

### 7: Thiourea – chemical leaching of gold

Thiourea has been heralded for decades as an alternative to cyanide, but as yet few if any industrial operations have proved to be a commercial success. In theory, thiourea can be used to recover gold from milled hardrock, and has potential for leaching gold from placer concentrates. Thiourea leaching can proceed four or five times faster than cyanide leaching, making thiourea more effective at dissolving large gold particles, such as those typical of placer gold. [42]

Thiourea CS(NH<sub>2</sub>)<sub>2</sub> is an organic compound that is classed by INCHEM/WHO as, “toxic. Known animal carcinogen and probable human carcinogen. May cause irreversible effects. May affect fertility. May be fatal if swallowed. May cause allergic skin reaction. May cause skin ulcers, liver damage. Handle as a carcinogen. Gloves, safety glasses, good ventilation. Protect against spills and the spread of dust.” An end product is cyanamide that contains the cyanide radical and reacts with acids to form a highly toxic gas. Cyanamide is toxic if swallowed, harmful to the skin and is an eye irritant.

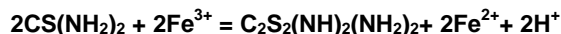
The thiourea method uses a weak solution of thiourea in the presence of an oxidising agent to dissolve (‘leach’) fine gold into solution, and then precipitate it as easy-to-recover gold.

In thiourea leaching of gold, ferric iron (Fe<sup>3+</sup>) is used as an oxidising agent, it being the most effective compared to alternatives such as hydrogen peroxide, sodium peroxide, ozone, potassium permanganate and formamidine disulphide. In contrast, cyanide leaching uses oxygen as an oxidising agent direct from the air.

Sufficient ferric iron (Fe<sup>3+</sup>) should already be liberated and available to make the addition of more oxidising agent either limited or unnecessary for a highly oxidised hardrock ore, or in a typical placer ore.

#### Operation

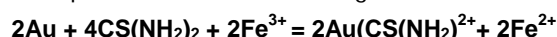
Thiourea is usually supplied in powder form sourced from specialised manufacturers. A weak solution of thiourea is prepared, and the first stage is the oxidation of thiourea to form formamidine disulphide:



The role of the formamidine is to oxidise the gold to form a gold-thiourea complex:



Importantly, “formamidine acts as an oxidiser as well as a complexing agent, supplying about 50% of the ligands to the complexation” and due to this thiourea leaching of gold is faster than cyanide leaching [43]. The overall equation for thiourea leaching is:



To drive the equation to the right, thiourea must be present in excess, and “the ratio of complexing and oxidising agents must be carefully adjusted” to avoid excessive oxidation of the thiourea solution and consequent excessive use of reagents [43].

In a final step, the formamidine breaks down irreversibly to cyanamide and elemental sulphur.

The sulphur is a potential problem to the success of the thiourea method, for it forms a fine grained sticky coating which can inhibit the leaching of gold.

#### Adoption by placer gold miners

The author is unaware of thiourea leaching being used at large-scale placer gold mines, large or small. The main deterrent is the uncertain technology, variable results and difficulty of controlling the process efficiently.

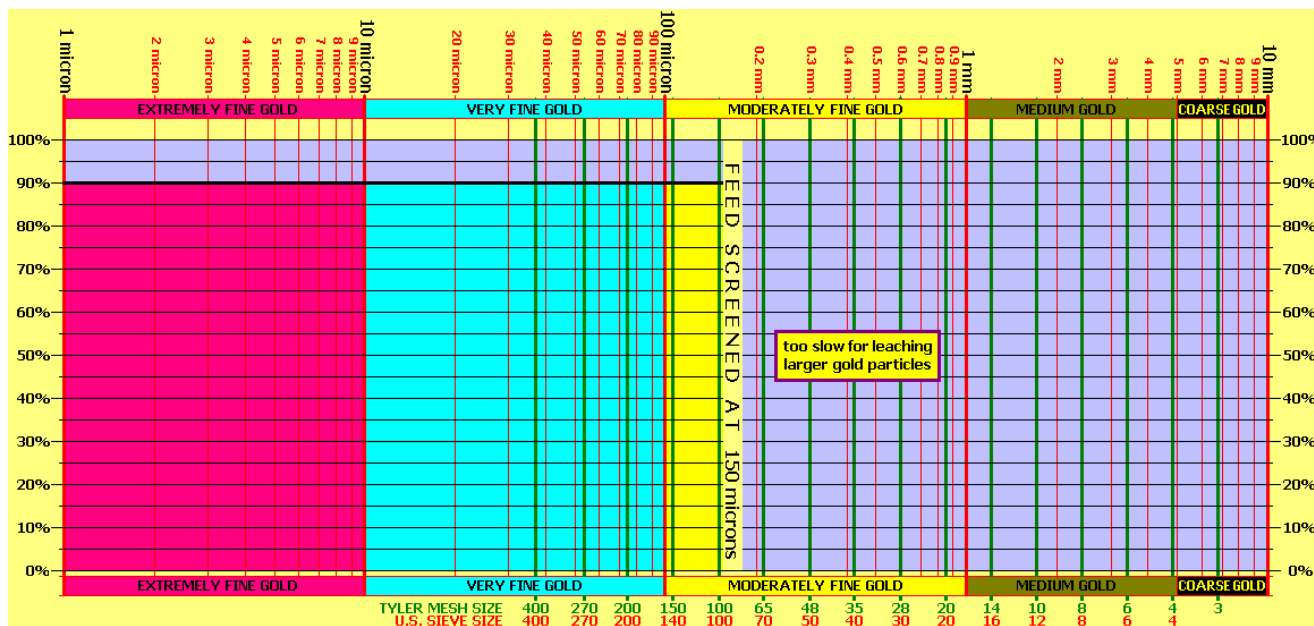


Figure 21. GOLD RECOVERY BY THIOUREA LEACHING  
Thiourea can dissolve (leach) >90% of gold smaller than about 150µ, but is too slow for leaching larger gold. (compiler: Robin Grayson)