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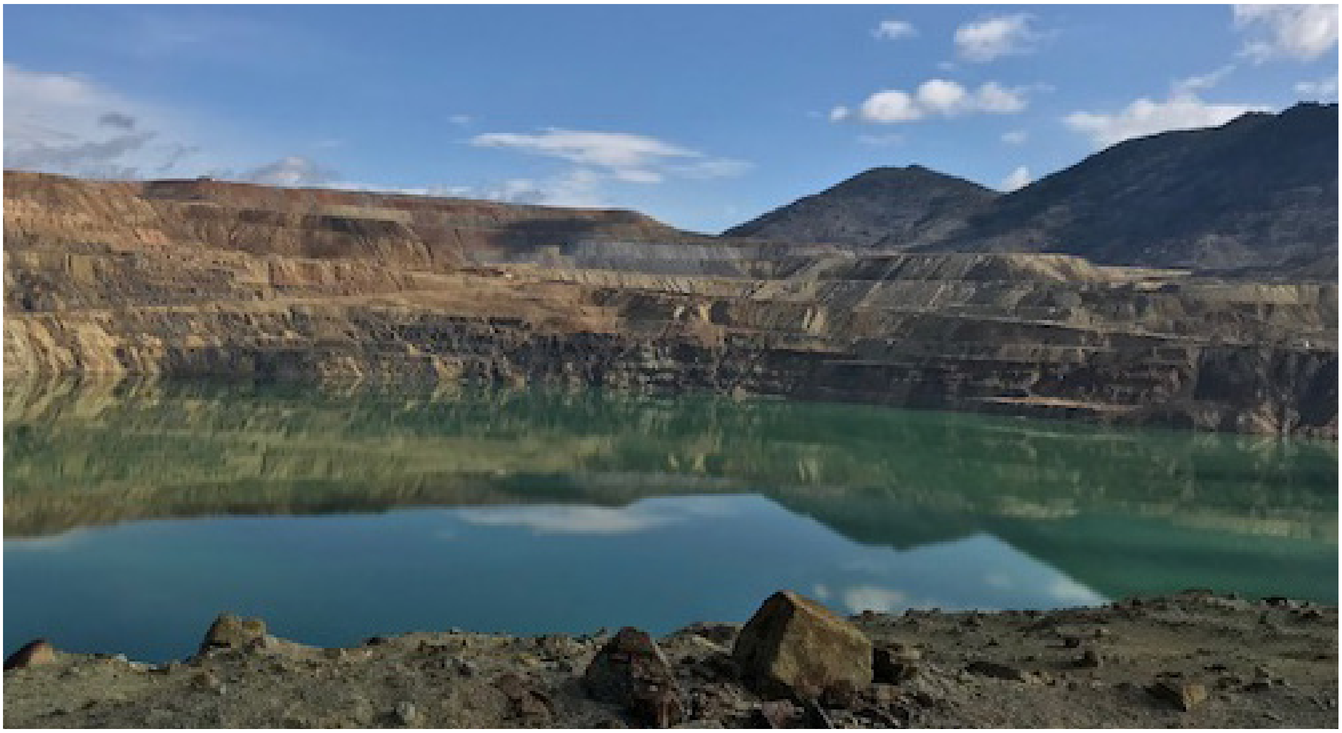
Large openpit mine closure considerations: Dry pit or lake?

by Anne Parry and Jim Stefanoff



The Berkeley Pit in Butte, MT is a former openpit copper mine that's filled with heavily acidic water.

Planning for closure of a large openpit mine presents numerous challenges and requires complicated decision-making, especially when the minerology can generate acid rock drainage, as is common with porphyry deposits all over the world. Benefits of a pit lake could include the potential to reduce acid production, defer water pumping and treatment costs, increase pit wall stability, and provide a convenient location to store site water. Careful study is recommended to determine if these benefits are real, or just a myth. Should a pit lake be allowed to form and to what depth? What is the expected water quality compared to goals, and how can the chemistry be controlled, if necessary? If a dry pit is maintained, how is that done, and how is the extracted water managed? These and other considerations are described, along with options and examples for each.

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Introduction

Mine dewatering is needed in openpit and underground mines to access ore bodies and to maximize geotechnical stability during operations. Once an openpit mine closes, dewatering could cease resulting in a pit lake with the following potential benefits:

- Eliminates the need to treat pit related water immediately following closure.
- Reduces acid production by minimizing oxidation of metal sulfides on pit walls (less oxygen would be available under the surface of the pit lake).
- Avoids or lowers pumping costs and other dewatering expenses.
- Stabilizes pit walls by applying a force against the wall before pit wall pore pressures increase.
- Provides water for migratory birds and other wildlife.
- Provides recreational opportunities for nearby residents and travelers.

