

30: Bioleaching – 1980s research in Wales and California

Bioleaching is the extraction of metal from its ore by means of microbes. An introductory account can be read at: <http://en.wikipedia.org/wiki/Bioleaching>.

The Pooley method of bioleaching was invented by Frederick D. Pooley of Wales and patented in 1987 (US #4,497,778) with limited success.

The Geobiotics method of bioleaching was invented by Dennis Kleid, William Kohr and Francis Thiobodeau of California who applied for a patent in 1992, awarded in 1995 (US #5,378,437). It met with greater success. The method is suitable for ores of grades as low as 0.02 Troy ounces per ton. Advantages are:

- ✘ economic: simple and cheap, and few technicians required;
- ✘ environmental: the microbes are natural and easy to cultivate.

Disadvantages are:

- ✘ economic: bacterial leaching process is very slow;
- ✘ environmental: Sulphuric acid and H⁺ ions can leak and turn surface water and groundwater acidic, and heavy metals such as iron, zinc and arsenic be leached by acid mine drainage.

Suitable microbes include:

- ✘ algae – *Chlorella vulgaris*, *Cyanopora paradoxa* and *Cyanidium caldarium*;
- ✘ blue-green cyanobacteria – *Anacystis nidulans*;
- ✘ bacteria – *Chromobacterium violatum*, *Chromobacterium flavum*, certain *Bacillus* species (*pyocyaneus*, *fluorescens*, *violaceus*, *mesentericus*, *nitrificans*), certain *Pseudomonas* species (*aeruginosa*, *fluorescens*, *aureofaciens*, *cyanogena*, *liquifaciens*, *cepacia*); and
- ✘ fungi – notably *Marasmius oreades* ('Fairy Rings'), the Snow Mould basidiomycete and some *Fusarium* species.

Cyanogenesis is the same in all these microbes, by the oxidative decarboxylation of the glycine in a process stimulated by methionine or other methyl-group donors:



An interesting approach is to co-culture microbes:

- ✘ bacteria producing glycine in bulk;
- ✘ same bacteria able of absorbing gold-cyanide ion complexes;
- ✘ micro-organisms liberating methionine in bulk; and
- ✘ algae able to produce cyanide from a glycine substrate.

Operation

This text is based on the Geobiotics method of bioleaching as presented in US patent #5,378,437.

Mass cultivation of the chosen micro-organisms is undertaken in outdoor ponds in a sunlit site close to the ore body. The culture pond is lined with plastic or concrete and the water body is 10-30m wide and 20-50m deep. The culture pond is fitted with a pumping system to permit harvesting and recirculation of the growth media.

Algae are the most convenient. Each species has particular tolerance of physical and chemical conditions, and nutritional requirements including phosphorous, nitrogen, sulphur, iron, manganese, trace elements and ions. The pond is kept strongly alkaline, pH7-10, by adding lime or phosphate buffer. Following guidance of the patent, annual yields of 40 dry tons per hectare are possible, and the microbes are sprayed onto the ore from the pond at the time of maximal cyanide production. Bioleaching may be done in three settings:

- ✘ tank bioleaching – milled ore in a tank;
- ✘ heap bioleaching – milled ore in a heap; or
- ✘ in-situ bioleaching – blasted ore in situ.

Oxidation of gold to gold-cyanide complexes commences once the microbes contact the ore, often with the gold (I) ion – [Au⁺][CN⁻]₂. Biosorption is “automatic and immediate” even if the microbes are dead.

The fluid with microbes and biosorbed gold is pumped into a settling pond or tank at least 3m deep and allowed to settle, aided by flocculants. The sludge of living and dead microbes is harvested and the biosorbed gold recovered.

Adoption by placer gold miners

Bioleaching has not been adopted by placer gold miners as it poses too many challenges. Eventually a simplified version may be acceptable.

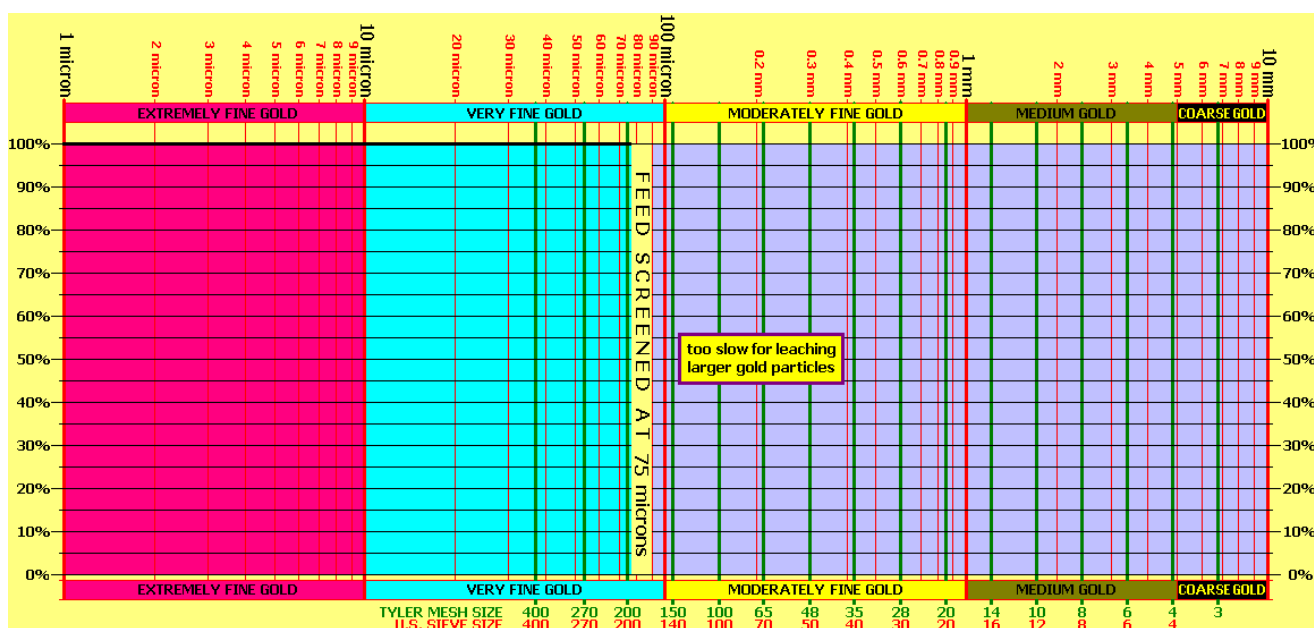


Figure 66. GOLD RECOVERY BY BIOLEACHING. Bioleaching can dissolve (leach) >90% of gold smaller than about 75µ, but is too slow for leaching larger gold. (compiler: Robin Grayson)