



Global Mercury Project



Technical Mission to the Artisanal Gold Mines in Upper Guinea

by

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Introduction

The Blacksmith Institute together with the GEF/UNDP/UNIDO Global Mercury Project sponsored the mission of three technical experts namely Marcello M. Veiga, Shefa Siegel and Patrick Schein to investigate the use of mercury in artisanal mining operations and to transfer knowledge about controlling mercury and cyanide in the gold mining industry to local authorities such as representatives of Ministry of Mines, Ministry of Environment, Ministry of Health as well as Prefectures of Mandiana and Kouroussa. The mission was conducted from April 17 to 27, 2006.



Fig. 1 – Map of Guinea, showing the main area of artisanal gold mining activities in Upper Guinea - red circle (Source: 2000 maps.com)

The local counterpart was The Centre d'Appui au Développement (CAD) a NGO based in Conakry with long history of implementation of rural development projects in the interior of Guinea. Mr. Cheick Camara and Joachim Dejean were the CAD representatives in this mission. Also as a counter part, Mr. Djibril Kamara representing the Guinea Ministry of the Environment, followed all the training classes and the filed trip to the gold fields in the Northeast of Guinea. The mission also counted with the valuable presence of Dr. Amadou Diouf from the Faculty of Medicine and Pharmacy of the Université Cheikh Anta Diop (UCAD), Dakar, Senegal.

The mission consisted of a series of classes to Guinean Government representatives and field visits. The classes were given by Marcello Veiga at the CAD headquarter in Conakry. The topics addressed in the 2-day classes were as follows:

1. artisanal gold mining around the world
2. mercury and gold processing methods used by artisanal miners
3. environmental and health effects of mercury misuse
4. techniques to reduce mercury emissions
5. techniques to increase gold production
6. awareness campaign used by the Global Mercury Project in African countries
7. use of cyanide in mining
8. environmental and health effects of cyanide complexes
9. problems with the joint use of cyanide and mercury in artisanal mining
10. sustainability aspects of artisanal mining,

The field visits took place at the Prefectures of Mandiana and Kouroussa in the Upper Guinea Region in which the artisanal mining activities are rampant.

The mission also consisted of meetings with the Minister of Environment, Director of Geology of the Ministry of Mines, Director of the Guinean Central Bank and Director of the Ashanti Goldfields, a mining company operating in Siguiri.

General Information about Gold Mining in Guinea

The main artisanal gold mining districts are located in Kouroussa, Siguiri, Mandiana and Dinguiraye. Artisanal mining has been conducted in Upper Guinea since the 12th Century when it has been indicated that 90-125 tonnes of gold were extracted. There are documents from 1909 to 1914 describing mechanized gold mining activities in the region of Siguiri-Mandiana. Geological exploration missions were conducted by French geologists in 1930s and 1940s, but only from 1961 to 1963 a mission of Russian geologists detected an important orebody in the Siguiri region. From 1970 to 1981, Chinese and Canadian companies established a vast program of geological exploration that has resulted in the establishment of gold ore reserves. The concessions were acquired by l'Union Miniere de Belgique in 1984. In 1998 the South African Ashanti Goldfields (85%) and the Government of Guinea (15%) established a mining company in Siguiri employing heap-leaching cyanidation to produce 10 tonnes/a of gold. In 2006 the company started a Carbon-in-Pulp circuit operating with ore with average grade of 1.54 g Au/tonne. Their proven reserve is 59.3 million tonnes of ore. The company has 1495 km²

of mineral leases and the company representative has mentioned that part of this area has been invaded by artisanal gold miners.

Three organized mining companies have produced in 2005 about 14.5 tonnes/a of gold in Guinea of which 9.5 tonnes came from Ashanti Goldfields, 2.5 tonnes from the Société Minière de Dinguiraye (SMD) SMD and 2.5 tonnes from SEMAFO. The SMD is 85% owned by Kenor of Norway (now Guinor Gold Corp) and 15% by the Guinea Government. They operate the Lero – Karta mine in Northern Guinea. SEMAFO'S Kiniero (previously Jean Gobebe) mine is a Canadian TSX listed company and it was officially opened in April 2002. It is located 500 km Northeast of Conakry in central Guinea.

The Upper Guinea region is experiencing remarkable mining activities with 200,000 to 300,000 miners. The amount of gold produced by artisanal miners in Guinea is estimated by the Central Bank to be around 6 tonnes/a. It is also estimated that about 2.3 tonnes/a of gold are smuggled to neighboring countries, in particular Mali. The Central Bank of Guinea controls all gold exports and has revealed that there is just one official private gold exporter in the country who exports about 4.8 tonnes/a.

