THE NORTHERN MINER since 1915 The Global Mining Newspaper

TABLE OF CONTENTS Nov 1 - 7, 1999 Volume 75 Number 34 - 0 comments

EAST KEMPTVILLE TIN

By: By Patrick Whitney
1999-11-01

Running the only tin mine on the continent may sound like a prestigious job. But try mining ore out of mineralization that assays as low as 0.12% tin. It can be a very trying experience, especially when recoveries were only 30% and the price for the metal was only $2.50 (us) per lb. Ask Kenneth Collison. He has been managing Rio Algom's East Kemptville tin mine in Nova Scotia for five years. And because the mine is one of the lowest-grade tin mines in the world, the job hasn't been a piece of cake -- there's no other mine in the world to turn to for advice when things go wrong. (Twelve countries produce cassiterite, the oxide mineral of tin, all at higher grades and lower daily tonnages than Rio's.) The company has forged ahead, breaking new ground, technically speaking. That learning curve may have cost the open pit mine some operating profits in the first years, but with 11 years of mineable reserves remaining (35 million tonnes) and tin recoveries and prices improving, the future looks much brighter.

"The market for tin is nothing like the market for copper or other base metals," Collison told The Northern Miner Magazine. "It's small, so small that the market price goes up and down like a toilet seat whenever a relatively small amount of the metal is dumped on the market."

Tin prices have been buoyant of late, however. The international tin cartel was smashed in 1985 and the metal did not begin trading again on the London Metals Exchange until June, 1988. Ever since then, the price has stayed in the $3.50-$4.00-(us)- per-lb range. In 1984, when Rio decided to spend about $170 million building the mine, tin was trading at about $7 a pound. One year later, after borrowing money from a group of banks to build the mine, the international cartel collapsed and prices dove to about $2.50 a pound. Rio wrote off the capital cost of the mine in 1986 and ownership reverted to the banks. In March, 1988, Rio bought back the mine from the banks for only $39 million and, at $3.50-(us)-per-lb tin, the mine now is making a profit. At current exchange rates, that means total costs are below $13 (Canadian) per tonne of ore treated.

"We'll be paying back the capital invested in the mine shortly," Collison said. Mind you, that's considerably lower than the original $170-million price tag. The difference was swallowed by the banks.

The ore at East Kemptville is complex. So complex that only one geologist has attempted to interpret the geology of the deposit. The difficulty lies in the lack of continuity between drillholes, even those spaced 25 m apart. One thing is certain though – the best tin values (in the 0.30% range) occur at the contact between the hard granitoid rocks of the South Mountain Batholith and the softer graywacke/ slates of the Halifax Formation. That contact runs in a north/south direction and tin values decrease gradually away from the contact to the east and drop off abruptly to the west.

The current pit, which measures 500 m wide (east/west) and 1.5 km long (north/south), encompasses an area which originally contained 56 million tons of mineable reserves to a depth of 100 m. The average grade of that mineable reserve is 0.18% tin and the total tonnage was calculated at a cutoff grade of 0.12% tin. There are tin values above 0.08% tin in the east wall and within the boundaries of the pit. The west wall, where the ramp is situated, is barren of tin.

To achieve a more detailed grade picture in a given mining area within the pit, Chief Geologist Claude Poulin samples cuttings from each blasthole and models these data, together with diamond drill hole data, on a personal computer. The company recently purchased a COMPAQ 386 desk-top computer, and it uses the GEMCO grade control software package. The idea is to bring the sampling up to the stage where the data can be included in a kriged ore reserve model.

"We want to send the blasthole information out (to Geostats Systems of Montreal, Que.) for geostatistical evaluation," Poulin said.

This would allow the mine geologist to project tin grades from one bench to the next, 12 m down. This way, mucking could be managed in such a way as to reduce, or at least forewarn the mill operators of, wild swings in millhead grades (at times, those swings can go from 0.15% to 0.30% over a 24-hour period).

As things stand, blocks of ore have been defined by 260 exploration diamond drill holes spaced at an average of 100 m apart. Only the central portion of the pit was drilled in any detail, at 50-m spacings. No additional diamond drilling was conducted in the first three years of operation. That means the mining blocks were 25 m on the side, which represents a block containing about 18,000 tonnes each. This level of detail is not sufficient to manage a selective mining operation. By adding detail to the block model, the mine will be able to reduce dilution by mining more selectively. The company hired another geologist in April, 1988, to assist in additional sampling.

