DIRECT SMELTING OF GOLD CONCENTRATES AS AN ALTERNATIVE TO MERCURY AMALGAMATION IN SMALL-SCALE GOLD MINING

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AGENDA
For Environment and Responsible Development

INTRODUCTION

- In ASGM around the world, mercury is used to recover gold particles from concentrates.
- Mercury is added during comminution, gravity concentration or more commonly after gravity concentration, when the gold is concentrated along with heavy black sands.
- During amalgamation, mercury is added to the gold concentrate and agitated vigorously to force it and gold particles to make contact, which results in a pasty amalgam.
- This is subsequently separated from the black sands and after 'squeezing' out excess mercury, the amalgam is often heated in the open air to obtain 'sponged' gold.
- Mercury is lost in the process either as globules due to spillage and careless disposal of amalgamation residues, as well as in gaseous form, released during the heating of the amalgam.

Introduction.....

- It is estimated that for every gram of gold recovered by ASGM, there is an equivalent or more amount of mercury is lost to the environment.
- Due to increased gold price in the global market, ASGM attracts more people hence, more mercury is released into the environment

Mercury-Gold Amalgam (approx Au: Hg = 1: 1.4)

Introduction.....

- Mercury is a toxic metal and when methylated, it becomes extremely toxic.
- Its impacts on the environment and human health in communities where ASGM flourishes have been documented
- Work undertaken in sub-Saharan Africa, Asia and Latin America shows that in small-scale mining communities, both miners and non-miners are exposed to mercury to varying degrees of exposure and contamination
- In response to levels of mercury intoxication in ASGM centres around the world, several interventions have been made with the aim of reducing its usage and losses to the environment
- Those includes retorts, coal gold agglomeration process, smelting, and leaching processes



Direct smelting

- As an alternative to extracting gold (from a concentrate) using mercury, the entire concentrate is melted. The gold sinks to the bottom of the melt and after cooling, gold can be separated by breaking off the glass-like slag.
- This method is sometimes referred to as the borax method, because sodium tetraborate (borax) one of the possible "fluxes" used in the process.
- Advantages
  - Does not use mercury, reduces health and environmental problems.
  - If concentrates contain unliberated gold, direct smelting can capture it whereas mercury will not. i.e. under some circumstances it gets more Gold
  - however only a very limited mass can be smelted (see obstacles)
- Requirements
  - An ore type and processing method which permits miners to create a concentrate containing at least 2% gold
  - Borax and other fluxes
  - Additional tools including small hammer, tongs, gloves

Direct smelting....

- Obstacles
  - Can only process a small mass of ~ 50g per smelt
  - At 2% 50 g of concentrate would only contain 1 g of Au so in reality this method is more suitable for high grade low mass concentrates
  - Heating requires power which is energy over time (watts) and in any system there are energy losses.
  - This means that melting double the mass of concentrate will require more than double the time if the same energy is applied.
  - The implications are (i) that direct smelting is difficult to scale up to larger masses; (ii) it cannot directly replace the action of mercury on a large mass of concentrate (like 1kg or 10kg).
  - The mass must be reduced to an amount that is meltable in a relatively short time.
  - The ability and patience required to produce high grade concentrates without losing gold in the process
  - Capital investment in equipment and materials – the cost of a direct smelting kit produced in Ghana by University of Mines and Technology (UMAT) is 500-1000usd.

Direct smelting....

Ghanaian method

- A small specially made furnace capable of > 1200 degree C
- Cone shaped clay crucibles that can withstand up to 1500C
- The Ghanaian direct smelting kit is designed to smelt around 50g of concentrate in 20 minutes.
- Heating a larger mass requires more time and more fuel or different equipment.
- 50 grams of a 5% gold concentrate will produce a 2.5 gram bead of gold.
- If smaller than this, the gold bead becomes more difficult to collect and losses to the slag are relatively greater - losses are never zero but percent loss decreases with increasing grade of concentrate

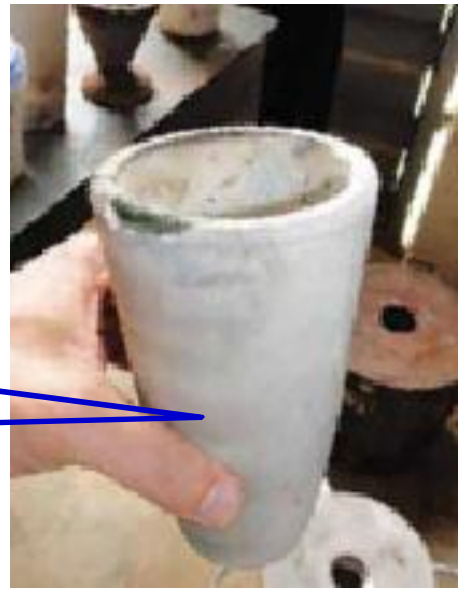
Direct smelting....

