Pebble and Perpetuity

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Ground Truth Trekking

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The life of a mine doesn't end when the metal is gone. The primary environmental risk posed by a mine comes from water flowing through waste rock and tailings, which can become highly acidic (/Issues/MetalsMining/AcidMineDrainage.html) and laced with toxic heavy metals. Waste rock and tailings remain behind long after the mine is closed, effectively retaining its ability to contaminate water forever (/Issues/OtherIssues/perpetual-waste-storage-perpetuity.html).

Current regulations and plans require mines to prevent contamination by containing wastes. Mine operators must put in place structures (such as dams) and systems (such as water collection systems and treatment plants) to operate "in perpetuity." For example, the closure plan at Alaska's Red Dog Mine (/Issues/MetalsMining/RedDogMine.html) calls for 7-15 perpetual workers, treating over a billion gallons of water annually using 7,300 tons of shipped-in lime, and producing over 70,000 tons of sludge, at a cost of over $10 million every year, forever.

Pebble's wastes and abandoned earthworks would need to be maintained and managed perpetually (/Issues/OtherIssues/perpetual-waste-storage-perpetuity.html), far longer than the 11,500+ (http://www.nps.gov/akso/akarc/early.cfm) years native Alaskans have inhabited the region. To accomplish this, a mining company is required to put up a reclamation bond which can theoretically generate enough interest to pay for maintenance forever. In reality, most of these bonds have already proven to be inadequate (http://www.csp2.org/REPORTS/Hardrock%20Bonding%20Report%20Executive%20Summary.pdf) over much shorter time frames. Key earthworks that would require maintenance to prevent serious environmental damage to the area would include large tailings impoundments (/Issues/MetalsMining/pebble-mine-tailings-storage-management.html), waste rock piles, the open pit, and underground mine workings. The containment capabilities of large tailings facilities, collection systems and treatment plants have not been tested over even hundreds of years, much less thousands. Over the infinite lifespan of these wastes, the eventual failure of containment and the resulting contamination of surrounding waters are inevitable.

Due to its vast size, Pebble Mine would generate an enormous quantity of sulfide tailings and potentially contaminated water, which could have a proportionally enormous impact if containment were to fail. Failure would result in the pollution of local waters and floodplains, and possibly the destruction of most plants and animals in downstream rivers leading into Bristol Bay.

The Tailings Impoundments

The Problem: Pebble's tailings impoundments (/Issues/MetalsMining/pebble-mine-tailings-storage-management.html) would contain billions of tons of processing waste (or tailings (/Issues/MetalsMining/MineTailings.html)), which are the finely ground rock left behind after metal-bearing ore is extracted. These tailings would pollute downstream waters if released. Hundreds of millions of tons of this material would be strongly acid-generating (/Issues/MetalsMining/AcidMineDrainage.html) pyritic (http://en.wikipedia.org/wiki/Pyrite) tailings. In theory, the tailings would be protected from reacting with air by being buried beneath an artificial "tailings lake" containing tens of millions of tons of water. This water would be contaminated with acid and heavy metals, and neither the tailings nor the water would ever become safe for release.

Management: Upon closure of Pebble Mine, the mine developer intends to turn the upper surface of the tailings impoundment into a wetland. Once the wetland is established, the earthen dams surrounding the facility will need to be maintained forever, to prevent gullies from eroding through them, which would lead to the escape of the buried tailings. Surface water will need to be kept separate from the entombed tailings, and will exit through one or more spillways, as running water moving through tailings could generate acid and leach metals (/Issues/MetalsMining/AcidMineDrainage.html). Water leakage from the underlying tailings will need to be captured below the dams, and either treated or returned to containment.

Considering that the dams will be miles in length and must remain intact indefinitely, some leakage is assured. The facility will need to be capable of capturing and pumping water permanently. Earthmoving capability would also be necessary on-site or nearby, to prevent the erosion and breach of the dams.

