A COMMERCIAL APPLICATION OF VIROMINE™ TECHNOLOGY

CASE STUDY
LANE XANG MINERALS LTD
GOLD MINE, SEPON, LAOS

"The Khanong attenuation pond and drainage gallery treatments were performed with minimal interruption to daily mining activities and without the need for significant investment in infrastructure."

The Khanong attenuation pond

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PROBLEM

Lane Xang Minerals commenced operation in 2002. The 2.5Mt/a Sepon Gold Mine in Laos – operated by Lane Xang Minerals Ltd, a subsidiary of Oxiana Resources Ltd – had problems with its acid mine drainage (AMD) management. During the wet season, in particular, the constructed Khanong retention pond, containing up to 150ML of heavy metal-contaminated AMD water, would readily overflow into the local creek system.

A mixing tank at Sepon Gold Mine.

TABLE 1: AVERAGE ANNUAL LOCAL RAINFALL AND GROUNDWATER FLOWING INTO KHANONG ATTENUATION POND (150 ML CAPACITY)

Month	Total inflow into Khanong Attenuation Pond (ML)
January	13.9
February	14.7
March	21.2
April	22.7
May	46.7
June	63.3
July	99.9
August	103.5
September	87.6
October	48.2
November	29.7
December	20.5
TOTAL (per year)	571.7

Existing technology for treating AMD at the open-pit mine, involving lime neutralisation, had failed to achieve long lasting separation of heavy metals, including copper and aluminium, and had proved to be expensive to implement. Furthermore, the residual sludge produced was unstable and therefore very difficult to manage.

VIROTEC TOTAL SOLUTION

After initial water samples were analysed in Virotec's laboratory, Virotec was able to deliver a customised, environmentally sustainable and economically viable solution to treat the AMD water so that it could be discharged into the environment under World Bank Discharge Guideline Values.

Virotec Global Solutions successfully treated the 150ML Khanong attenuation pond at Sepon using ViroMine™ Technology. The Acid B Extra™ reagent, was applied as a slurry using an in-situ aerial application treatment technique. The Acid B Extra™ reagent neutralised acidity in the water and bound metals in non-bioavailable, chemically inert forms without producing the large volumes of unstable sludge typically associated with lime-based treatments.

Additionally, Acid B Extra™ reagent pellets were engineered into filtration devices using gabion baskets to maintain the porous media in an optimum-flow configuration. The baskets were strategically placed through a drainage gallery to treat various strength AMD flows running through the channel, due to the high variance in local rainfall.

ViroMine™ Technology Acid B Extra ™ reagent is designed to treat sulphidic waste rock and soil.

BACKGROUND

AMD is associated with the weathering and oxidation of pyrite and other sulphide minerals. AMD commonly has pH values below 3.0 and is enriched in Al, As, Cd, Co, Cu, Fe, Hg, Mn, Ni, Pb, SO4, Zn and sometimes other metals (Rogers *et al.*, 1998; Nordstrom & Alpers, 1999). Iron and sulphur oxidising bacteria, especially thiobacillus ferrooxidans, and dissolved ferric iron can increase reaction rates at low pH by up to six orders of magnitude (Rybicka, 1996) and accelerate the release of metals and acidity from soil, waste rock and tailings.

AMD is not just the result of oxidation of pyrite and other sulphide minerals in the presence of air and water, but involves complex interactions between chemical, physical and biological processes (Karczewska, 1999). Under highly acidic conditions, metal ions including Al, As, Cd, Co, Cu, Fe, Hg, Mn, Ni, Pb, and Zn may be released from sulphide minerals and leached from other minerals in the waste rock, tailings and exposed pit walls in concentrations that can be toxic to terrestrial and aquatic plants and animals. Acidification can also influence toxicity as well as metal concentration through its influence on metal speciation. The direct effect of acidity on plants is the inactivation of enzyme systems and the restriction of respiration and root uptake of mineral salts and water.

