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SMALL-SCALE GOLD MINING OPERATIONS IN BENGUET AND CAMARINES NORTE, PHILIPPINES

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ABSTRACT

Small-scale gold mining in the Philippines has been practiced since the early 1900s. Today, however, with more than 100,000 families currently involved in the operation, more "modern" methods have been employed. A more sophisticated system for mining the ore has been developed, and gold production is being done through amalgamation. Inspite of the low efficiency of the method and the hazards to health, the people find amalgamation the most convenient method in terms of economics. This paper reports the activities connected with the recovery of gold in the small-scale mining communities in Benguet and Camarines Norte.

I. INTRODUCTION

Since the early 1900s, small-scale mining operations have existed in the Philippines, especially in the northern provinces of Luzon, the largest island. Two interesting regions are found in this island. These regions have been experiencing frenzied small-scale mining operations due to the presence of many gold prospects. Presently, the number of small-scale miners have escalated from a mere handful to a little over a hundred thousand (100,000) people (Broad, 1993), spread all over several gold-rich communities the Philippines. This paper chronicles the related activities of a typical small-scale mine observed during a visit to Benguet and Camarines Norte provinces of Luzon.

II. SMALL SCALE MINING AREAS VISITED

The mining communities visited were Balatoc and Antamok, in Itogon, Benguet Province, and Paracale-Gumaos in Camarines Norte Province. Other gold rush areas like Davao, Surigao, and Agusan in Mindanao island were not visited due to problems in peace and order.

Primarily, these two areas have been gold-producing regions for several hundred years (Bureau of Mines, 1973). Both have been mined by large companies before low metal prices forced their closure in the late 1900s. These areas are now occupied by small-scale miners who use amalgamation to recover the free gold. Amalgamation is the most economical method for recovering gold for them. Awareness of the ill effects of liquid mercury, which is being used liberally during amalgamation, appears to be low.

The area shown in (**Figure 1**) is the former tailings pond of Benguet Corporation in Balatoc. It is used as the Central Tailings Dam of the small-scale mining communities and is where 72 ppb of mercury has detected. Also, in (**Figure 2**), women are seen sorting and washing the gold bearing rocks from the same area.

Figure 1. The Open Pit of Benguet Corporation, now the Central Tailings Dam.

Figure 2. Women Sorting and Washing Gold-Rich Rocks

Baguio City can be reached by car from Manila in six hours. From Baguio City, vehicles can reach Balatoc and Antamok in two hours over partly paved roads. On the other hand, the town of Panganiban in Camarines Norte can be reached in ten hours through a mountainous route in Quezon Province from

Manila. The small-scale mining site in Gumaos, about twenty (20) kilometers away from Panganiban, can be reached in one hour due to bad roads.

III. MINING METHODS

The typical residences in the small-scale mining communities of Benguet are built on steep slopes. Concentration and amalgamation processes are usually done beside the residences. The raw materials are taken from operational holes through entrances **(Figure 3)** leading down to drifts where the gold ore is mined. The entrance is roofed and locked to prevent thievery. Gold ore is mined in tunnels which are connected to the surface by drifts and shafts. Ore is then put in sacks and stored in bins **(Figure 4).**

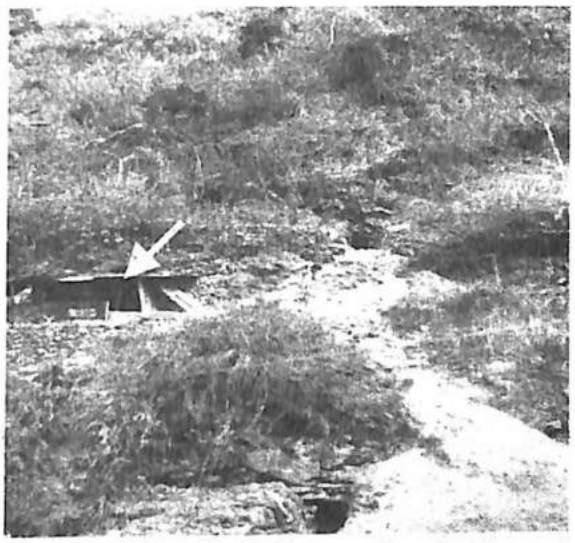

Figure 3. An Operational Hole in the Site Showing an Entrance to the Drift.