If water does at any point incise through the dam rims and expose the buried tailings, the tailings will begin to erode quickly. This will be a concern during mine operation as well as once the mine is decommissioned. Once the mine is decommissioned, a spillway will need to be installed as an outlet for overflow water. With the construction of a spillway, a fully staffed response force will not need to be on-site, resulting in slower response times to potential breaches. The spillway and the tailings facility will need to be monitored in perpetuity (/Issues/OtherIssues/perpetual-waste-storage-perpetuity.html), to be certain they are working properly. For instance, if the spillway became choked with earth or debris, a gully could form elsewhere, cutting into the tailings.

The Open Pit

The Problem: After mine closure, Pebble 's pit would slowly fill with water, predominantly from local underground flow and rainfall. Similar to the Berkeley Pit (http://www.pitwatch.org/) in Butte, Montana, water and oxygen would react with the exposed sulfide rock of the Pit's walls, and generate sulfuric acid (/Issues/MetalsMining/AcidMineDrainage.html). The resulting acid would then leach heavy metals from the rock walls and ore debris, potentially filling the pit with acidic chemical brine.

Much like the Berkeley Pit and other pit mines around the world, the Pebble Pit would draw surrounding groundwater in until it filled to the level of the local water table. At that point, its contaminated water would begin flowing into groundwater.

Management: One solution would be to perpetually pump water out of the pit to keep the water level of the tailings lake below the local water table, treat the water, and release it. This solution is being used at the Berkeley Pit. Another approach, which would be highly unlikely to contain water contamination, would be to simply let the pit fill with water, and allow the resulting leakage.

During the initial years after closure, while the mine filled with water, theoretically no staffing or equipment would be required. After this “grace period”, the open pit would require a perpetual water pumping and treatment facility, including pumps, fuel, and a water treatment plant.

The Underground Mine

The Problem: Pebble ’s deeper deposit would likely be mined from below using block caving (/Issues/MetalsMining/block-caving-underground-mining-method.html). Block caving leaves large, frequently unstable sinkholes (http://en.wikipedia.org/wiki/Subsidence) on the surface, and a deep underground zone of disrupted rock, through which water readily flows. Groundwater saturation of this zone would lead to a similar situation as the pit, but would perhaps be more difficult to control or monitor. The underground mineworks would quickly flood, and a lake or pond would likely fill the sinkhole at the surface. In other mines, surface sinkholes associated with block caving are often contaminated by acid mine drainage. Horizontal water movement would create the same local water contamination problem as described with the pit.

Underground mining would likely occur after pit mining. Due to the geometry of the Pebble deposit, an underground block caving mine would be closely adjacent to the pit, and water could flow easily between them. For this reason, the pit would need to be kept dry and empty of backfill until underground mining was completed. This sequence of mining events would affect what type of material could be backfilled into the pit, which would in turn affect perpetual management issues. For instance, if acid-generating waste rock was placed in the pit, it would be easier to manage than if it remained in piles.

In at least one instance, block caving has destabilized (http://www.csp2.org/files/reports/Questa-Molycorp%20Subsidence%20Impacts%20-%20Blodgett%20Feb%202002.pdf) associated pit mines. In the long term, this could accelerate water leakage and management problems from Pebble's pit. In the short term, it could exempt the developer from reclaiming the pit, due to the pit becoming a toxic hazard.

Management: Water would likely need to be removed from the underground mineworks and treated, perpetually. As with the pit mine, the vast size of the project and quantity of water in the environment might make this treatment functionally unachievable.

Can Pebble's Waste Be Perpetually Managed?

No: It is not physically possible to keep Pebble's wastes completely contained forever. In either the near or distant future, it is a geological certainty that the containment facilities will be breached. However, the geological impossibility of perpetual waste storage statistically comes into play only for very long time periods, thousands of years or more.

Over a time frame of tens or hundreds of years, the feasibility of perpetual waste storage is less clear. It has at least three facets: technical, financial, and social. The breakdown of any of these three necessary components could lead to a containment failure.

Technical Feasibility

Mineworks the scale of Pebble's are a very recent human invention. Tailings facilities of any sort have only been used for the last 100 years. The scale of pit mines, underground mines, and tailings impoundments has ballooned in recent decades. There is no case history to suggest we are successfully engineering facilities to last for hundreds of years, much less thousands, or that we will be able to technically maintain them and protect them from all reasonable threats.

