M I N I N G I M P A C T S O N T H E E N V I R O N M E N T`

Mining is the first step in the commercial exploitation of a mineral or an energy resource.
Mining has been defined as the extraction of material from the ground in order to recover one or more component parts of the mined mineral (Lottermoser, B, 2007).
At a mine site, mining is nearly always accompanied by some form of mineral processing or metallurgical extraction system. Both of these associated procedures produce waste and have the potential to cause serious effects on the surrounding environment. But waste alone from both these practises and mining itself isn't the only issue that may lead to harmful consequences for an ecosystem. Before, during and after mining operations there are many factors that play a contributing role in impacting the environment. Air, soil and water can all be affected and harmed in numerous ways, whether it be caused from the direct physical requirements needed to establish a new mine or become contaminated due to prolonged exposures to waste and pollution.

One of the most pressing factors on the environment that is a direct result from mining is the creation of Acid Mine Drainage (AMD), which is derived from the oxidation of sulphide minerals. It contaminates both surface and ground water, impacts aquatic life and leads to sediment contamination. There are, however, certain environmental strategies used to counteract the impacts. In fact, there are many forms of strategies, processes and treatment technologies utilised to reduce/ remove and remediate the unfortunate environmental effects that are connected with all forms of mining.

The art of mining itself comes in many different forms, and incorporates many different styles and techniques in obtaining precious resources from the ground. This, as a result, creates a large number of possible threats that have the ability to bring an imbalance to an ecosystem.
The two main classifications of a mine site are 'underground' and 'open pit' which employ different methods like dredging, drilling and water application to remove minerals from the ground.

In the setup of a new mine various changes will occur to the landscape. Large areas of vegetation will be cleared, infrastructure created, remanence of early exploration and the creation of large voids. During full production of mining there is the large amounts of waste produced and the facilities created to deal with it, as well as the excessive volumes of water used which requires both storage and treatment facilities.

From beginning to end of a mine site's life there are the immediate disturbance and long term destruction of natural habitat, sites and cultural significants (Lottermoser, B, 2007). Emission of heat, noise and the release of contaminate, gas, solid or liquid, all contribute to the degradation of a surrounding environment. It should also be noted that the level of magnitude by which an ecosystem can be impacted upon from mining processes is dependent on natural factors such as the geology of the resource being mined, climate condition and topography (Lottermoser, B, 2007). The physical practises involved with mining often result in immediate impacts but the more serious and long term environmental issues that surround the industry are often a result of the negative chemistry associated with mining which are aided by natural occurring environmental events. Many of the impacts from mining are caused from a direct

release of harmful elements and compounds. They enter the environment by aerial transport, interaction with flowing liquids (usually water) and direct injection through spills and accidents.
The main forms of air pollution are dust created by strong winds disturbing mine waste which contains small particles, eg coal dust. Also, the release of sulphur into the atmosphere is another issue created from the roasting of sulphide ores (SOx), which can later lead to acid rain.

Many environmental impacts occur from mine waters, which is water that has undergone compositional modifications due to mineral-water reactions at mine sites (Hore-Lacey, I, 1978).
At modern mine sites, mine water is collected in settling ponds and tailing dams to prevent entering the environment. However, uncontrolled discharge of mine waters carrying dissolved minerals and particulate matter does inevitably occur and once in contact with receiving water bodies, lakes, rivers or streams the waters can cause undesirable results. The worst form of poor mine water is Acid mine drainage (AMD) but this will be explained in detail later.

Three varieties of mining that demonstrate the previous effect are the mining of Gold, Copper and Uranium. All three processes work by leaching, a method that removes a substance from a solid by a liquid extraction media **(**The Chemical Engineers' Resource, 2008).

Gold is leached with the use of cyanide; cyanide refers to a group of compounds where carbon and nitrogen are combined. The associated problems with cyanide are that in high concentration it can be potentially lethal. If the toxic substance is released and sufficient amounts are taken up by aquatic life and animals, cyanide poisoning is highly probable. Interestingly, cyanide itself does not present many threats to plant life. Another issue associated with the mining of gold is dealing with the presence of Pyrite (FeS2), as Pyrite is the most abundant of the sulphide minerals. When gold and pyrite are both present in the same ore the efficiency of removing gold via leaching is heavily minimised. Two methods used to remove FeS2 are by roasting of the ores and pressure oxidation. Roasting removes both Fe and S in the form of oxides. Oxidation is carried out at 200oC and high pressure and Fe is also removed in the form of an oxide but it also produces sulphuric acid (H2SO4) (Hughes, J, 2010, gold mining).
Uranium and copper are both leached using sulphuric acid (H2SO4) as well as hydrochloric acid (HCl) for copper sometimes. As would be expected, the radioactive element Uranium produces radioactive waste. The potential environmental problems with uranium mining are excessive radioactivity level due to incorrect covering of tailings or exposure to erosion, failure of tailing damns leads to soil and sediment contamination and the inappropriate use of tailings or waste rock.

Historically, uranium waste has been incorporated into landscaping, gravel and cement which are used for a variety of purposes; as a consequence elevated levels of radioactivity are dispersed across large areas (Hughes, J 2010, Copper and Uranium mining).
Copper, as just mentioned, uses both H2SO4 and HCl for the leaching process. It has many similar environmental impacts to that of gold as most copper is found within sulphide ores. So roasting once again is a common method to remove S, however, the toxic substances arsenic (As) will also be released.

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Copper mining and processing produces roughly 85% recovery which leads to a relatively high concentration of Cu residual left in tailings which also contains traces of molybdenum that, in high concentration, can pose threat to animals (Hughes, J 2010, Copper and Uranium mining).