Discussion

These potential benefits may not be realized due to poorer-than-expected water quality, or pit wall stability issues. Saturation of the toe of potentially unstable slopes as the pit lake rises could result in geotechnical failures. If poor water quality develops in the pit lake, an untreated or poorly treated pit lake could result in bird kills and other risks. A well-known example of this is the Berkeley Pit in Butte, MT, due to its poor water quality and location.

If a pit lake forms, what is the optimal depth? Hydrogeological studies and model work can establish the predicted terminal pit lake elevation where evaporation equals inflow, provided the pit walls do not transmit water through fractures or mine workings.Older mines are especially at risk for unmapped workings. Similar studies can also predict pit lake elevation for flow-through lakes in communication with the local-area aquifer. An interesting example of this is the Island Copper Mine on Vancouver, Island, British Columbia, CA, that was flooded with sea water and capped with a layer of fresh water.

Geotechnical stability models can assess the overall stability of wet pits, but do not predict the timing of potential failures. If geotechnical model work is done, predicted failure masses may be used to simulate the generation of waves in a pit lake following a pit wall failure. This can be simulated at several pit lake elevations to evaluate the risk to people and infrastructure if a pit wall failure occurred.

Limnologic modeling, coupled with geochemical modeling, can be used to predict if a given lake elevation is expected to be meromictic or susceptible to seasonal turnover. This is important for assessing the potential exposure risk.

Pit lake elevations should also consider the expected geochemistry based on highwall exposure and expected volumes of runoff, as well as the seasonality of runoff. Higher water level depths result in lower pumping costs if dewatering is needed (lowers the head from the pit lake surface to the pit crest), and pit lakes with larger surface areas result in less water due to evaporative losses.

Monitoring of pit lake water quality will likely be required for some period to fulfill environmental regulatory obligations. If water quality in the pit lake degrades, in situ pit lake treatment and pit dewatering for external treatment can be difficult due to:

- A rising pit lake and corresponding changes in surface area can complicate chemical dispersion needs and water treatment goals.
- Continued sulfate and metals loading to the pit lake through pit wall runoff may be more subtantial than predicted.
- Pit lake turnover can rapidly change surface water chemistry, complicating treatment.
- Scaling can be a major issue. The specific gravity of gypsum is over two times that of water, causing water collection and treatment infrastructure to sink if covered with scale in high sulfate pit lakes treated with lime.
- Access for placement of infrastructure is problematic if geotechnical stability is in question.
- Placement of water treatment and dewatering infrastructure at the terminal lake elevation may require the addition of a bench, with high capital costs from haulage and backfill placement.
- Accumulation of precipitates in the pit bottom can complicate limnology and dewatering.

Flooding of Island Copper Pit from Rupert Inlet.

- Ineffective treatment may threaten nearby aquifers and surface water.
- Water may travel through unmapped workings or fractures to create risks of catastrophic release or other undesirable impacts.
- Low pH, high-metals content in water may threaten birds and other wildlife.

Options for in situ-pit lake treatment include:

- Use of barges for dewatering and recirculation of pit lake water with chemical addition.
- Gravity application of lime/water mixtures using perforated down drains (or spigots) as the pit lake rises.
- Floating nozzles dispersing lime/water mixtures.

Because of the potential problems associated with creation of a pit lake, dry pit options should be seriously considered due to:

- Relative simplicity of dewatering.
- Dry pits are well understood systems and are typically maintained during ongoing mining.
- Does not sterilize the resource if additional mining becomes economically viable in the future.
- May result in lower water treatment costs due to better water quality from dewatering and no need to treat an in-situ pit lake with inefficient treatment methods. Collection of water from lower in the pit can reduce contact time with pit walls, especially if a lake water surface were to fluctuate, resulting in better water quality.
- May result in the most geotechnically stable pit closure option.
- Reduces risks to migratory birds and other wildlife (limits exposure to mine impacted water).
- Dry pit flows can be treated in a conventional water treatment plant, resulting in more efficient use of chemicals, and increased options for beneficial reuse of the water.

Conclusions

The best approach includes systematic study and decision-making processes to avoid potentially catastrophic results. The following criteria are suggested in options evaluations:

- Scientific studies to assess pit lake geochemistry and limnology.
- Water balance and pit hydrogeology work and geotechnical evaluations of pit wall stability under dry and wet pit conditions.
- Preliminary engineering of viable options and cost estimates.
- Risk analyses and potential mitigation measures.
- Environmental and regulatory obligations register.
- Documentation of stakeholder expectations.

A formal decision analysis process is strongly recommended to provide documented decision criteria, input from multiple stakeholders, and strong recommendations with supporting information for pit closure.

Closure timeframes necessitate adaptive management strategies. Dry-pit options provide the most flexibility in responding to changing conditions over time, although wet pit options can result in several very compelling benefits as well. ■