REHABILITATION AT HBM&S MINES
NORTHERN MANITOBA, CANADA

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Synopsis

Hudson Bay Mining and Smelting Co., Limited, a Canadian company, has operated a copper smelter and zinc refinery at Flin Flon, Manitoba for nearly 65 years. During that time, 28 mines have provided feed to eight concentrators. Five mines are currently operating, as are three concentrators.

Over the last decade, the environmental liability of the shut down operations has been recognized, and HBM&S has embarked on an aggressive - and expensive - decommissioning program. Two mills and ten mine sites have been completed; work is currently underway on five mine sites.

During decommissioning, one point continues to emerge - had mine and mill planning, construction and operation been done differently, very large sums of money could have been saved at the time of closeout. Every mine must close sooner or later - designing should be done with closure in mind.

Hudson Bay Mining and Smelting Company, Ltd., a Canadian Company, has operated a copper smelter and zinc refinery at Flin Flon, Manitoba, for nearly 65 years. During that time, 28 mines have provided feed to eight concentrators. Four of the mines were combined open pit and underground, with the remainder solely underground. Mines have ranged in size from less than 100 000 to nearly 60 million tonnes. At the moment, five mines are being operated - one recently opened; three concentrators are running while one is on standby.

In the early days, two mill sites and seven mine sites were dismantled or turned over to others. Over the last decade the remainder have become environmental liabilities requiring decommissioning. Two mill and ten mine sites have been completed; work is currently underway on five mine sites. Some six million dollars Canadian has been spent or committed to date for these projects; many more millions will be required for the remaining sites.

During decommissioning, one point continues to emerge - had mine and mill planning, construction and operating been done differently, very large sums of money could be saved at the time of closeout. Every mine must close sooner or later - designing should be done with closure in mind.

The concept of designing for closure is, in principle, simple - look into the future to the end result and the waste products that will be left behind, and design the most economical management and operating plans which will cause the least harm to the environment. These plans, when conceived, should consider the proposed project and its operations, and design them to meet satisfactory closure and decommissioning criteria.

Over the history of mining, our industry has traditionally disposed of waste products into the environment in the most economical manner. The general attitude was to concentrate efforts on the extraction of the mineral and pay little attention, if any, to the nature of the waste products, their long term stability, and the impacts that they could have on the environment. Today, the consequences of such waste management practices are well documented.

Engineering principles have been evolving that address the long term stability of waste products. We can now examine both the chemical and physical stability of waste materials. We have two choices - plan ahead and handle things properly the first time, or do things as we used to and do the clean up later, at markedly higher cost.

When I speak of waste materials and waste products, I am speaking of everything left at the end of a mine life that is different than, or in a different place than it was before the minesite was developed. That basically includes everything after re-usable equipment is removed.

When a minesite is decommissioned:

- The operator should be protected from all foreseeable future environmental liability.

- The regulators, and perhaps more importantly the public, must be satisfied with the end product.

The latter point may include a large measure of aesthetics, and may or may not be based on prescriptive regulations or guidelines. In any case, foresight should be combined with a good measure of doing more than is required, to simply meet existing regulations.

The following comments on maxims that appear to have guided mine design in the past reflect experiences of operations in the forested regions of Canada, but it is hoped that they provide insight applicable to mining areas anywhere in the world.

Minesites and Access

> "You never know what you may need in the future, so make the site big." "The shortest distance is a straight line, so let's make the roads and service corridors straight."

Sound familiar? But why not make the site as small as you can, and perhaps leave a few clumps of native vegetation behind. Access roads, power and pipeline routes, should be curved to prevent a direct line-of-sight from public areas to the mine. When site preparation is being done, overburden and soil should be cleared and saved for eventual decommissioning.

Buildings

> "Let's over design - nobody will ever know, and we do not want these to fall down."

Mines, unfortunately, are not forever. So why do we lay concrete and build structures to last forever? It is difficult to defend leaving concrete foundations and footings behind - we mine millions of tons of rock but can't remove a few hundred tonnes of concrete? We also tend to put enough reinforcing bar in our concrete to make a lot of steel mills very happy. Why not design concrete with structurally-acceptable break points, and why not cast in-place plastic tubing which can later be packed with explosives to break up the concrete for removal.

As to the buildings themselves, most of the smaller buildings can be reused or sold if dismantling costs are reasonable. If dismantling is considered when buildings are designed and specified, this reuse can be made easier. Materials of construction, insulation, etc., must be carefully considered. Other buildings - and particularly metal headframes - may not be economically reusable. They can, however, be converted to scrap at a reasonable expense if appropriate dismantling techniques and equipment are employed.

Wastes and Spills

> "Bury it - nobody will ever know."

Some of the biggest surprises in dismantling minesites is the amount of foreign material that has been buried. Some sites have as much scrap buried on them as is yielded by the dismantling of the buildings. There is nothing fundamentally wrong with properly managed landfill operations. However, wastes must be segregated - metals, combustibles, domestic - and utmost attention must be paid to ensuring that no chemicals or hazardous wastes get disposed with non-hazardous materials. Further, petroleum products and soluble or liquid process chemicals must be stored in impoundment areas with impervious liners to protect ground water and to stop contamination of otherwise clean site material.

Waste Rock

> "We produce two things - ore and waste rock. And waste rock makes good construction material."

The biggest cost we have in decommissioning minesites is in dealing with acid generating mine rock. HBM&S mines are all sulfide based and, except for one, have acid rock problems. Without recognizing the long term liability of this rock, we have used it both on and offsite for civil works. Current and future mining will consider that we produce three materials - ore, stable rock, and acid-generating rock.