Figure 4. A Bin Where the Sacks of Ore are Stored Prior to Processing.

The drifts are well-made. Apparently some small-scale miners gained much experience by working for big mining companies in the past and applied their skill in their own small-scale mining operations. Most of the miners in the area are former employees of Benguet Corporation when it was operating both the Antamok Gold Operations and the Paracale-Gumaos Gold Operations. The company closed operations three years ago due to economic difficulties.

The support system for the drifts impressed the mining engineer consultant who accompanied us to the site. The safety of the mine workers was of primary consideration in the construction of the support system. The ventilation and lighting system were also sufficient to support an efficient operation. An improvised mine-cart-rail system transported the mined ore to the dump area. **(Figure 5)** shows a portal fitted with make-shift rails while **(Figure 6)** shows a portal with an improvised mine car at the entrance. The usual procedure in transporting ore out of shafts utilizes three men. One man is posted at the top of the shaft, and it is his duty to pull up the pail containing the muck. The two other men go down and dig the ore. Communication inside and outside the shaft is through signals using the rope that is connected to the pail.

Figure 5. A Mine Portal with Rails for Ore Transport.

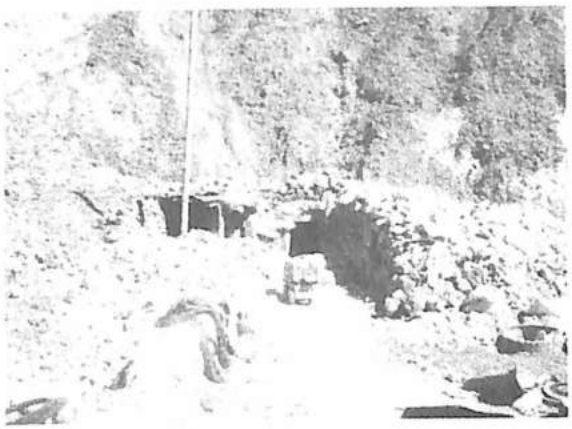

Figure 6. A Portal Showing an Improvised Mine Car for Ore Transport.

IV. GOLD AMALGAMATION IN THE BENGUET AND CAMARINES NORTE SITES

The concentration and amalgamation methods for both areas are basically the same. The flowsheet is outlined in (**Figure 7**). Primarily, the run-of-mine ore is crushed and ground to a fine size, usually 100-mesh using a ball mill. A typical ball mill in operation is illustrated in (**Figure 8**). The ground ore is then emptied onto a bin. The bin is thoroughly cleaned before a fresh batch of ore is introduced (**Figure 9**).

