

## Tin mining and processing methods

### Hard-rock mining

Hard-rock underground mining is predominant in China, South America and Australia, although there are some open pit operations in all these places. Vein and disseminated tin deposits are mined by the same methods used in hard-rock mining of other non-ferrous ores such as zinc. The ore is broken by drilling and blasting, transported to a concentrator where it is crushed and ground and then concentrated primarily by gravity methods. The concentrate is usually of a lower grade (typically 40 – 60% tin) than placer concentrate because of the fine grain size of the cassiterite (tin oxide) and the difficulty of removing all the associated sulphide and other heavy minerals.

Although flotation is not as efficient for tin ores as it is for sulphide ores, it is used increasingly to improve the amount of fine tin recovered and to recover tin from the residues of earlier treatment. Processing circuits may also allow for the recovery of by-products including copper, lead, zinc and a range of other minerals. In some mines tin is itself a by-product of the mining of other metals, including zinc, silver, tantalum and tungsten.

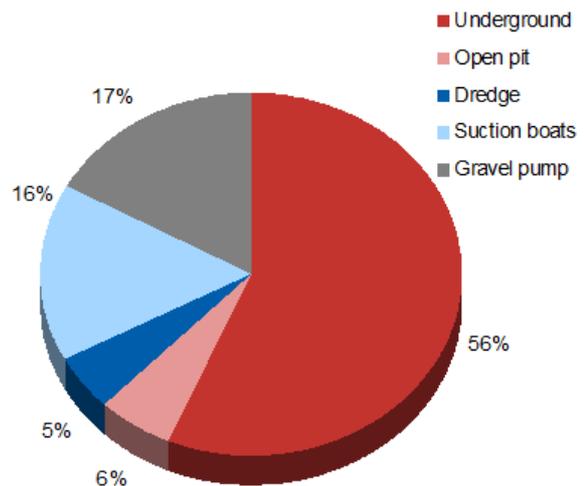


*Minsur's San Rafael mine in Peru – the world's largest tin mine*

### Alluvial mining

Until the mid-1980s, the main method of mining large placer tin deposits was by bucket ladder dredging. The alluvium containing the tin is excavated and transported by a continuous chain of buckets to the interior of the dredge where it is washed and roughly concentrated.

### World mine production by method



In the last few years smaller cutter-suction dredges have become widely used, which are more manoeuvrable and produce a higher grade concentrate on-board.

In South-East Asia particularly, smaller deposits, or those unsuitable for dredging (e.g. because the bedrock is very rough) are worked by gravel pumping. The alluvium is broken up by a high pressure jet of water and the resulting slurry is pumped to the concentrating plant. In recent years there has been a boom in small-scale alluvial mining in Indonesia, using simple gravel pumps or off-shore suction boats - floating platforms or converted fishing boats.



*PT Timah cutter suction dredge*



Bucket ladder dredge followed by suction boats

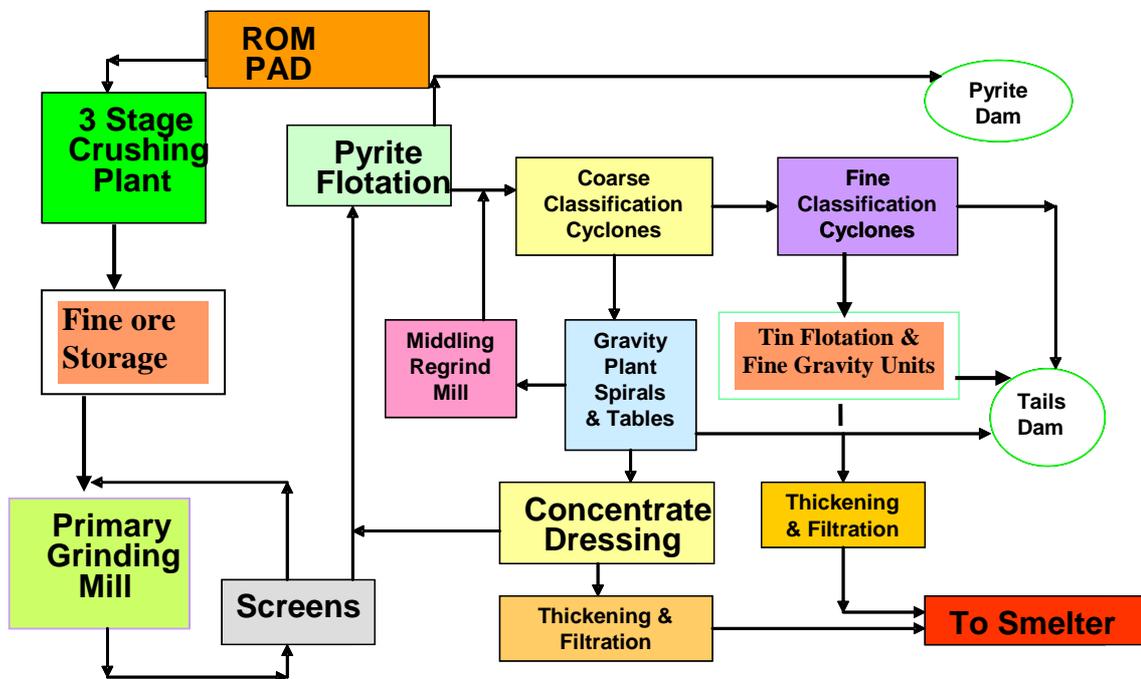
The impure cassiterite concentrate is further concentrated by gravity methods which involve passing the concentrate in a stream of water over equipment such as jigs, spirals, or shaking tables. This separates the heavy cassiterite from the lighter minerals such as quartz. Magnetic or electrostatic separation removes the heavy mineral impurities. The end product is a cassiterite concentrate containing about 70% tin.

### Hard rock mineral processing

The practical mineral dressing options to achieve a separation using the properties of minerals are size, specific gravity, magnetic susceptibility, conductivity, colour, floatability and solubility. In the case illustrated below, the practical options available the use of certain combinations of gravity, floatability, is the approach selected from ore characterisation test work to achieve targeted outcomes.

The simplified process flow sheet below shows ore from a Run-of Mine Stockpile (ROM PAD), delivered to a 3 stage crushing plant and reduced to - 12 mm followed by ball mill grinding to liberate the cassiterite (tin oxide) from the gangue, sulphide flotation to remove pyrite and any other sulphides, then concentration of the tin by a combination of hydraulic classification, gravity plant and fine tin flotation to produce concentrates acceptable to tin smelters.

It is essential not to over grind and early removal of liberated cassiterite from the grinding circuit should be arranged, usually by fine screens as shown in the flow diagram. Further liberation of the cassiterite is achieved by regrinding gravity tails.



This note is based on a fact sheet posted on the Australian Mines Atlas website (<http://www.australianminesatlas.gov.au/>), with additions and updating by ITRI and the section on hard rock mineral processing and flow sheet contributed by Ron Goodman (e-mail: [Ron.Goodman@optusnet.com.au](mailto:Ron.Goodman@optusnet.com.au)). Photos: Minsur and ITRI.