AMD control and treatment is the highest remediation priority for the international mining community. The scope of the worldwide AMD problem is highlighted by the situation in the United States. Nordstrom and Alpers (1999) estimated that 19,300 km of rivers and streams and more than 180,000 acres of lakes and reservoirs were affected by AMD in the US. In 1997, heavy metal contamination contributed to 65% of superfund sites and by 1999 there were 1206 metal contaminated sites on the USA Superfund National Priority List (Pierzynski, 1999).

Permeable Reactive Barrier inside the Padan drainage gallery designed to treat contaminated runoff from the

> Acid B Extra™ Reagent: Benefits compared with lime

Acid B Extra™ Reagent Powder

The major alternative to Acid B Extra™ reagent in acid reduction and heavy metal contamination is the use of lime, in one form or another (usually calcium carbonate or calcium hydroxide). A comparison between the use of lime and Acid B Extra™ reagent can be summarised as follows:

> Lime dosing of contaminated water results in the production of large volumes of unstable contaminated sludge that have to be managed and disposed of safely. In contrast, the use of Acid B Extra™ reagent to treat the same water results in the production of comparatively small volumes of stable, readily consolidated, inert sediment.

> The sludge produced from lime dosing is unstable and will readily release trace metals if geochemical conditions change slightly or when exposed to even mild leaching. In contrast, the use of Acid B Extra™ reagent to treat contaminated mine water will not release the bound metals. The longer that the sludge is left to age after treatment with Acid B Extra™ reagent, the more tightly the metals are bound.

> Under-liming can result in increased acidity because bicarbonate ions that form when lime dissolves can accelerate the decomposition of sulphides. In contrast, extensive applications show that the application of insufficient Acid B Extra™ reagent, which contains very little carbonate or bicarbonate, does not accelerate the decomposition of sulphides.

> Over-liming can result in higher than desirable pH levels because lime is not adequately buffered. In contrast, Acid B Extra™ reagent is well buffered at around pH 8.5, and overdosing can not cause environmental problems. If the pH does rise above about 9.0 the concentration of elements such as, As, Sb and Se that are present as oxyanions and the concentrations of elements such as Al, Cu and Zn that form anionic species (eg. $Al(OH)_4^-$) at elevated pH can increase substantially.

> The use of Acid B Extra™ reagent to treat metal contaminated waters results in much lower metal concentrations in the treated water than can be achieved by using lime or its equivalents.

TREATMENT METHODS

Aerial application of Acid B Extra™ reagent

After initial characterisation of the AMD solution, Virotec found they could optimise the treatment by applying Acid B Extra™ reagent for reducing metal concentrations in the Khanong attenuation pond and drainage gallery.

In order to minimise additional metal-contaminated AMD from seeping into the attenuation pond and potentially disturbing the ViroMine™ Technology treatment process, an additional layer of Acid B Extra™ reagent was to be used to coat the base and sides of the dam, effectively forming an isolation barrier.

As shown in the figure below, the water was treated using an in-situ aerial application technique. This application method can be used on small dams, but also has been used successfully on large dams, such as the 14 ha surface area dam at Mt Carrington in Australia. The engineering and plant requirement to implement this treatment technique is very simple and can be constructed from machinery available at most mine sites.

The spillway for Khanong AMD attenuation pond

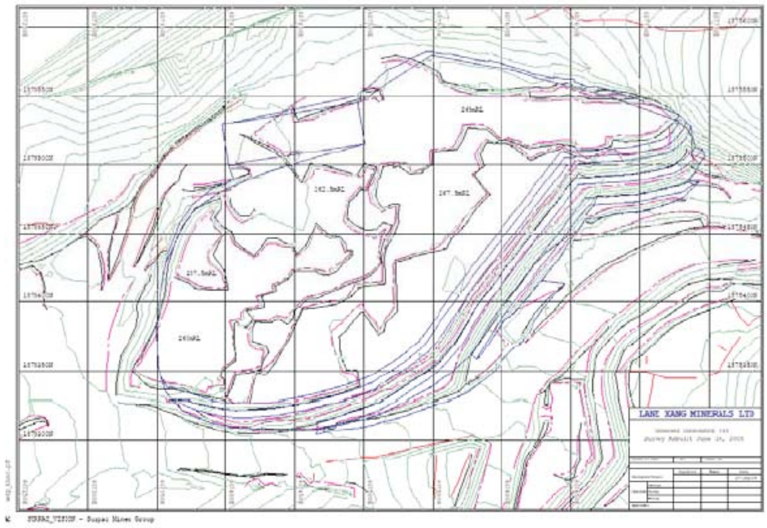
> Carbon-in-leach Mining Process.