There are literally dozens of types of tests which can be used to determine the acid generating potential of rock, the dynamics of the reactions, and so forth. Some are technically elegant, others are quite expensive. But in the end, one should not rest comfortably on the selective choice of methods to prove that a rock is not going to be a problem at some time in the future.

The simplest test is that of determining the amount of sulfur present, presuming that all of it will become acid, and comparing that to the titrated value for acid consuming ability. After that, we need to make a judgement call - will or will not the material in fact be a net acid generator?

To decompose to acid, three things are necessary - sulfur, air, and moisture. If either of the last two can be controlled, acid generation will not be a problem, whatever the sulfur level. Arid climates provide little moisture, or in any case, perhaps no vehicle to transport generated acid out of a rock pile, and there may be no problem. In other climates, control can become a significant problem or at least a significant cost.

In Canada, under a joint industry-government research program called MEND - Mine Environment Neutral Drainage - some $18 million (Canadian) has been or will be spent researching ways and means of achieving control of acid generating materials. The best method has been determined to be placing fresh material underwater. Second choice, and a distant second, is covering the material with an engineered, multi-layered, soil cover. Better than both of these is leaving the suspect rock where it was - in the mine - or placing it there post-operation.

Which brings us to the planning phase. When we do exploration drilling to define an ore body, we are in the position to determine a great deal about the host rock through which we will be driving declines, sinking shafts, and doing development work or that we will be stripping for open pit mining. By doing the afore-mentioned acid/base accounting on the rock, we can determine, before mining, whether the rock will present a problem. After we have removed the rock, and mixed it together in a pile of several hundred thousand tonnes, we have a major problem - all the rock is contaminated if any of it is, and how can we representatively sample the pile in any case?

So how do we know, or how can we predict with surety whether a material will be acid generating? If the acid potential exceeds the neutralizing ability, there is no question - net acid will result. Beyond that, the mechanism of the reactions must be understood, and the composition of the rock must be viewed within that context.

When sulfur-containing minerals decompose to form sulfates, continuous renewal occurs of fresh mineral faces for subsequent reactions. Sooner or later, essentially all the sulfur will be converted, with the rate of reaction being the only unknown. Neutralizing minerals, on the other hand, tend to get occluded with precipitation salts, and may only be partly consumed before they are rendered inert. Complicating the situation are physical factors such as the degree of homogeneity in the rock - stringers versus intimately mixed microscopic crystals - and the relative size of the rock. Various rules of thumb are available to assist in interpreting the acid/base data:

- minimum 20 kg per tonne of excess alkalinity required.

- ratio of base to acid of at least two to one, and in some cases as high as four to one required.

With a fine grain, well mixed, crushed rock of low sulfur content, less than 0,5%, the low side of these rules of thumb are probably reasonable. With higher sulfur, or irregular rock, the higher side would ensure safe prediction. The ultimate test is in the field, of course, but it may take years for an acid "breakout" to occur, at which time red coloration and elevated sulfate seepage becomes evident.

With a prediction of the probable stability of particular rock units while they are still in the ground, a decision can be made as to whether the rock can be safely used for civil works - roads, site levelling - or whether it should be stockpiled for later rehandling, mitigated in the short term such as with a water cover, or left in the mine or returned to the mine as backfill. The additional money spent during design, development and operations for a proper waste rock program can mean economic returns many times greater at time of closeout.

Handling of rock which is already oxidized presents different problems than that of controlling oxidation in fresh rock. Underwater disposal of oxidized material will lead to release of soluble values and contamination of the overlaying waters. Once placed underwater, no additional sulfide decomposition will occur; control and mitigation may well require water treatment for a period of time, but at least the time will be finite.

Some Concepts Used Successfully

- Contaminated water management at a site can result in two streams to be handled - mine dewatering effluent and runoff. If the precipitation regime allows it, contouring and sloping of the site to direct surface drainage from ore and mine rock piles into the underground collection sump system results in a single waste stream and pumping system.

- Head frames can be particularly expensive to dismantle, and yield little reusable structural steel. Recognizing the strength built into these structures, we have developed a simple means of dismantling which does not require the use of cranes. The structures are burned, followed by cutting one metre long sections out of all but four of the vertical members. These are then blasted to topple the structure. A hydraulic shear on a back-hoe boom is then used to cut the steel into short, recyclable lengths.

- Shafts, raises, and underground stopes provide secure storage of acid-generating and pre-oxidized rock. At the end of mine life, a raise driven to surface from an open stope can provide access for dumping; an engineered concrete plug set in bedrock isolates the rock and it's products from the surface environment.

- Most open pits will eventually become lakes; problem rock can be layered in the bottom of a pit and covered with silt or clay. The pit water can be treated or otherwise managed during initial flooding and to remove contaminants leaching from the rock.

- In-situ treating of water while waste is being placed in a pit offsets the need for separate treatment. Broadcasting of slurried lime on the water surface, followed by a short period of settling, allows the treatment sludges to settle into the voids in the rock mass. Clean water is then decanted; an impervious clay cover when the pit is filled then seals the sludge and rock in place and prevents re-mobilization of contaminants.

- As a final step in decommissioning, the site should be fertilized but seeding may not be necessary or even desirable. Establishing a non-natural vegetation mono-culture may well hinder site recovery, while a site merely fertilized will begin natural growth succession. If erosion is a problem, a non-reseeding annual plant will provide sufficient surface stabilization to allow "mother nature" to seed the site.

- At least a portion of the decommissioning work can be done while the mine is still operating. The availability of manpower and equipment, as compared to the high cost of mobilizing after operations are shutdown, make it desirable to do all that is possible while the mine is still running.

Mine closures are an unfortunate but predictable step in our industry. Properly planned, they can be done at an acceptable cost. The time to start that planning is before mining even begins - planning for closure makes sense.

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