The equipment currently used to mine the East Kemptville deposit is not exactly sized for selective mining. "The equipment is too big," Chief Metallurgist Harold Wyslouzil said. The company owns seven used 70- tonne trucks, one production drill, two used shovels (one from the Steep Rock mine in Ontario and one from Wyoming) and one new Michigan loader, plus several pieces of auxiliary equipment (a grader, dozer and several pickup trucks).

The new Marion M-3 blasthole drill garners the most praise from Mine Superintendent Gary Smith. "It's a very marvelous machine," he said. The machine drills 13.5-m holes, 25 cm in diameter – all on automatic mode. Since buying the machine, the company has chalked up more than 24,000 hours, with downtime only for routine maintenance. The Marion is used for the vast majority of pit drilling (about five million tonnes per year), but Archibald Drilling, a local contractor, does some 16.5-cm- diameter drilling (about 1.4 million tonnes per year) using an Ingersoll- Rand T4 blasthole drill. The company was using Varel tri-cone bits at the time of our visit, but it has used Hughes and Sandvik bits for a while. Bit manufacturers are paid by how many metres each bit drills and the company uses whichever manufacturer asks the lowest price. Penetration rates have been 17 to 18 m per hour drilling in the metamorphosed sediments and about 9 m per hour in the granite, Smith said. Cost per metre is currently about $3.

The haulage trucks generate less praise from Smith. The engines date back to the late 1970s, so Rio had to have them rebuilt after only 2,000 hours of operation. The company recently bought four new Silver Series Detroit diesel engines to replace older engines. Two new engines have been installed; one was being put in and another was on its way to the mine site at the time of our visit in September. Next year, Rio plans to start buying new trucks to replace some of the older trucks in its fleet.

The company is also shopping around to replace its Michigan loader. The machine has been plagued with engine and transmission problems, resulting in only 60% availability.

The 42x65-inch (107x165-cm) primary gyratory crusher, too, is undersized for the operation. Because of the small opening on the crusher, Rio loads about 0.4 kg of explosives per tonne of ore blasted to get the necessary fragmentation to avoid choking the crusher. A 140-cm opening would be ideal, Smith says.

The East Kemptville mine is one of many open pits in Canada using emulsion explosives as opposed to slurry explosives. The emulsion, which is a mixture of ammonium nitrate liquor, fuel oil and water, is mixed on site in a plant constructed by cil in 1985. Liquor is shipped from cil's plant in McMasterville, Que., and is mixed in the East Kemptville plant, explained plant co-ordinator Fenton Henry. The emulsion, which has the consistency of petroleum jelly, is then mixed with anfo in a Gelmaster cement-mixer- type tru ck and hauled into the pit to be loaded into the blasthole. About 2,500 tonnes of emulsion are used at the tin mine and about 625 tonnes go to several quarries in Nova Scotia. The plant is able to produce about 12,000 tonnes per year.

"The emulsion is a higher-cost product," Smith said. "But using it allows us to expand our drilling pattern and still achieve good fragmentation. About 3% of our fragmentation is oversized now, compared with about 15% before, when we used straight ANFO."

A Teledyne 900 series hydraulic hammer, mounted on a hydraulic boom, breaks any oversize dumped into the crusher. That boom was re-positioned from the corner of the crusher opening to the centre of the crusher building to allow operators to use a backwards clawing action rather than a sweeping motion. Oversize can now be broken up in about three minutes, the hammer operator says, compared to 15 minutes using the previous Teledyne 700 rock-breaker. The crusher was breaking ore to minus 12.7 cm at the time of our visit.

The lack of consistency to the East Kemptville orebody renders complicated the process by which the cassiterite is concentrated into a saleable product. Having 16 different minerals to contend with doesn't simplify things either. Optimum recoveries are achieved at a millhead grade below 0.23% tin, and the mines cutoff grade is 0.12%. Low-grade mineralization in the 0.08%-to-0.12% range is stockpiled. There are about two million tonnes in that stockpile and it should grow to about 15 million by the time the deposit is completely mined out. The operating philosophy of the mill is to simplify the process as much as possible.