In both sites visited in Mandiana and Kourossa, at least 50 to 70% of the miners are women, and children might represent 10 to 20% of the work force. All processing steps, such as ore-transporting, crushing and panning, are conducted by women and kids. It was not observed any woman in the mining shafts but we have spoken with two kids around the ages of 10-14 who were both shaft workers.

In interview with miners it was revealed that they work 5 days a week (they do not work Mondays and Fridays). Considering occasional stops and holidays, it is reasonable to consider that a miner work 250 days/a. Considering a population of 200,000 miners, each miner would make 30 g Au/a or 0.12 g Au/day which is almost US\$ 2/day. If we consider 300,000 miners in the country, this income is reduced to 0.08 g Au/day or US\$ 1.3/day. In Kourossa, miners mentioned that they make between 0.12 to 0.17 g Au/day/miner. This is a simplification since the division of the gold production is not quite equitable and the owner of the shaft ends with more gold (~50%) than the operators.

The Prefecture of Mandiana is reached by car from Conakry after 14 hours of driving. The main town in the region is Kankan (765 km from Conakry) which is also a commercial center for miners. The Prefect of Mandiana has estimated that out of the 180,000 people living the Prefecture region, there are as many as 100,000 people directly involved in artisanal gold mining. In Mandiana alone there are more than 600 mine sites operated by artisanal miners. The Prefect was proud to say that artisanal gold mining is conducted in the region since the Middle Age (year 780) using the same “traditional” methods.

The local Government does not have any estimate about the gold production in the region. Artisanal miners however obtain permits to mine with the Prefecture. There is no clear and formal definition of which deposit or type of operation is or must be classified as

artisanal mining, however the Prefect does not allow the miners to use any electric machine. This is also very relative and the Prefect evaluates each case separately. In fact the National Mining Code of 1986 establishes in the article 86 that *artisanal mining is allowed only for Guinean individuals using "little" mechanized methods*. In the article 89 it is said that the *authorization for artisanal mining is valid for one year and can be renewed by the General Direction of Mines and Geology, if all norms of security were followed*. It seems that the characteristics of the mining methods are negotiable since the "Chef de l'Etat" can define precisely what can or cannot be used in a mining and ore processing operation. The Code also mentions that *the "Chef de l'Etat" (President of Guinea?) defines the areas to be exploited by artisanal mining methods* but the mining concessions are given by the Ministry of Mines. The Prefect of Mandiana mentioned that the Ministry of Mines delegates this function to the Prefect. It was also mentioned by the Prefect that the Government of Guinea gives preference to organized industrial mining operations over the artisanal mining activities and this is contemplated in the Mining Code.

The Kourossa mines are situated 680 km from Conakry. The region has 50,000 miners working in 54 mine sites. In a meeting with the APOCO, a 7-month old Cooperative of Panners and Gold Buyers, it was mentioned that the gold production that is commercialized by APOCO is 10 kg/months but this represents only 30% of the region gold production.

Mining and Mineral Processing

The local Government has a strong presence in the field controlling the mining activities and the way in which the miners work. The Prefects of Mandiana and Kourossa have ensured that the miners do not use any mercury since the enforcement is very strong. In the field it was observed that miners excavate shafts with diameter of 1-1.5 meter to the depth of 10-15 meters. It was told that some miners can go as deep as 30 m. Without any forced ventilation, this seems an enormous risk. They mine the weathered layers of the ore until finding the main quartz veins. Then they stop as they do not have tools to penetrate the hard veins. The only tools used by miners are: a flash light and a metallic pick locally forged. Miners work in groups of 3-4, usually consisting of family members, for 8 hours per day. In the shafts, miners work in two shifts: 9am to 1 pm and 1pm to 5 pm. All shafts are established by a local Government representative that also controls the entrance of the miners into the site. In Kourassa, miners pay everyday 500 Guinean Francs (US\$ 0.10) to "controllers" at the moment they enter the mine sites. All miners are listed when they enter the mining area. After 5 pm the miners leave and they allow some non-listed miners to extract and process some ore. This does not last too long since it becomes dark after 6 pm.

Miners working at depth of 10 to 15 meters have low levels of ventilation and it was reported that there are frequent fatal accidents. Some shafts are less than 2 m distant from another. Some miners connect shafts with tunnels but this makes the shaft support fragile and it collapses easily. The extracted material, a mixture of quartz fragments and weathered rock, is lifted in a 5-10 kg bucket and transported by women and children to the crushing area. Crushing is conducted manually by women using wooden pestles and

mortars. Some women use steel pestles, but this is not common. The efficiency of the crushing process is extremely rudimentary and not sufficient to liberate gold particles. The ground material is then transported to small water pools filled with rain water where women and children concentrate the gold by panning with locally-made gourds (“calabace”). The process is very rudimentary as the level of clayey sediments in the water is high and all coarse quartz fragments (likely with gold inside) are discarded. Few grams of concentrate with at least 70-80% of gold are obtained by this panning process. This is dried in a bonfire and further processed by men. The heavy minerals in the dry concentrate are separated by blowing. It is evident that all fine gold is lost in this process. This reduces the weight of the concentrate to 1/5 to 1/10 of the original weight. Gold recovery process was not chemically evaluated but it is estimated that about 5-10% is the overall gold recovery of this rudimentary processing step.

