CHALLENGES IN MINE DEVELOPMENT AND CLOSURE IN THE AUSTRALASIAN REGION

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ABSTRACT

Consultants working in Australasia (South East Asia and Australia) face unique challenges for mine development and closure. In South East Asia the consultant has to be sensitive to the local social, political and religious situation. The environmental lobby has a significant and important role on assessment of mining projects. Foreign mining companies have to be responsible corporate citizens to survive.

Mine development and closure scenarios have to be innovative and appropriate to the given technical, social and political situation. Mine development and closure designs have to be flexible in approach; meet the financial objectives of the mining company; comply with international best practice standards and address the perceived needs of the local community and government. In many cases the development and rehabilitation solution is likely to be different from classical textbook designs.

INTRODUCTION

Consultants working in South East Asia face unique challenges for investigation, development, operation and closure of mines. These challenges include:

- natural activities such as an active tectonic belt (earthquakes, volcanoes, landslides), monsoonal rainfall (<30 mm/year to >6 m/year);
- political/religious activities (military dictatorships, remnant communist groups, radical religious groups);
- social activities (transmigration/displacement of ethic groups, roving bandits, loss of land and cultural heritage);
- previous bad name of the mining industry, for example small scale miners (hill sluicing, mercury contamination, and premature and accidental deaths); and public and private mining companies (periodic collapse of tailings dams, discharge of waste to rivers).

In Australia the environmental lobby has a significant and important role on assessment of mining projects. Mining companies have to be responsible corporate citizens to survive.

For a consultant working in the mining industry in South East Asia and Australia all the above challenges have to be met. If not, the consultants should not be working in the region. To overcome the above challenges (and more) the consultants have to be sensitive to the local social, political and religious situation. They have to be innovative and flexible in approach and have an ability for thinking laterally to develop a mine to the satisfaction of the mining company, meet international best practice standards and be sensitive to the needs of the local community. The consultant has to be able to modify classical textbook mine development/rehabilitation designs and sculpture the technical (geology, hydrogeology, topography, surface hydrology) aspects with the needs of the local community into a sound, innovative, practical engineering solution.

This paper presents examples of mine development and proposed closure in such environments. Other examples will be presented at the conference but are not given in the text due to client reluctance of print release of such information or current political situation in the area of working.

DINKIDI COPPER/GOLD MINE, DIDIPIO PROSPECT, THE PHILIPPINES

The Didipio Prospect is located in Nueva Viscaya Province, north-east Luzon Island, The Philippines. The proposed open cut and underground block-cave mines are located within the Dinkidi Orebody. It is situated in an area of significant tectonic, political and social activity.

The Didipio Gold Project is located within a collapsing caldera and major earthquake zone. Hydrogeologically this area is very complicated. This includes regionally extensive, active, highly sheared, vertically dipping faults systems hydraulically connected and orientated in different directions. For example, the highly crushed Biak Shear, which extends some 1000m vertical depth, has an average transmissivity of 150 m^2/day, and abuts the orebody. The hanging wall of the Biak Shear is 75m to 100m wide, is highly crushed to at least 1000m and truncates the Dinkidi and True Blue orebodies. Some of the encapsulating country rocks have high groundwater yields and groundwater frequently flows at the surface. Adjacent rivers recharge the underlying alluvium, which, in turn, overlie the faults for indirect flow to the operating mine. Recent small scale miners and farming communities occupy the valley.

Open cut mine dewatering of around 20ML/day will be achieved through production bores located along the major shears and from in-pit sump pumping.

The underground mine will be developed to some 500m beneath the surface and adjacent to the Biak Shear. The initial dewatering requirement for the underground mine may be around 100ML/day to 150ML/day. Taking advantage of the complex hydrogeology and topographic relief, and with considerations of mine economics and social requirements, the mine design and dewatering of the underground, block caving operation will be fairly unique in that:

- the dewatering operation to 500m beneath the surface will be by gravity through a large diameter drainage tunnel to a watercourse some 6.5km away. Groundwater interception will be through an array of interception bores drilled along galleries abutting the Biak Shear (initial pressure likely to be around 1500kPa), which will drain up to 150ML/day to the main drainage tunnel (4m diameter) to the river. The initial flow velocity along the drainage tunnel may be up to 1m/sec within a tunnel depth of 1m. Precautions, such as elevated working platforms will be in place to avoid mine personnel being swept away. Due to the high rainfall, aquifer recharge and throughflows, the groundwater is of low salinity and overall metal ions are below detection limits.
- after the initial capital cost for tunnel construction there should be little additional dewatering costs for the life of the mine;
- the dewatering tunnel also gives access for deep mineral exploration drilling of other anomalies along the route of the tunnel;
- taking advantage of the drainage tunnel, power generation to the mine and community may be through turbines driven by water passing through the tunnel; and
- at mine closure one of the considerations is to install an engineered design tunnel blockage near the mine to raise water levels back to near current levels (i.e. some 500m above the base of workings). A water regulation pipe will be constructed through the blockage and generator installed for long term electricity generation for the community within the valley.