When the milling process was first designed five years ago, it was so complex that it had to be tested in bits and pieces. The grinding circuit was designed by one metallurgical consulting lab, gravity separation by another and electrostatic separation by yet a third. All the information was combined and the Rio Tinto Zinc (rtz) Group in Britain made a "best guess" of the capacities required. The mill was built without the process being tested in a pilot plant.

In the past five years, much has been learned about milling the East Kemptville ore. A great deal of this knowledge pertains to the mineralogy of the deposit. Hand specimens show that cassiterite appears to be coarse- grained, leading one to suspect that a coarse grind would sufficiently liberate the valuable mineral, which could then be separated by gravity (spirals, cones and shaking tables) to produce a high-grade concentrate. Not so. Because the cassiterite crystals had been stressed over geological time, many of them fell apart as soon as the minerals around the cassiterite crystals were broken up. A lot of fines were generated, making it difficult to separate the tin from the other minerals.

"Once you get into the 75-micron size range, other effects, such as surface tension and friction, take over from gravity separation and we would lose the fines out to the tailings," Chief Metallurgist Harold Wyslouzil explained. "So we have to grind the ore in stages. And in order to make the separation based on densities after the grinding stage, all the particles have to be the same size."

So ways had to be found to deal with the fines and classify the ore by particle size. When the mill first started up, only 30% of the tin in the ore was being recovered. The rest went out into the tailings pond. Since then, the company has added extra regrinding, dewatering and gravity equipment, boosting recoveries up to the mid-to-high-60s range. And changes continue to be made.

Vibrating screens are used instead of cyclones following the initial grinding step. This way, only the tin which has been liberated goes through th e screen. The oversize is sent back to the mills for regrinding. The first separation of the liberated tin is carried out in cyclones. The coarse underflow goes through 64-tonne-per-hr Reichert cones. The high-grade stream from these units then goes to a bank of Vickers spirals. One hundred and forty-four of these units have been added to the mill since it started up. The concentrate stream is then classified before going to the shaking tables. Each classification circuit consists of a screen, classifier and hydrosizer. The concentrate streams from the hydrosizer pass over shaking tables for further concentration. There are now 80 tables in the mill, up from 56 in the original design.

From the tables, the concentrate goes to a regrind circuit, then a flotation circuit to remove the sulphides. The sulphide tails then report to a magnetic separator to pull out the grinding steel while the sulphides go to a regrind and cleaning flotation circuit, producing copper and zinc concentrates. The flotation tailings go to an electro-static separator to remove topaz from the cassiterite, resulting in a final concentrate of 55% tin.

"We have had some inquiries about our topaz from a firm in Australia," Wyslouzil said. "They would like to drive off the fluorine to form mullite, which can then be used to manufacture refractory bricks."

An additional 10% of tin in the ore will likely be recovered once a new, $6-million flotation circuit is fine- tuned. That circuit required a new addition to the mill building. Once tune-up is complete, the overall recovery for the mill could reach as high as 72% to 73%. But modifications to the mill do not stop there. Once the flotation circuit is on-stream, there will be 27 tables available for other work.

"We'll have to go back to the preconcentration area, which was previously limited by the number of available tables and re-evaluate the situation there," Wyslouzil said. "It may be possible to recover the less- than-75-micron tin.

"We'll also look at ways to increase copper and zinc recoveries from the de-sliming cyclones." About 40% of those metals are lost in this part of the circuit. Column flotation cells, 3 or 3.5 m in diameter, will be constructed outside the mill building to recover more of these base metals. "This will be a very challenging project which will take about a year or so to complete."

Stepping into the East Kemptville mill is like stepping into no other mill in Canada. With some 57,000 L of water flowing through the mill every minute, one feels as if one were inside a huge hydraulic machine. (It takes about 20 minutes for a crystal of cassiterite to travel from the grinding circuit through to the concentrate bin.)

With 11 operators per crew, operating on 12-hr shifts, labor is one of the biggest cost items in the mill. Training and job rotation for mill and pit operators is similar (see separate story). Each mill operator was trained in different areas of the mill operation. After completing the required evaluation, the operator can advance to another area.

The other high-cost item is power. There are three stages of crushing and eight mills in the concentrator – two rod mills and six ball mills. Controlling the whole process is a top-of-the- line Bailey Network 90 MCS system. It calculates mass flow to control feed to the spirals.