To counter act the damage done by the previous three types of mining there are effective conventional measures used to remediate mine site.
With gold, the main issue is the uses of cyanide. A high recovery exists with cyanide compared to many other leaching substances used so little amounts are released with waste but do still pose a threat. Cyanide will degrade natural overtime but certain methods can be utilised to help speed up the process and reduce the potential toxicity of the substance. Increased exposure to UV radiation can help. This simply involves making the tailing dams and ponds have a larger surface area allowing more substance to be treated. A better engineering approach is using chemical oxidation, adding chlorine gas or sodium hypochlorite as strong oxidants destroys cyanide and makes it harmless.

For uranium, treatment of radioactive waste water is the biggest issue; this is balanced by neutralisation, wetlands and radium removal. Neutralisation refers to the AMD generated; AMD is explained in greater detail later. Wetlands are used for they have an abundance of clay, organic matter and micro-organisms all which are very effective at dealing with contaminates. The Uranium is absorbed onto the organic-rich wetland sediment immobilising the ions and reducing there environmental impact (Lottermoser, B, 2007).

Final radium removal includes adding barium chloride to waste water where the radium coprecipitates with barium sulphate which is later collected via settling and filtration.
The major issue associated with mining of copper is the formation of AMD (Lottermoser, B, 2007).

As previously mentioned, Acid mine drainage is the poorest form of mine water and it originates from the oxidation of sulphide minerals. Sulphide oxidation is an autocatalytic reaction and therefore, once AMD generation has begun the process can be very hard to halt. In some extreme cases, AMD has the potential to continue on for thousands of years.

Mining of metal ore such as Cu, Au, Zn & Ni, phosphate ores, coal and mineral sands all give the chance to expose sulphide minerals to oxidation and AMD water formation. Tailing storage facilities, waste rock heaps, underground and open pit mines all have the potential to be the starting location of AMD generation. It can form through numerous processes such as: groundwater entering undergrounds workings that exits via the surface opening, runoff from rainfalls that comes into contact with mining, mineral or extraction processing and uncontrolled discharge of spent process waters from tailing dams, ponds and heap leach piles.

The impacts that AMD has on the environment can best be analysed by separating in to four components; surface/ ground water contamination, impact on aquatic life and sediment contamination due to the high concentrations of salts and heavy metals in AMD waters. Exposure to surface water such as streams and rivers can have adverse effects on downstream water bodies which impacts on fishing, irrigation and stock watering.

Simile if portable water supplies are affected drinking water will be lost if quality standards put in place by authorities are not met. Also, bad quality water will limit the ability of process water to be reused in mine sites (Lottermoser, B, 2007).

AMD impacts are much more common in ground waters. Contamination usually originates from water migrating from mine workings and through waste repositories into aquifers (an underground layer of water-bearing materials: gravel, sand, silt, or clay). Sulphates, metal and other contaminates can all migrate through mine workings and enter ground water plumes. If the process is not set right, over time water will travel underground, spreading much further than the mine site, surfacing at seepage points and spoiling surface waters. The distance spread and the rate of speed are all dependent on the physical and chemical characteristics of the water as well as geological and climate conditions.

In regards to aquatic life, AMD waters severely affect the bicarbonate buffer system which helps keep natural water within a range of pH's suitable for the majority of aquatic life. Once the buffer system has been wrecked by extreme amounts of hydrogen ions the acidity of the water increases, a pH below 4.3 will virtually finish all micro-organisms that use bicarbonate for photosynthesis. Elevated levels of heavy metals and metalloids can be lethal to many forms of aquatic life and of concern to humans and animal health.

Finally, sediment contamination caused by precipitation of dissolved constituents from mine waters being released into the environment can from abundant colourful mineral coatings of large areas. This can lead to soil and floodplain sediments having elevated concentrations of metal and metalloids hindering the natural growth of vegetation and contaminating moving water bodies that come into contact with the area.

As devastating as the effects of AMD are, many strategies and treatment methods are currently in use to lessen the impacts and reverse the damage.
Strategy wise, the biggest issue to tackle is the amount of waste water produced. Greater recycling and reuse, controlled release to nearby waters and evaporation ponds are all effective measures employed to reduce the volume of waste.

Around coastal climate/areas, distributing mine waters to the sea is highly considered due its strong buffering capacity because of the shear abundances of bicarbonates, however, water quality guidelines usually prevent direct release and pre-treatment is required before discharge.
Water quality guidelines and water authority standards are continually being altered and reviewed to ensure mining techniques stay current, clean and aim to produce the least amount of impact as possible.
Actually, treatment and control measures for dealing with AMD impacts is very site specific, and usually more than one form of remediation method is needed for effective treatment. Well established processes included are: evaporation, neutralization, construction of wetlands and controlled release. Other more technologically advanced processes involve: osmosis, ion exchange, biosorption (metal removal by biologically cell material), solvent extraction and

many more. The majorities of innovative technologies is not standard practice or are still in exploratory phases.
Both established and innovative techniques are designed to: reduce volume, raise pH, lower dissolved metal and sulfate concentration, to reduce or oxidize the solution and finally, collect, dispose or isolate any mine water or any metal rich sludge (Jeff Skousen, n.d).

The form of treatment can be classified as either active or passive. Active requires constant attention and continue maintenance, like the addition chemical reagents to neutralise a solution. Passive requires little or no attention, maintenance or addition of chemical reagents, the use of biological process from the creation of wetlands is a good example of a passive technique.

Since the dawn of time, man and environment has always clashed. With increasing developments in modern technology, human's power to utilise the rich resources the earth can provide is constantly expanding. The impacts from mining have been known for many years, but the way in which the effect can be treated and countered is still a growing field. Finding the correct balance between nature and mining will create technological, environmental and social problems. But if the mining industry and the community together can recognise and share the goal of environment protection and conservation the needs of today can be meet without spoiling those of tomorrow.

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