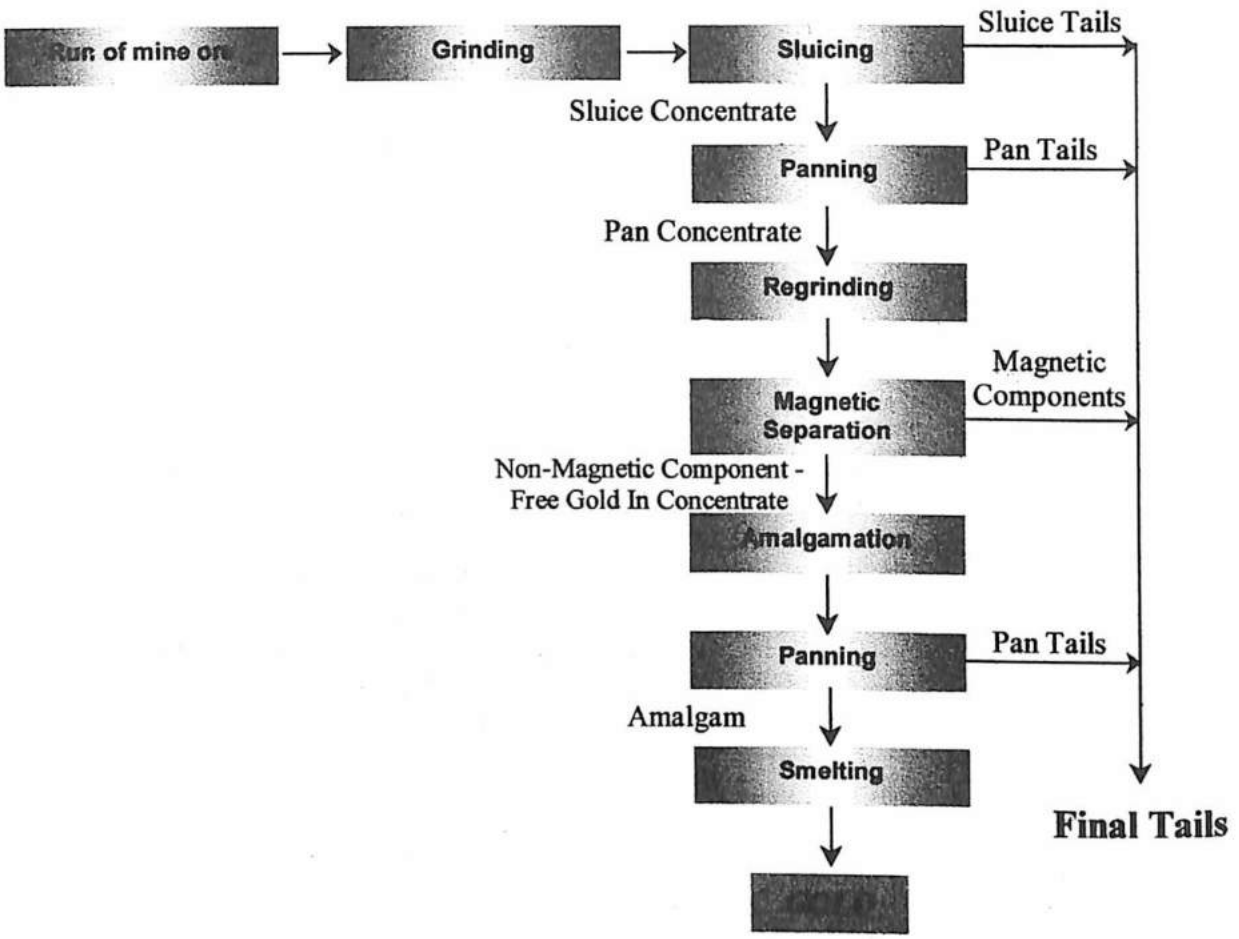

Figure 7. Basic Flowsheet for the Amalgamation of Gold.

Figure 8. Operating Ball Mill.

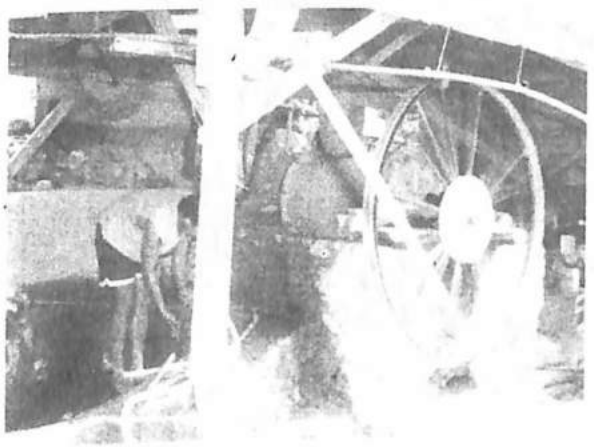

Figure 9. The Bin is Cleaned Thoroughly

The discharge from the bin is passed through sluice boxes (**Figure 10**). A thin film of water is passed over the concentrate to separate the precious minerals. The flow of water carries with it the light minerals while the gold is left as a sluice concentrate. The concentrate is then collected manually (**Figure 11**) by scooping and then transferred to a separate pan.

