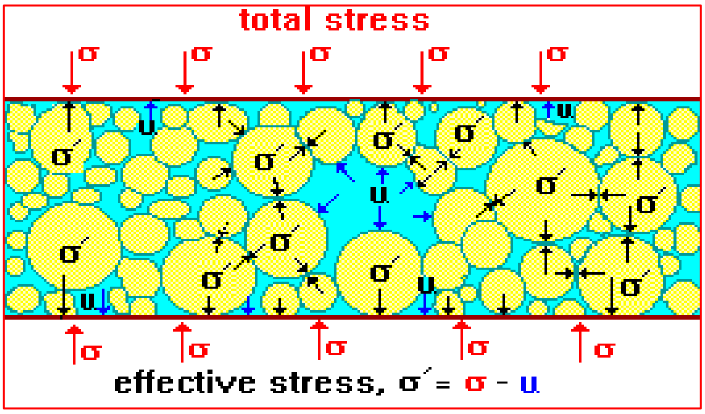

Figure 1: Relationship between Pore pressure and effective Stress (after Farahmand and Diederichs, 2021)

In summary, the higher the pore pressure the less stable the ground conditions. Also, poor water management can lead to wet mining conditions including challenges such as wet blasting, wet haulage, decreased trafficability and poor ground stability (Beale and Read, 2013).

Therefore, characterisation of the water management regime (including groundwater and surface water) is crucial to safe operational practice, water management and environmental stewardship.

Key messages:

- Wet ground and slopes are more likely to fail; and
- Poor mine water management can affect both ground stability and production.

2.0 Mine Water and Open Pit Slopes

Mine water management is key to the safe operation and management of open pits and their slopes. Groundwater control is essential to the safety of the open pit by preventing rock mass instability and ensuring trafficability and safe working conditions on the pit floor (Beale and Read, 2013). A water management programme is essential to avoid saturation of pit slope walls with surface or groundwater. Surface water can be managed with appropriate infrastructure including diversions and in pit conveyances. A dewatering system including passive or active groundwater control and appropriate monitoring will be essential when the depth of the mine descends below the groundwater table.

Developing an open pit below the water table will result in:

- Groundwater flowing into the pit; and
- A reduction in slope stability due to higher pore pressures in the pit slopes.

Therefore, the groundwater table needs to be lowered below the pit floor and away from the pit slopes. This can be achieved by several methods, including the following (after Cashman and Preene, 2012):

1. Production dewatering wells;
2. Drain holes;
3. Dewatering tunnels;
4. Water collection systems and sumps; and
5. Passive groundwater cut-off systems.

Dewatering by various methods, alongside monitoring to confirm effectiveness can be used to mitigate risk by lowering the groundwater table and reducing localised high pore pressures in the pit slopes. Should localised high pore pressures be encountered, horizontal drains and vertically placed drains can be used to alleviate locally high pore pressures on the pit slopes.

3.0 Considerations in Underground Mining with a Spotlight on Cave Mining

The importance of mine water in regard to underground mining will be presented in this paper, with a spotlight on cave mining.

Underground mining is most often progressed below the water table. Cave mining is a type of underground mining which involves undermining an ore body to allow it to progressively collapse under its own weight.

All underground mining requires water management to control pore pressures and allow workable conditions underground; however, due to the disruptive nature of the cave mining method, localised seepage or inflows may occur (i.e. inrushes and/or mudrushes).

Groundwater models with input from rock mechanics modelling is used to predict inflows and to design appropriate water management infrastructure to control ground conditions and mitigate the risk of uncontrolled inrush. Integration of the hydrogeological and geotechnical programmes and modelling is important inform water management infrastructure design to optimise project value and limit project risks (Yungwirth *et al.,* 2025).

Typical elements included in mine infrastructure design to mitigate ground control risks related to mine water include the following (after Yungwirth *et al.,* 2025):

Infrastructure Design Elements:

- Effective ground support systems.
- Targeted advanced dewatering of mining areas.
- Well-designed drainage and monitoring systems.
- Draining or diversion of connected surface water bodies (where possible).

Operations Procedures:

- Early warning systems through robust monitoring programs.
- Emergency response plans.

4.0 Mine Waste Facilities and Water Related Stability Concerns

Effective engineering and water management at a Mine Waste Facility presents one of the major risks to the safe performance of the facility during operation, closure and post-closure. The presence of water in the facility is often the greatest contributor to impact the risk profile of a mine waste facility and reducing the amount of water is a primary method to reduce the risk of catastrophic failure at a mine waste facility.

Typical risks to a mine waste facility from improper water management include:

- **Surface water overtopping** – leading to erosion of the dam and saturation of the tailings. A balance between outlet discharge/freeboard capacity vs probability of extreme storm weather events is required (Ind, Rynhoud and Brand, 2016).

- **Excess pore pressures within the tailings** – reduces shear strength, leading to liquefaction and slope failure. Exacerbated by poor drainage systems and excessive infiltration.

These conditions, if not managed, can lead to facility failures through some of the following mechanisms (this is not an exhaustive list):

- Overtopping Failure - e.g. Merriespruit dam failure, South Africa in 1974 (Tailings.info (n.d.) Merriespruit),
- Foundation Failure - e.g. Mount Polley TSF Failure, Canada in 2014 (Independent Expert Engineering Investigation and Review Panel (2015)), or
- Slope Stability Failures e.g. Brumadinho Dam Collapse, Brazil in 2019 (Correia, B., (2019)).

Risk of physical instability can be reduced by designing for good drainage of the mine waste and management to have little (if any) ponded water on the facility.

Mine Water Management Systems and Tailings Management Facilities are interconnected systems, and infrastructure must be designed to be site specific.

5.0 Environmental Considerations

Any dewatering or mine water discharge activity, and associated mine water management Systems) need to consider the potential environmental risks, such as:

- Reduction in groundwater or surface water availability – is that local borehole going to dry up?
- Reduction in groundwater or surface water quality – is that local river going to receive dirty water?
- Reduction in ecological quality – is it going to affect the local wildlife?
- Reduction in public health or loss of life – is it going to impact a drinking water supply?
- Permitting risk – are there any permitting risks associated with residual environmental risks that could stop the project or the ability to manage water?

Ways to mitigate environmental risks to allow safe operations for all stakeholders and the mine operation:

- Understand the water environment – develop a hydro(geo)logical Conceptual Site Model (CSM).
- Identify the potential problems – test and understand the water quality / geochemistry (Millán-Becerro, *et al.* (2023); GTK (2025)).
- Manage contact / non-contact water – use lined facilities and separate flows where appropriate.
- Dewater efficiently – less pumped out means less to manage.
- Reuse water where possible – is the quality suitable for use in processing or other uses (see Dama-Fakir *et al*. 2024)?
- Treat water before discharge if needed – and budget to do so.
- Embed mitigation in design – consider Mine Closure at design stage!

Closing

In summary, the previous sections have demonstrated the critical importance of considering mine water in design of mines and mine infrastructure. Effective mine water management is an essential component of safe, effective, and economical mining operations and it is critical that mine water is considered in all aspects of mine infrastructure through all stages of mine life from exploration to post-closure. Engineering design of mine infrastructure must consider integration with all connected water users, across relevant disciplines, and should be coupled with targeted monitoring and informed operating procedures to allow for safe and effective mine operations.

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