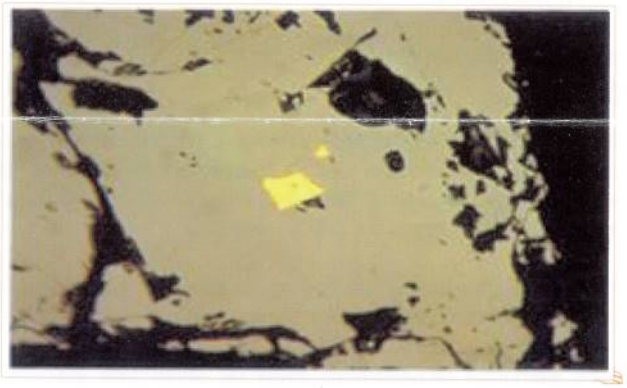
Refractory Gold: Opportunity or Problem

Free milling simple gold ores will always generate the maximum profitability. Complex and refractory gold ores on the other hand involve higher capital and operating costs as well as higher technical risks.

The degree of "refractoriness" can vary from mild to extremely refractory gold ores (solid solution gold). Scanning Electron Microscopy can determine the nature and occurrence of the gold and its liberation characteristics.

In the majority of cases, but not always, refractory gold ores are sulphidic in nature. This means that flotation is invariably the first process option to consider. This is relatively straight forward and achieves high gold recovery. The higher the gold to sulphur ratio the better in terms of downstream processing options. For refractory gold ores gravity recovery is usually poor and of little benefit.

The processing options for the concentrate represent the greatest challenge technically. The concentrates can be roasted, sold to a smelter, bacterially oxidised, subjected to pressure oxidation (POX), subjected to ultra fine grinding (UFG), or processed by some of the new technology options.



Refractory Gold in Sulphide

If the concentrate contains marcasites or pyrrhotite shipment may be a problem because of spontaneous combustion.

Traditionally roasting of the concentrates was used to remove sulphur and arsenic followed by leaching of the calcine. This was the lowest capital and operating cost. However with changing environmental regulations it represents the highest capital and operating cost when the cost of meeting new regulations is taken into account.

POX is a high capital cost option that usually requires its own oxygen plant and has a very high capital cost. Gold recovery is usually very high and a low cost neutralising calcrete is required. Macraes, Lihir and Porgera are examples of such projects.

Bacterial Oxidation (BIOX) has a chequered history of success and failure. There are many issues such as water quality, cooling, nutrients and materials of construction but the technology is getting better. Harbour Lights, Youanmi, Beaconsfield and Wiluna are examples of such Australian projects.

Ultra Fine Grinding (UFG) uses Isamill technology to grind the ore to sub 10 microns and then leach the ore. The risks are low but power costs and suitable low cost grinding media are important. This is particularly applicable to particulate refractory gold ores. An example of the use of this is by Kalgoorlie Consolidated Gold Mines (KCGM)

The Albion process represents atmospheric leaching technology which is emerging and attractive.

Geobiotics represents using barren concentrate coated scats which are bacterially oxidised in heaps and then processed in a conventional carbon in pulp (CIP) plant.

For one project the outcomes were:

ASPECT	ROASTING	BACTERIAL LEACHING	PRESSURE OXIDATION	ULTRA FINE GRINDING
Technical Risk	Low	High	High	Low
Environmental Risk	High- depending on gas clean up	Low	Lowest	Low
Capital Cost	Prohibitive	High	High	Low
Operating Cost	Low	High	High	Low
Simplicity	Not with gas cleaning	No complex plant	No materials of construct	Simple
Acid neutralisation	low	High	High	Low
Cyanide use	Medium	High	High	Modest
Power consumption	Low	Very High	High	Medium
Materials construct	Typical	Exotic	Exotic	Typical
Process Chemistry	Simple	Complex	Complex	Simple
Major Driver	Sulphur level	Power cost/Au:S ratio	Operating pressure & temperature	Power cost
History	Tried & true	Poor, failures	Difficult	Good, growing
Operability	Simple	Difficult, learning Curve applies	Fine, getting better all the time	Good, wear issues Power cost impt
Recovery	Very good	Subject to "bug Health"	Excellent	Grind sensitive