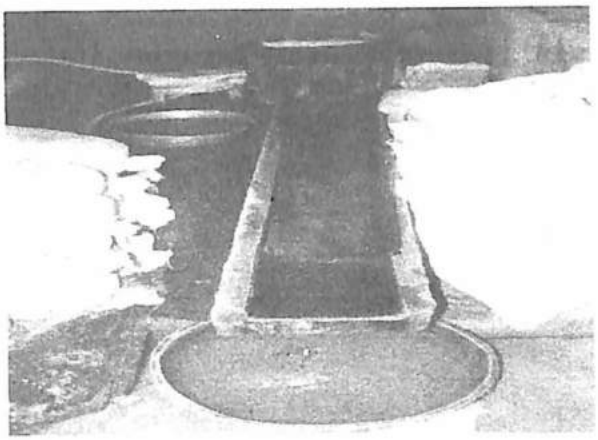

Figure 10. The Sluice Box

Figure 11. Concentrate Collection

The sluice boxes are usually fitted with removable canvas floorings to facilitate the collection of middlings and fine concentrates that may have rolled off due to the current of water (**Figure 12**). The canvas is removed and then washed in barrels (**Figure 13**). The washings are then let to settle. The settled particles are collected and combined with the panned concentrate for the subsequent amalgamation and smelting processes.

Figure 12. Canvass Cover on Sluice Box.

Figure 13. Barrel Where Canvass is Washed.

The concentrates are then panned using 16 to 20-inch in diameter pans. The pan is swirled to facilitate the segregation of the light and the heavy minerals (**Figure 14**). Gold, being a heavy mineral, settles to the bottom of the pan. A laminar flow of water exposes the gold at the bottom of the pan (**Figure 15**). After panning magnetite is removed using a magnet wrapped in plastic to facilitate collection (**Figure 16**). The non-magnetic portion is ground further using a hard stone to ensure complete liberation of the gold. The hard stones are carefully chosen to avoid those with cracks since the gold could easily be trapped in these cracks (**Figure 17**).

Figure 14. The Panning Process Using a Wooden Pan.

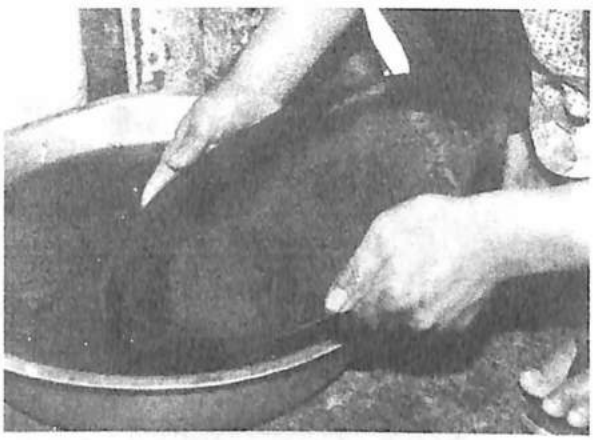

Figure 15. The Panned Concentrate

The finely ground material is returned to the pan and panning procedure repeated. The free gold particles are then transferred to another container called a "kuskusan" where mercury is added (**Figure 18**). During amalgamation, pressure is applied to the mercury on the "kuskusan" to allow the complete adsorption of the gold. Gold and silver form amalgams with mercury. To ensure complete amalgamation, the mercury is brought back to the pan and pressure is applied to the amalgam using the thumb (**Figure 19**). The panning process is repeated to separate the mercury amalgam from the rest of the material. The amalgam is then collected using bare hands and pressed firmly into the palms to ensure coherence (**Figure 20**). This "ball" of mercury is then wrapped in plastic with short straw for easy handling during the smelting process (**Figure 21**).

Figure 16. Magnetic Separation.

Figure 17. Putting Pressure on Mercury with a Rounded Stone.

