The true cost of groundwater

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Groundwater in mining

**Water supply:**

- Dry regions - groundwater may be critical to operation e.g. Atacama, Patagonia, Pilbara
- Evaporation losses minimized
- Water “banking”, sharing and trading likely to occur in future
Groundwater in mining

Mine inflows/ dewatering:

• Groundwater inflows dominant factor in some operations
• High inflows not restricted to wet climates – e.g. Nevada gold mines
• Highest inflow mines often associated with carbonates; coal, lignite mines also often high inflows
• What to do with excess water?
## Groundwater in mining

### 10 of the wettest metal mines:

<table>
<thead>
<tr>
<th>Project</th>
<th>Company</th>
<th>Commodity</th>
<th>Location</th>
<th>Geology</th>
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Groundwater in mining

**Slope stability:**
- Pit slope stability influenced by groundwater pore pressure

**Generalities:**
- High inflows = drained slopes
- Low inflows = undrained slopes
- Low rock strength – slope stability relatively sensitive to pore pressure
- But some notable exceptions!
Groundwater in mining

Environmental impacts/ closure:

• Groundwater contacting mine workings often creates AMD; on closure, leaking adits and poor-quality pit lakes – often requires water treatment over long-term – can migrate offsite
• Precipitation contacting mine waste often creates AMD which seeps to the water table
• Mine drawdown of water table can affect supply of neighbouring users and surface water bodies/ ecosystems
• Subsidence from water table drawdown
Groundwater in mining

Groundwater-dependent ecosystems:

- Characterized by biodiverse flora, fauna and cultural significance:
  - Springs, freshwater and brackish marshes and ephemeral rivercourses
  - Forested areas with shallow water tables and largely or partially phreatophytic vegetation
  - Subsurface ecosystems
Groundwater in mining

Mine safety:

• Groundwater plays a role in many mine fatalities, notably:
  ➢ Ground failures in open pit and underground mines
  ➢ Sudden water inrushes
  ➢ Mud rushes
  ➢ Tailings and waste rock pile collapse
  ➢ Sinkhole collapse
How groundwater affects economics

**Water supply:**

- Lack of available groundwater can sometimes result in large pipeline / water treatment costs (e.g. Escondida)
- Security of supply critical
How groundwater affects economics

**Dewatering:**

Major direct costs associated with wet pits:

- Delays to production
- Increased haulage and tire maintenance costs
- Increased blasting and explosives costs
- Ore drying – ore moisture
How groundwater affects economics

Dewatering:

Major indirect costs associated with wet pits:

- Loss of production as below water table (BWT) tonnes unavailable - extra haulage to access replacement ore and short-term loss of in-pit dumping sites

- Capital brought forward to open replacement pit or pit expansion as BWT pit is unavailable
How groundwater affects economics

**Dewatering/ slope stability:**

- Strip ratio increased by flatter slopes due to high pore pressure
- Ore lost when depth is limited by slope stability
- Price penalties occur as desired ore becomes unavailable and must be substituted by inferior product
- Costs associated with loss of optionality
How groundwater affects economics

Excess water management – dry areas

• Most excess water discharged to surface, resulting in unsustainable artificial ecosystems; discharges of some mines contributing to inflows at others

• Surface discharge often not favored

• Now:
  • Irrigation – increasingly utilized (e.g. Pilbara (alfalfa), Peru woodlot)
  • Evaporation ponds
  • Piping of water from mines in excess to ones in deficit
  • Reinjection; often best option for brackish to saline water; injection bores and recharge basins used
MAR Schematic – Fortescue Valley

In-pit bores
Ex-pit bores

Upconing of brackish to hypersaline water
Groundwater mounding

Freshwater injection bores
Saline/hypersaline injection bores
Mixing zone – brackish to saline

Saline
Hypersaline

Tertiary alluvium
Calcrete
Channel Iron Deposit
Banded Iron Formation
Ore
Dolomite
How groundwater affects economics

Mine closure:

- Leaking mine adits, leaching from waste rock, tailings and leach piles can result in long-term water treatment legacy delay in handover
How groundwater affects economics

Common dilemmas:

• Groundwater regime often inadequately characterized as project advances to mine; costing often not feasibility-level at feasibility stage

• Principle reason is complexity of groundwater systems, low budgets to characterize and inadequate use of other sources of data

• Result: detailed designs for dewatering systems, pit slopes and water management systems often based on poor understanding of groundwater occurrence and inflows

• Too often results in surprises
Managing groundwater

Collect good data, early:
A lot of good quality hydrogeological data may be collected at very low cost at drilling exploration stage, including:

Geophysics
- Consider hydrogeological application when running surface and downhole geophysics
Managing groundwater

Collect good data, early (cont’d):

Drilling

• Diamond drill and mud rotary circulation losses
• Elevated hydraulic pressures encountered
• Air rotary airlift yields
• Document below water table voids closely
Managing groundwater

Utilize exploration, geotechnical, metallurgical holes:

- Packer-based hydraulic testing
- Open hole piezometric monitoring
- Piezometer installations (standpipe and VWP)
- Good quality installations
- Holes in pit slopes where pore pressure may be an issue may act as passive drains, particularly if outfitted with slotted PVC casing after drilling; also permits access for monitoring or installation
Managing groundwater

- Use mineral exploration drilling to define deposit hydrogeology, other drilling to define hydrogeology external to pit.
Managing groundwater

Mine dewatering – maintaining production:

• Large scale of mine pits and “ore is aquifer” hydrogeology - dominantly in-pit dewatering. To minimize interference:
  ➢ Maximize production capacity of in-pit bores;
  ➢ Improve survivability of in-pit bores through robust design, blasting ballast and controlled blasting around bores;
  ➢ Ensuring dewatering infrastructure is ready in advance and with adequate capacity;
  ➢ Minimize downtime through blast cycles through rapid removal and re-establishment of pumps;
  ➢ Taking advantage of ex-pit or bench dewatering when opportunities arise.
Thank you

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