31: Biooxidation – 1980s research in British Columbia and California

Biooxidation oxidises both iron and sulphur under acidic conditions, causing the solubilisation of iron as ferric (III) ion and sulphide as sulphate ion. This liberates the encapsulated gold making it accessible to leaching.

During the 1980s, biooxidation became the focus of intense research effort, offering a low-cost means of preparing refractory hardrock ores to make them responsive to leaching such as cyanide leaching. Biooxidation research continues unabated and a few milestone patents are outlined below.

The Hackl biooxidation method was invented by Ralph P. Hackl, Frank W. Wright and Albert Bruynsteyn of British Columbia, patented in 1991 (US #4,987,081) and assigned to GB Biotech Inc of British Columbia. The method cultures of at least three species of bacteria - *Thiobacillus thiooxidans*, *Thiobacillus ferrooxidans* and *Leptospirillium ferrooxidans*. The cultures are subjected to increasing concentrations of dissolved arsenic and low pH to raise their tolerance.

The Kohr biooxidation method was invented by William J. Kohr of California, patented in 1995 (US #5,573,575) and assigned to Biotech Inc of California. Refractory sulphide ore is crushed and separated into a fine and coarse fraction. The coarse fraction is stacked in a heap, and a concentrate produced from the fine fraction. Alternatively biooxidation can be assisted by forming particulates that are then heaped (US #5,246,486) and polymer agglomeration may be beneficial (US #5,332,559).

Biooxidation of carbonaceous and carbonaceous-sulphidic ores is difficult, and requires a specific carbon-deactivating microbial assemblage (US #5,244,493).

The Oxidor column reactor for testing and evaluating refractory ores was invented by Andrew Carter of Texas and patented in 2002 (US #6,498,031), assigned to Oxidor Corporation.

Operation

The ore is first batch tested to determine if biooxidation is effective. Batch testing may require six months due to the time required for the bacteria to adapt to the substrate and the time gap between inoculation of the ore and its oxidation. The testing and evaluation can be accelerated using a device such as the Oxidor column reactor. Suitable cultures include the following species of bacteria, either alone or in combination: *Thiobacillus thiooxidans*, *Thiobacillus ferrooxidans*, *Sulfobacillus thermosulfidooxidans*, *Metallosphera sedula* and *Leptospirillium ferrooxidans*.

A bacterial culture is developed that can grow in high acidity and high metal content. The bacteria suspension is used to inoculate ore stacked in the open air resting on a pad system. Biooxidation has a choice of settings:

- tank biooxidation - for refractory ores of relatively high grade
- heap biooxidation - for refractory ores of relatively low grade.

Typically 180 to 600 days is required to oxidise the iron and sulphur in the ore. This puts pressure on cash-flow, increased the mine footprint and adds to production costs. Care is needed in the heap design to ensure fine materials do not plug the voids essential for aeration and liquid flow. Plugging results in starvation of nutrients, carbon dioxide and oxygen and uneven distribution of the bacteria. Adequate air flow is essential to cool the heap from the exothermic effects of biooxidation.

After biooxidation the resulting oxidised ore is highly acidic and, for leaching by cyanide must first be treated with lime to raise the pH substantially.

Adoption by placer gold miners

Biooxidation is inappropriate to placer gold ores as sulphides are rare and gold is in the form of free particles.

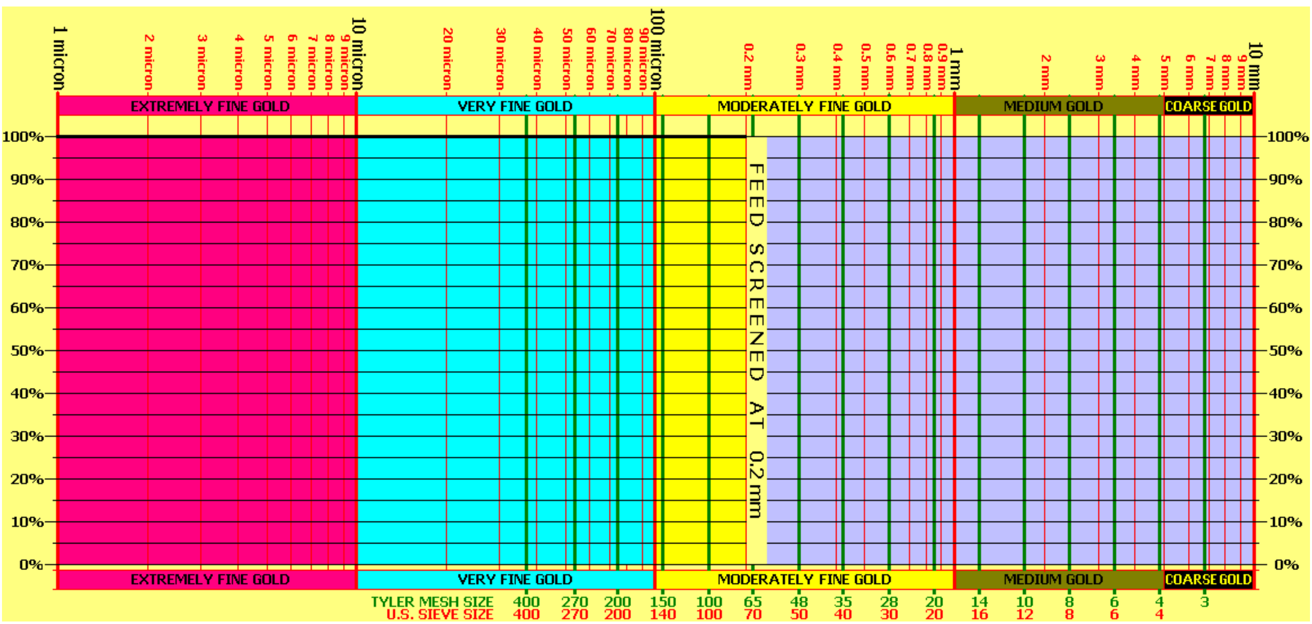

Figure 67. **GOLD RECOVERY BY BIOOXIDATION**

Biooxidation can oxidise sulphide ores sufficient for leaching. (compiler: Robin Grayson)