It is clear that the miners need a substantial training to introduce better methods to liberate (by crushing and grinding) and concentrate gold. The amount of gold recovered from the concentrate by the blowing method is extremely low (probably lower than 5%) and they lose all flaky and fine gold particles. The mission could not find any evidence of use of mercury in the sites visited in Mandiana and Kourossa. Nobody has provided a clear reason why mercury is not used, but clearly the lack of availability and cost are the main impediments. The Mandiana Prefect mentioned that miners do not use mercury because this is bad for the environment and due to “his strong enforcement”. Miners seemed to understand that mercury use in the process would increase their gold production, but they mentioned that the Government prohibits the use of mercury and “nobody sells it”. In fact, with such a strong restriction, if someone has been selling mercury the cost might be prohibitive for these poor miners. Miners mentioned that mercury has been used by artisanal miners in Siguiri where the Ashanti-gold mining is located but this was not confirmed.

Once the gold specks are produced, they are immediately sold to gold dealers at the mine sites for US\$ 15-17/gram¹. These “djatis” (middlemen) bring the gold to town to be “refined” and melted. The specks are leached with hot concentrate nitric acid on fry pans to be melted with borax afterwards. “Refining operators” are exposed to high levels of nitrous gas as a result of the thermal decomposition of the nitric acid. These “refining” facilities are located in populated areas and neighbors definitely receive part of the nitrous gas emanating from these rudimentary operations. As the gold grains are still coarse this “refining” procedure is not very effective and just superficial crusts of iron oxide are removed. Unlikely substantial silver and copper are leached from the coarse gold particles.

Suggestions

Miners would certainly benefit from crash courses in mineral processing and mining engineering. The Transportable Demonstration Units (TDU) operating in the mine sites in

¹ US\$ 1 = 4,500 Guinean Franc (official)

US\$ 1 = 5,000 Guinean Franc (parallel market)

Price of pure gold on April 25, 2006 (London) = US\$ 625.5/oz or US\$ 20.11/g

other African countries is a landmark of the GEF/UNDP/UNIDO Global Mercury Project that transfers simple techniques to miners teaching them how to increase gold recovery without human and environmental impacts. The main problem in Guinea seems to be the lack of support from authorities to establish a long-lasting educational and financing program for artisanal miners. Without a strong organization of the miners it is hard to introduce collective solutions.

Since mercury is not used, other more efficient concentration methods using carpets or magnetic sluice (e.g. Cleangold sluice) could be introduced, however, the main bottle neck to increase gold recovery is not in the concentration process. The comminution process (crushing and grinding) is very inefficient as it is done manually with pestles. The gold liberation is definitely insufficient to improve gravity concentration. Manual ball mills made of gas tanks such as those used in Mozambique are adequate solutions. The use of electric motors is not totally prohibited and a cooperative of miners can negotiate this with the Prefect. Hammer mills or a small ball mill like the ones used in Indonesia can be extremely effective to improve gold liberation and increase substantially the gold recovery.

The possibilities of introducing mercury-free processes are very good since miners do not use amalgamation. There are a series of methods (e.g. Mintek IGoli method) to leach gold from concentrates that can be introduced. If a good gold liberation level is obtained, it is also possible to keep just the gravity concentration process as the main procedure to produce gold. However, organization is fundamental to introduce practical measures such as micro-credit. This is badly needed since these miners, as individuals, do not have possibilities to buy anything. A Cooperative or Association would empower groups of miners to acquire pieces of equipment to have their own processing centers.

It was also obvious that a complicated network of middlemen causes miners to lose significant profits from the small amount of gold they recover (0.08 to 0.17g Au/miner/day). Again, lack of a collective system for pooling recovered gold, and the difficulty of finding reliable transport to nearest trade centre in Kankan or in Kouroussa are serious impediments for miners.

