Summary of the Concentrating Process in Mill No. 3

Introduction

This is the process of separating precious minerals from waste rock.

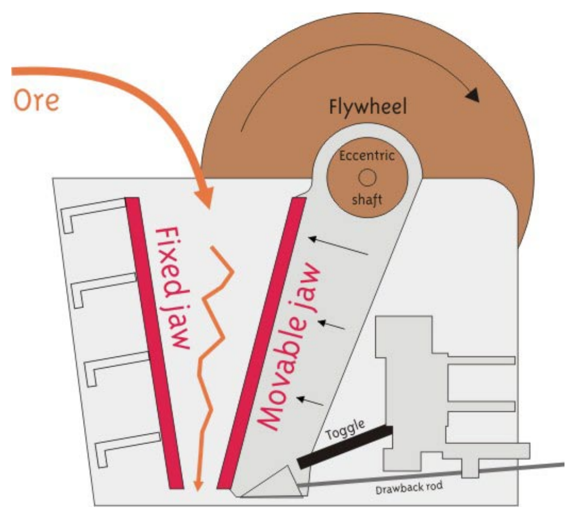
At Britannia the copper ore contained just over 1% copper (though in the early years it was around 8%). The remaining 99% was mostly waste rock, called 'tailings'. In the rock, chemical and physical bonds hold the valuable minerals to the waste rock. Some ore contains minerals in an elemental or almost pure form such as native copper, native silver, etc., but most valuable minerals are compounds, in this case chalcopyrite ($CuFeS_2$).

The process used to separate the minerals is called 'concentrating'. Breaking the chemical bonds and separating the elemental copper from the other mineral components is called 'smelting' and 'refining'. This was done elsewhere as there was never a smelter located at Britannia Beach. In the Mill No. 3, the various stages in the milling process took up all of the building. A number of different types of equipment were used to mill the ore as it travelled down from level to level. Some of this equipment is explained below.

Crushing & Grinding Ore

Crushing – Primary

Primary crushing was done by a jaw-crusher – like a giant nutcracker. This consisted of two jaws, one static, and one moving. Ore would move between the jaws and was crushed if it was larger than the gap between the jaws. The jaws did not close completely but were set 4 or 6 inches apart.

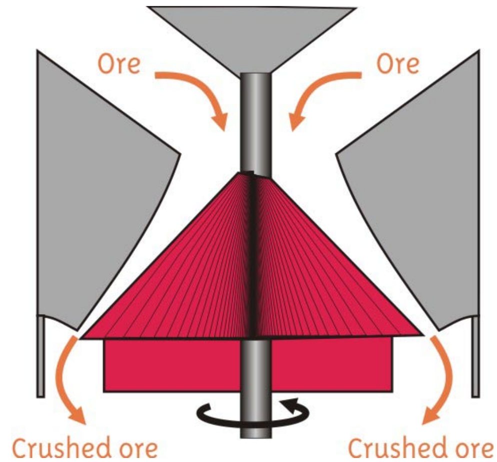


This crusher and many others were not designed to crush every piece of ore. After the ore passed through a crushing device it was generally "screened" and any ore above a certain size would be fed back through the crusher.

In many mines, including Britannia, primary crushing was done underground. This could facilitate handling and transport of the ore.

Crushing – Secondary (Cone Crushing)

Secondary crushing was done in this mill by a cone crusher – like a giant pepper mill. This consisted of a cone-like chute, down which the ore passed. Inside the cone, a smaller cone-shaped crusher rotated, breaking the ore between the crusher and the wall of the chute.



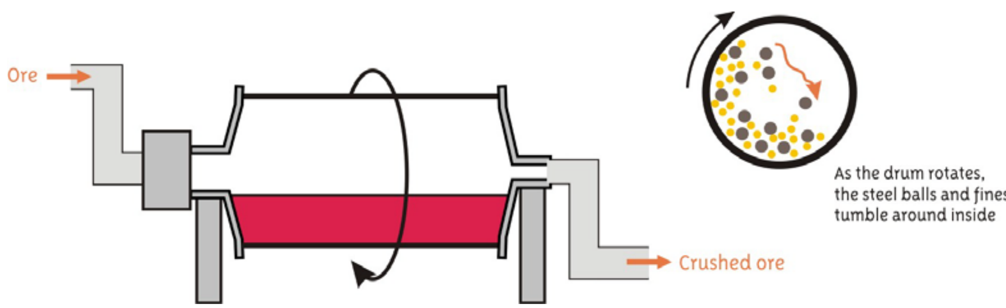
Grinding – Rod Mills (Large cylinders similar to cement mixer)

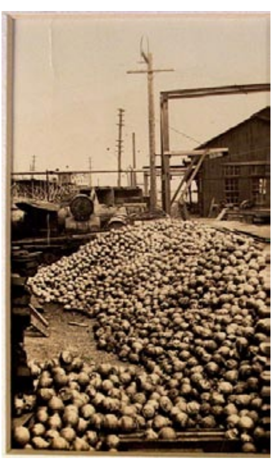
These mills worked by rotating and having a mixture of the crushed ore and water flow through them. Inside the rotating mill there would be a number of long steel rods, which would rotate with the ore, grinding it down. Rods vary from 4 to 6 inches in diameter and 5 to 15 feet in length.