- ST EP 1: Produces 50-100 grams of concentrate containing at least 5% gold.
- ST EP 2: Place the concentrate in a high temperature clay crucible. If the concentrate contains sulphide minerals it may help to first oxidize it by hand with a torch.
- STEP 3: Mix in appropriate fluxes and reagents to lower the melting temperature and viscosity of the non gold minerals. The most effective recipe will depend on the ore and must be learned experimentally. Two common recipes are provided below (by mass)
- ST EP 4: Place crucible in furnace and heat until the melt is above the melting point of gold (1064 degrees C) for at least 5 minutes.

Cone-shaped clay Furnace for Ghanaian method

This will produce two separate liquids or "melts"
– a silicate melt that is typically thick but light (low density), and a metallic melt of the gold and other metals such as silver lead and copper.

crucible for use in Ghanaian method furnace



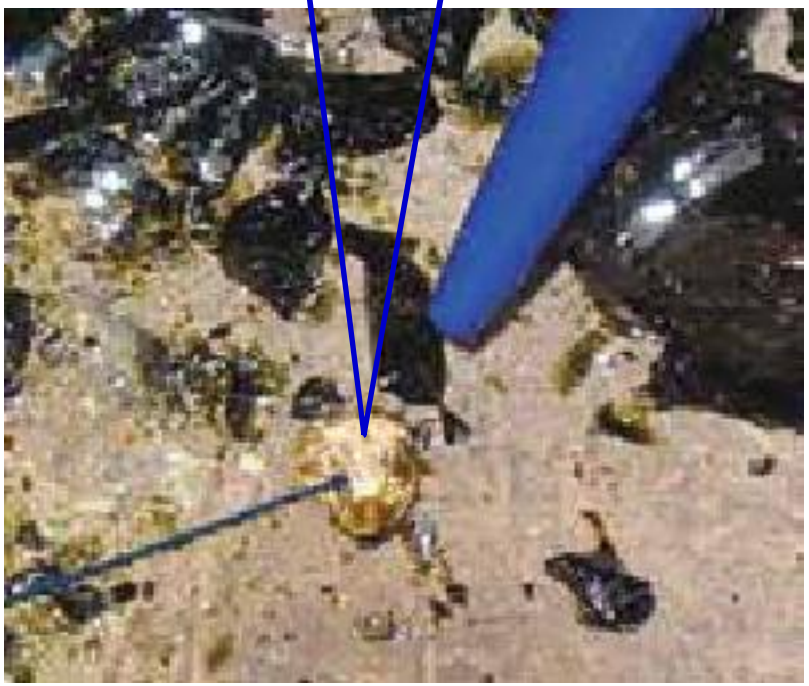
Direct smelting....

- STEP 5: Remove the molten concentrate (the melt) from the furnace and pour into a cuppel. The gold will sink into the bottom tip of the cuppel.
- STEP 6 Cool and remove the cone shaped solid from the cuppel and break the gold off the bottom with a hammer. Wire brush to clean.
- Mixing ratios of the ore concentrates and smelting fluxes are:

Furnace in operation

Pouring melted concentrate into a cuppel

Gold bead after separation from slag



Direct smelting....

- Mixing ratios of the ore concentrates and smelting fluxes are:

Option Ratio 1	Option Ratio 2
1 part concentrate	1 part concentrate
1/2 parts borax	1/2 part borax
1/2 part CaO (lime)	1/2 part potassium nitrate
	1/2 part silica

Conclusion

- Direct smelting works best and will be most appealing for situations where a high grade concentrate with significant un-liberated gold in it can be easily produced.
- In such cases it can obtain more gold than use of mercury. It will not however be able to replace mercury everywhere - it is a special case.

Thanks for your attention