The biggest problem lies in reducing the amount of tin going to the tailings pond. Because each shaking table can handle only so much tin (one to two tonnes per hour), some tin can end up in the tailings stream when millhead grades swing with no warning. With two operators looking after 80 tables and all the pumps, it is difficult to react (manually changing the product dividers) to a change in head grade. This should be ameliorated somewh at by the grade control improvement program in the pit, thus bringing millhead grades under tighter control. On-stream analysis (two Courier 20s) will be used in the new tin flotation circuit, but it cannot be used elsewhere in the mill because the material is so coarse that it is difficult to obtain a representative sample. Similar units are being considered for use in the rest of the mill.

Rio has also been experimenting with a 5-tonne-per-hr centrifugal jig designed by C. Kelsey and supplied by Geologics of Australia. This compact unit may eliminate the mill's entire electro-static separator circuit. The mill has been evaluating the unit for about six months. If it is installed permanently, power and propane costs should decline. "I think you'll probably see this unit more in gold mines in the future," Wyslouzil said. The unit runs on a 17-hp motor and is a continuous process, not a batch process like the Knelson concentrator.

The final products (4,000 tonnes of tin in concentrates per year, grading 55% tin, 1,800 tonnes of copper in a 28% copper concentrate per year and about 1,800 tonnes of zinc in a 50% zinc concentrate per year) contain 8% moisture. About 21.5 tonnes of tin concentrates are loaded into tractor- trailer containers and trucked to the container pier in Halifax for shipment to smelters in Malaysia. Rio has three seperate tin contracts: one with Metallgesellschaft, one with Phillips Brothers and one with Datuk Keramat Smelting of Malaysia.

Copper and zinc concentrates are sold to Noranda Inc. Nine 32-tonne trucks per month haul the copper concentrates to Murdochville, Que., and the zinc concentrates to Valleyfield, Que.

There are 11 separate tailings streams in the East Kemptville mill. These are classed as either coarse or fine tailings. The fines, which contain pyrite, chalcopyrite and zinc sulphides, are deposited below water on the bottom of the main tailings impoundment area. This keeps the sulphides in a reducing environment (which prevents oxidization), therefore reducing the problem of acid mine drainage. Coarse tailings are piled in a horseshoe-shaped dam around the fine tailings. Two additional dikes have been constructed of mine waste rock to subdivide the settling ponds downstream of the main pond. This work created a clarification pond and a polishing pond, allowing more time for the fines to settle out before finally being discharged into the east branch of the Tusket River, a popular recreational canoeing and fishing river.

In February, 1989, Rio commissioned a treatment plant which adds lime to the tailings water. The lime is quarried in Havloc, N.B., and costs about $150 per tonne. "We found that lime is just as effective as a cationic polymer and caustic soda which promotes settling of fines in the final polishing pond," said environmental engineer Kenneth Black. Since lime is less expensive, it has replaced the polymer in treating the mine's tailings. During spring run-off in March, Rio used 75,000 kg of lime to treat a discharge stream which averaged about 35,600 L per minute. The final discharge from the ponds has a pH of about 9.5 during the winter months and about 8 during the summer. Since the river's PH is about 4.3, the discharge has a buffering effect on the river. All water requirements of the mill are served by the tailings pond (i.e. 100% of the mill water is recycled). The only fresh water used on the site is well water for drinking. "We have put a tremendous amount of effort into making sure we do the right thing," Black said, "but the local people continue to take a watchful attitude toward the mine."

The long-term future of the East Kemptville tin mill rests with the exploration potential in the area. Rio has appointed a project manager to eval uate this potential. "If someone comes up with a deposit in the area averaging 0.20% tin, we'd be glad to talk to them," mine manager Collison said. A smaller, 2-million-tonne deposit situated about 200 m south of the pit is already known. Called the Baby deposit, this mineralization averages 0.25% tin and could be reached by a ramp from the pit bottom. If the deposit were mined by open pit methods, the stripping ratio would be about three tonnes of waste per ton of ore.

Rio has also done some diamond drilling. About 600 m were drilled in 1988 and some 4,000 m (20 holes concentrated in the south end of the pit) were drilled in 1989. Chief geologist Poulin was waiting for assays at the time of our visit. (Another thing the company has learned over the past five years is to have all its core assayed for arsenic as well as tin, copper and zinc.) Those data will then be put into the company's VAX 750 mainframe for block modelling. One thing seems certain. If another mineable tin deposit is found, the technical expertise required to mine and mill it will already exist in southwestern Nova Scotia.