The watercourses will be redirected and lined to reduce infiltration of water to the mine and to preserve flow to villages in the Dry Season.

COWAL GOLD MINE, AUSTRALIA

The Cowal Gold Mine is located in central New South Wales and on the shore of an internationally recognised significant bird breeding/sanctuary area. The lake is ephemeral and bird breeding only takes place when the lake in inundated. The 60 million ton orebody, which partially extends out into the lake area, will be mined by the open cut method. Peripheral dewatering bores and sand drains will depressurise the clays (up to 60 m thick) as well as dewatering the alluvial and fractured rock aquifers. Low salinity water supplies are available from a deep palaeochannel (100m beneath the surface) some 30km from the mine site, on the opposite side of the lake. Water salinity within the lake is around 300μS/cm when full, to around 2500μS/cm when near empty. Beneath the lake aquifers occur within multiple clayey sands/gravels (usually deeper that 8m beneath the surface under organic clays) and deeper fractured volcanics. The piezometric surface is 1m above and 2 m below lake bed level when the lake is full and dry respectively. The weight of the lake water has a strong pressure load on the shallow aquifer. Groundwater salinity under the lake and regionally, ranges from 5,000μS/cm to 70,000μS/cm. The lake is mainly private property and the farmers cultivate the lake bed when dry for agricultural purposes.

Mine emplacement and tailings storage facilities are located on shore and the whole active mining area is encapsulated by a water retention bund. The tailings storage facility is underlain by clay and sand with a depth to piezometric surface of around 12m to 20m beneath the surface. The peripheral earth bund is required to:

- isolate all rainfall derived surface water runoff within the active mining and water rock emplacement areas, under a no release water policy, so that no water can drain to the lake. Water will be captured in storage dams or, under sever rainfall conditions, back to the open cut pit;
- isolate the tailings storage facility so that any accidental release would be directed back to the pit;
- prevent lake water inundation flowing into the mine pit; and

- act as a sound and light buffer to minimise effect on local farmers and animals.

Mine rehabilitation has to ensure that the highly saline groundwater and any contamination from the tailings/mine emplacement areas do not seep into the ephemeral lake with its bird breeding and agricultural significance. The mine rehabilitation plan takes advantage of the local hydrogeological, mine design and the high evaporation at the mine site. It is proposed to:

- maintain the open pit and active area peripheral bund and to allow the void to infill by gravity from the saline groundwater aquifers and internal surface water runoff;
- evaporation will maintain a pit water level below original piezometric surface, thus creating a local groundwater sink. It will be impossible for the local saline groundwater from the shallow aquifer, or from within the pit, to move to the nearby shallower lake bed;
- the local groundwater depression will force any groundwater beneath the tailings storage facility and waste emplacement towards the open pit, not towards the lake bed;
- hydrogeological considerations indicate that groundwater flow from the tailings storage facility and lake edge would take between 300 years and 1000 years. Solute transport modelling indicates that if leakage from the tailings storage facility occurred all metals, including cyanide, would be absorbed onto the clays within 50 m downgradient of the tailings storage facilities.

With this mine closure plan in place it is believed that the integrity of the bird breeding area and the concerns of the local farming community can be achieved. Since mine closure has been designed according to the local hydrogeology condition the likely cost to the mining company will be in long term surveillance. Remediation of the site should be through gravity and natural hydrogeological and hydrochemical processes.

LONGOS SILVER/GOLD MINE

The Longos underground mine is located at Camarines Norté, Luzon Island, The Philippines. This mine was developed at a time where roving anti-government armies were active and where 34 high graders were drowned when their illegal mining operation breached the overlying river. The vuggy quartz orebody is an aquifer and, along with the fractures/faults in the hanging wall, is adjacent to and hydraulically connected to the ocean. The footwall is relatively impermeable. Unique methods of mine dewatering have been installed including:

- underdrainage by horizontal drains in deep levels of the footwall below ore extraction levels;
- directional drilling to intersect the faults in the hanging wall under the ocean;
- and grouting of the upper orebody.

The method of mine closure will be discussed during the conference.

Other mine closure examples will include the Monywa Copper Project, Myanmar and the Chatree Gold Project, Thailand.