Figure 18. Mercury in the Kuskusan

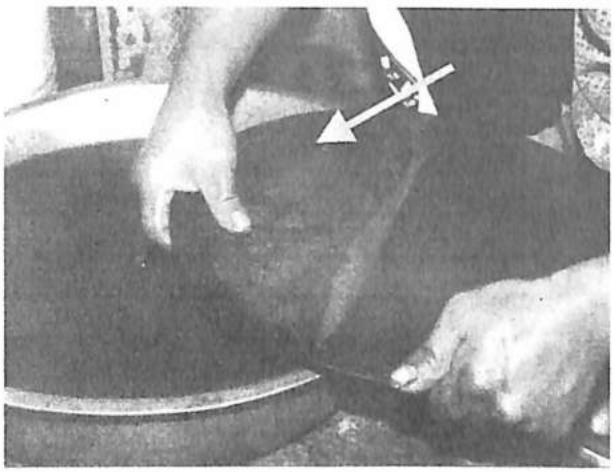

Figure 19. Pressure Applied with the Thumb

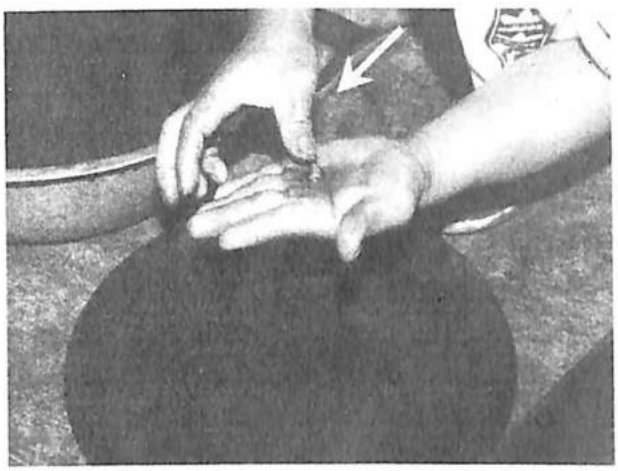

Figure 20. The Amalgam Being Balled in the Palm.

Figure 21. The Amalgam in a Plastic Ball.

An empty clay crucible is placed under a pile of charcoal and pre-heated until it turns red-hot (**Figure 22**). Air is pumped into the pile from a manually rotated blower. The amalgam wrapped in the straw is placed inside the hot crucible (**Figure 23**). Mercury is then allowed to evaporate. No means of collection for the mercury vapor has been introduced in any phase of the collection. The melted gold left in the hot crucible is then water-quenched to produce a button of gold (**Figure 24**).

For a vein material containing around 220 grams gold per metric ton of ore, forty five to fifty kilograms of the ore material (one sack) yields a button of gold containing 3 to 5 grams. This represents a recovery of around 27%.

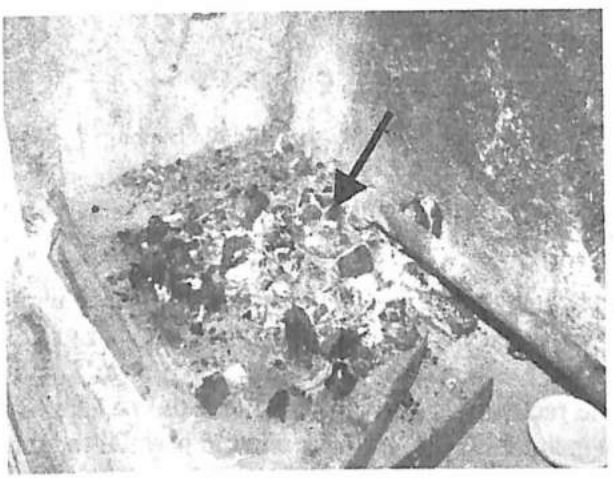

Figure 22. The Crucible Covered With Coal.

Figure 23. The Red Hot Crucible.

Figure 24. The Gold Button.

V. CONCLUSIONS

Small-scale mining has been in existence in the Philippines for more than a hundred years. At the present, with the rising cost of gold, most small-scale miners actively practice amalgamation to recover gold. It has been noted, however, that the recovery is quite low and that the resultant tailing materials contain mercury in amounts that have been found harmful to humans.

Thus, we are encouraged to continue with our research on the various means of eliminating mercury in our wastewater systems.

VI. ACKNOWLEDGEMENTS

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