Grinding – Ball Mills

The ore would then flow into ball mills similar to the rod mills. Steel balls inside the ball mills were about the size and weight of a shot-put ball.

These grinding mills rotated anywhere form 1 to 5 times per second.





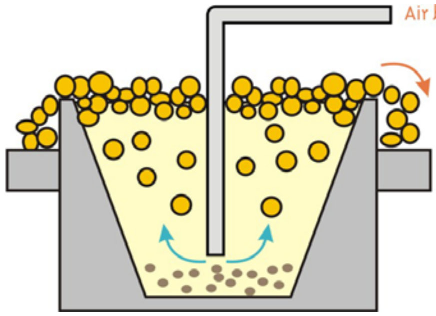
Steel balls used in the Ball Mills

The end product of the milling process is ore ground to the consistency of sugar or salt (small enough to pass through mesh having 100 holes per square inch). This material is called 'fines' and is still mixed with water as it leaves the milling circuit.

Flotation

The ore/water mixture then had more water and chemicals added to it to form a thick soupy mixture called 'slurry'. This is when the flotation process began – most base metals (non-precious) are separated by flotation during the mining process.

'Bulk flotation' took place in large flotation cells (troughs). The slurry continually flowed into these cells, keeping them relatively full. At the same time air was added to the mixture, blown through pipes which fed air to the bottom of the cells.



Bubbles form as the air is forced out the bottom of the pipes. These bubbles then rise to the surface of the cells. As the bubbles rose, sulphide minerals would cling to the bubbles and rise to the surface. This was due to the chemicals which had been added. One chemical (called a 'frothing agent') was added to create a frothy mass of bubbles. The other chemical (called a 'collector') essentially waterproofed the valuable minerals and made them stick to the bubbles.

The mineral-laden bubbles would reach the top of the cell. The continuing stream of bubbles would overfill the cell and force the bubbles over the side of the cell and flow down to the next level. Any minerals not coated would sink to the bottom of the cells. This was generally waste material or 'tailings'. The tailings were refloated to make sure that no valuable minerals had been left behind.

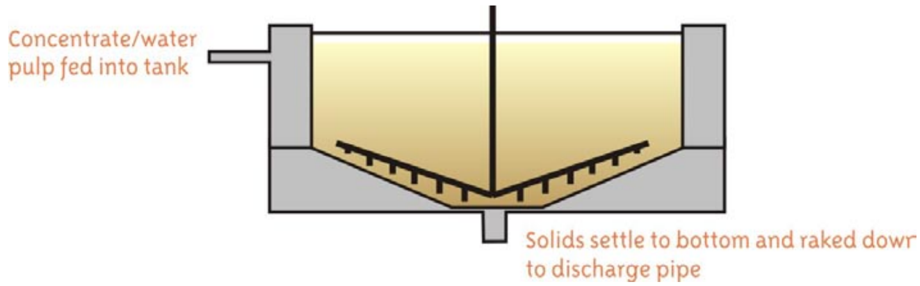
The large flotation cells used for bulk flotation at Britannia were called "Britannia deep cells" because they were developed here by one of the early mill managers.

With the waste removed, the next step was to separate the metal sulphides – namely copper, zinc and iron. This happened in a step called 'differential flotation'. The flotation process was repeated in small cells using slightly different chemicals, which enabled each sulphide mineral to be separated from the rest.

Not all of the waste rock or tailings drawn out of the flotation cells was worthless. In the later years when road transportation to Vancouver was possible some of the tailings high in silica values were sold for use in the making of cement blocks and other cement products. Today in many mines, tailings are returned into the mine where they are used as fill for mined-out areas or they remain contained in a 'tailings pond'.

Dewatering (Thickening)

The final stage in the concentration process is called ‘dewatering’. This involves removing the water from the valuable mineral particles (the concentrate). Dewatering took place in large dewatering vats, three of which are on the bottom level of the mill.



The mineral-laden bubbles flowed into the top of the vats, which were full of water and bubbles. Rake-like agitators moved through the mixture breaking down the bubbles and allowing the mineral to settle to the bottom. Here it was pushed toward the centre where it was pumped out through canvas filters, which would allow removal of most of the water. The still damp mineral, now called “concentrate” was then dried before being taken out of the Mill on a conveyor belt across the road to the storage and docking area.

The process used in the Mill was able to recover at least 90% of the valuable minerals mined.

Beyond Britannia

From Britannia, the very first copper concentrates were shipped to a smelter at Crofton on Vancouver Island. When that became uneconomical they were shipped to Tacoma, Washington, and in the later years to Japan and Montana.

The iron and zinc concentrates were also shipped to smelters – the iron concentrates for making ‘pig’ (raw) iron, and zinc, along with the copper, for smelting and refining into pure metal.

At a smelter the concentrate is melted, breaking all the chemicals bonds and allowing the elements to be almost completely separated from each other. Metal coming out of a smelter is approximately 99% pure and in the case of copper is called ‘Blister Copper’.

From the smelter, it is transported to the refinery where the final impurities and by-products are removed. The pure copper metal emerging from the refinery is one of our most valued metals because of its resistance to corrosion and the ease with which it can be joined. Alloyed with zinc, it becomes brass and with tin, bronze. Copper is essential for everything electrical and plays a vital role in making some of the wonders of modern technology possible.