Conclusion

The amount of gold produced by artisanal gold miners in Upper Guinea (around 6 tonnes/a) is significant and it has been increasing as a result of the current high price of gold and high level of poverty in the country. The gold processing methods used by 200,000 to 300,000 miners in Guinea are the most primitive ones in the planet and the gold recovery might be around 5 to 10%. This results in insignificant production levels of gold, ranging from 0.08 to 0.17 g Au/day/miner, which is one of the lowest in the African continent and probably in the world². The introduction of sluice boxes covered with carpets or even sisal would improve a bit gold concentration, however the lack of gold

² In most African countries artisanal gold miners extract 0.5 to 2 g Au/day/miner depending on the processing method used and the grades of the ore.

particle liberation by inefficient manual comminution (crushing and grinding) is likely the main cause of low gold recovery.

The establishment of Miners' Cooperatives or any other type of organization would provide the miners with possibilities to have access to micro-credit in order to establish small processing centers in the area, where appropriate crushing, grinding and concentrating plants could be installed. There are also manual-driven procedures (e.g. the Mozambiquean gas-tank-ball mills) that could bring to the attention of miners. Besides the simple technical solutions, this proposed Cooperative or Association could sell the gold production from their members directly in Conakry. This would improve immediately by 20-25% the miners' income. The empowerment and organization of miners is a necessary condition to improve their living conditions. If this is not done prior to any action, then there is risk to see any revenue improvement not being distributed fairly among miners and this will benefit mainly the landlords and middlemen ("djatis").

It was not observed the use of mercury in any of the mining sites visited in Mandiana and Kourossa. Despite the fact that amalgamation could double or triple the artisanal gold production, most miners do not have knowledge, funds or even access to mercury due to strong restrictions of the Government and high poverty. Some miners mentioned that mercury has been used by artisanal miners in Siguri, near or in the mining claims of Ashanti Goldfields, but this was not confirmed.

The many problems observed and reported in the area are:

1. narrow, deep and non-ventilated mining shafts causing visible respiration problems; fatal cases reported;
2. mining shafts not properly supported with wood and subjected to frequent collapses; fatal cases reported
3. rudimentary mining and processing methods leading to high gold losses;
4. use of nitric acid to "partially-refine" gold in populated areas; operators and neighbors are exposed to nitrous gas;
5. complete lack of sanitation at the mining sites;
6. lack of technical assistance from the Government; inspectors are frequently at the mines just to collect money;
7. extreme poverty.

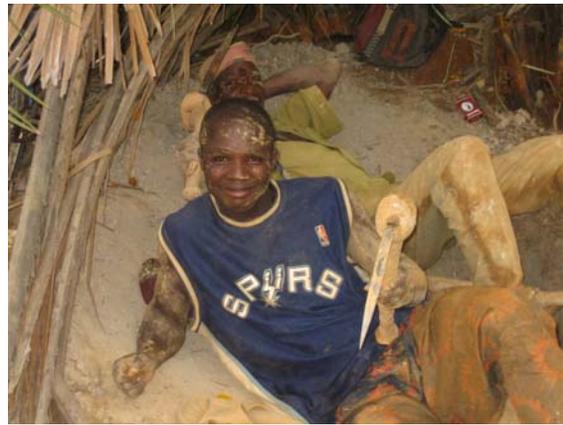
The technical knowledge of local authorities and miners related to mining and mineral processing as well as health and safety must be improved. The high level of poverty in the region creates hurdles to introduce new techniques or even to organize miners. Trust building is definitely the first step towards a technical and social intervention in the mining areas.

It seems clear that Guinea is an extremely complex country to start a project to introduce education, organization and technical procedures for artisanal gold miners. The political situation in Guinea is complex and the Government institutions are not well structured to establish a long-term efficient process towards a sustainable artisanal mining policy. Although the mines themselves are quite safe, Conakry is a threatening environment where most economic activity is clearly run by the informal sector. It would be nearly

impossible to operate at any level without confronting the demand for royalties from many different groups, making it difficult to see how project funds could effectively reach and benefit local communities. For the moment, the NGO CAD represents the only legitimate hope that a transparent system can be developed with working conditions that are both safe and effective. CAD has indicated it wished to work towards an artisanal gold mining project by conducting a national inventory of gold mining in Guinea. This initiative was encouraged, and GMP as well as Blacksmith Institute would be interested in providing analytical advice during the research period, and examining the results of the study upon completion.



Miners excavate shafts using home-made picks



Excavating tools are forged locally



The clayey ore is lifted with a 5-10 kg bucket

*Global Mercury Project and Blacksmith Institute
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Women and kids transport the ore to crushed



Women crushed the ore using wooden pestles and mortars



Women concentrate the ore in small pools using rudimentary gourds



Heavy minerals are separated from gold by blowing; at the end lots of fine gold is lost



Miners sell the gold to local gold-buyers (“djatis”)



Gold particles are leached with nitric acid to remove iron oxide crusts



Gold “cleaned” with nitric acid is melted with borax



Melted gold is transformed into bars and “cleaned” with lime



Any intervention should start removing babies from the mine sites