The carbon-in-leach process is a technology which has been the first choice for gold plant design for the past 20 years.

The ore is delivered to a stockpile from the mining operations. It is continuously recovered from the stockpile to the plant and fed to a crushing and grinding circuit where it is ground to enable extraction of gold. Water is added to the ore and the slurry is transferred to the carbon-in-leach circuit where the gold is dissolved in cyanide solution. Carbon in the circuit extracts the gold from the resulting gold cyanide complex. The gold loaded carbon is removed from the circuit, the gold is stripped from the carbon, electrowon on to steel wool cathodes, and then smelted to produce gold bars. The bars produced are a mixture of gold and silver called Dore.

Waste rock that does not have a gold content high enough to make extraction cost-effective is disposed of to a waste rock stockpile on site. The waste rock is commonly acidic and high in trace metals. When exposed to atmospheric conditions (i.e. Following excavation), the metal-containing acidic solutions (AMD) permeate the rock and gradually infiltrate in to the surrounding natural environment. Mining operations mitigate AMD contamination by constructing retention ponds to capture and store the water. Mining operations in areas with elevated rainfall, such as the Lane Xang Minerals Ltd site, experience significantly greater challenges with storing and stabilising AMD, both from an economic and environmental point of view.

Khanong Attenuation Pond Plan



RESULTS

The ViroMine™ Technology application significantly reduced the soluble heavy metal concentrations in Khanong Retention Pond, especially iron and aluminium which recorded approximately 90 percent reduction.

TABLE 2: KHANONG AMD ATTENUATION POND HEAVY METALS ANALYSIS (CAPACITY: 150ML)

Analyte	Before Treatment with ViroMine™ Technology (mg/L)	After Treatment with ViroMine™ Technology (mg/L)	World Bank Discharge Guidelines (mg/L)
Aluminium	0.45	0.06	0.5
Copper	0.61	0.3	0.3
Iron	0.3	0.02	2.0

As part of the ViroMine™ Technology process, the use of Acid B Extra™ reagent in both the attenuation pond and drainage gallery allowed for a wide range of heavy metals to be extracted from solution and become bound to the reagent.

Most of Virotec's specially formulated reagents promote the permanent binding of the metals. The metals are immobilised and will not be dissolved by additional AMD seeping into the retention pond, and therefore there is a recognized environmental and human health and safety benefit from treating with ViroMine™ Technology. Additionally, the binding strength of Acid B Extra™ reagent with various metals, once initially bound, is known to increase with time.

One of the advantages of the ViroMine™ Technology is that treatment can be stopped as soon as all target values have been reached to minimise reagent costs. At sensitive sites where lower treatment targets apply, the addition of more reagent can lower metal concentrations to values well below those required at this site.

Extensive field sampling and laboratory testing yielded highly varied results due to a continual inflow of AMD through the permeable rock in which the attenuation pond is situated. Virotec offered a solution to reduce this inflow by applying the Acid B Extra™ reagent to the sides and floor, creating an impermeable barrier.

CONCLUSION

ViroMine™ Technology is a versatile, long-lasting and highly efficient means of treating acid mine drainage containing heavy metals. The Khanong attenuation pond and drainage gallery treatments were performed with minimal interruption to daily mining activities and without the need for significant investment in infrastructure. Virotec's technology successfully reduced contaminant concentrations to below World Bank Guidelines and can be expected to maintain reduced metal concentrations for an extended period of time.

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