Of particular concern are conventional tailings impoundments and waste rock piles. They may be temporarily stabilized as wetland-like areas, but this does not constitute permanent reclamation. Over the long-term, water erosion concentrates on the edges of such elevated plateaus, eventually cutting deep channels through them. If and when the tailings themselves are exposed to water erosion, they will be quickly mobilized and flushed downstream, beginning a self-reinforcing process likely to lead to a tailings badland (http://en.wikipedia.org/wiki/Badlands) formation. Alternative management strategies (/Issues/MetalsMining/pebble-mine-alternative-tailings-storage-management-options.html) might delay, lessen, or prevent a tailings breach or waste rock dump failure.

Although engineering solutions have been proposed for the long-term stability of tailings impoundments, recently built tailings dams are failing at a rate equal to older dams. Statistically (http://www.csp2.org/files/reports/Long%20Term%20Risks%20of%20Tailings%20Dam%20Failure%20-%20Chambers%20%26%20Higman%20Oct11-2.pdf), such assertions appear to be an overconfidence bias.

Financial Feasibility

The State of Alaska would likely require the mine operator to post large reclamation and post-closure maintenance bonds, which would theoretically fund these activities even if the mine operator went bankrupt. These bonds are commonly used financial instruments intended to preserve funds for the perpetual management of mine sites, and theoretically, they would cover all future costs. Unfortunately, analysis (http://www.csp2.org/files/reports/Hardrock%20Bonding%20Report%20Executive%20Summary.pdf) has shown these bonds to be consistently too small. For example, the reclamation bond posted at Illinois Creek (/Issues/MetalsMining/IllinoisCreekMine.html), Alaska's only large mine bankruptcy to date, was inadequate to close the mine.

Closure bonds do not take into account the uncertainty of the future and are vulnerable to future economic disruptions, which can erode or completely erase their value. Although the State could presumably sue the mine operator for additional funds once these bonds are exhausted, the liable operating firm has frequently dissolved.

If Anglo-American, the large mining firm which is co-owner of Pebble, operated the mine and continued to exist after the mine closed and the bonds were exhausted, it would still not necessarily be held liable for costs. The complexities of limited liability, ownership law, and the potential legal challenges of securing funds could stymie such efforts. For instance, in Alaska, Rio Tinto sold the Green Creek Mine (/Issues/

MetalsMining/GreensCreekMine.html) to Hecla Mining Company, a much smaller firm with far fewer resources. Hecla, not Rio Tinto, is now liable.

Post-closure financial support from mine developers will likely only last for a short period of time. Historically, as mining firms go out of business, or go into bankruptcy and transfer their assets to new firms, abandoned mines are inherited by the public sector. The current average lifespan of an S&P 500 company is 15 years (http://www.bbc.co.uk/news/business-16611040). Anglo-American is currently a strong global mining firm, founded in 1917 and international since 1960, but history tells us that it can be expected (http://www.bbc.co.uk/news/business-16611040) to eventually go out of business or transform into another company. This would happen if it came under sufficient stress, for instance if post-closure costs for Pebble became too high, and it were held liable.

In this context, the abandoned Pebble Mine will eventually become a ward of the state, or simply an unmanaged site. There is no guarantee that future government will have the financial or technical means to maintain the facilities, and there is cause to question whether that expectation is even reasonable.

Social Feasibility

Human history has been characterized by periods of upheaval, social disruption, and dramatic economic cycles. Particularly during periods of hardship or strife, costly activities that neither aid in immediate survival, nor are recognized as socially or economically critical, are seldom continued. Even critical tasks are often neglected, for lack of means. Based upon this history, the long-term successful management of Pebble's wastes seems highly unlikely. The descendants of Alaska's current population will at some point be called upon to deal with escaped mine wastes. In the long term it is the 'public' that assumes the responsibility for closed mines, either by providing funds to continue water treatment and/or monitoring and maintenance, or by bearing the environmental and social costs abandoning these closure commitments.