Artisanal Gold Mining in the Tambacounda Region of Senegal

First Report on the Reduction of Mercury Emissions Through Appropriate Technologies Training

TRAINING PHASE 1 – TRAIN THE TRAINERS

Project Team:
Olivier Savornin
Kally Niang
Amadou Diouf

Kedougou, Senegal
January 2007

A Project of the Blacksmith Institute

I. BACKGROUND

Artisanal, or small scale gold mining (also called ASGM) is one of the most significant sources of mercury release into the environment in the developing world, with at least a quarter of the world's total gold supply coming from such sources. ASGM miners combine mercury with gold-carrying silt. The gold and mercury combine to form an amalgam, making recovery of the gold easier. The amalgam is subsequently heated with blow torches or over an open flame so that the mercury burns off, and gold is left at a purity of 70 to 80 percent. The gaseous mercury is inhaled by the miners, or by their immediate family, including their children. Mercury which is not inhaled during the amalgamation process settles into the surrounding environment, or circulates globally at regional and global scales for future deposition far from the site, where it is absorbed and processed by a variety of living organisms.

As a consequence of its misuse, mercury amalgamation results in the discharge of an estimated 1000 tons of mercury per annum which represents about 30% of the world's anthropogenic mercury releases. It is estimated that between 10 and 15 million artisanal and small scale gold miners worldwide, including 4.5 million women and 600,000 children[1]. This process transforms elemental mercury into methyl mercury. Methyl mercury is one of the most toxic organic compounds and a powerful neurotoxin that works its way up the food chain through bioaccumulation. According to UNIDO, as much as 95 percent of all mercury used in ASGM mining is released into the environment, constituting a danger on all fronts – economic, environmental and most tragically, human health.

There are a number of cleaner technology alternatives to current methods of mercury amalgamation. The use of retorts during the mercury burn-off stage is a simple and cost-effective way to decrease the occupational exposure to mercury and minimize its release into the environment. Retorts allow for the efficient capture and reuse of mercury.

Experience has shown that the biggest barrier to the uptake of such technology is educational. This project was implemented in conjunction with the Global Mercury Project, Africaclean, USEPA and the Government of Senegal to break this cycle of dangerous mercury use by supplying ASGM miners with the education and technology needed to minimize their exposure to mercury and its release into the environment.

[1] Veiga, M.M., Baker, R. (2004). Protocols for Environmental and Health Assessment of Mercury Released by Artisanal and Small Scale Miners, Report to the Global Mercury Project: Removal of Barriers to Introduction of Cleaner Artisanal Gold Mining and Extraction Technologies, GEF/UNDP/UNIDO, 170p.

Gold mining in Eastern Senegal

PROJECT LOCATION: The Tambacounda Region

The Tambacounda region was chosen for this project based on information and recommendations from the government of Senegal as well as substantial consensus on the assets of the region as is general knowledge in the international mining community. This region is known throughout the world as having one of the largest gold deposits in West Africa, the Sabodala Deposit. The Sabodala Deposit is estimated to yield 1 million ounces of raw gold. It is a 230 square kilometer area that features similar environments that hosts most gold deposits in that part of the African continent. Senegal is a stable country favorable to mining.

According to mining industry sources, in 2004 Senegal opened the Sabodala Concession to the international mining community in a competitive, open-tender bidding process. Large mining companies and high profile exploration companies became involved in the bidding. Mine-Tech/Oromin (Canadian) and Mineral Deposit Limited (Australian) were awarded the rights to develop the project in the fall of 2004. Their local partners are Senegal/France based organizations.

Artisanal gold mining has been historically practiced throughout the southeastern region of Senegal. Although the people of this region are known for being traditional gold miners, a gold rush in the 1970's further impoverished the population and degraded the land at an exponential rate, bringing drought and sickness.

With the global price of gold at the highest its ever been, more people throughout the region, including citizens of Mali and Guinea, have been drawn to artisanal mining activities in Tambacounda, specifically around the Sabodala gold deposit. Although the current estimated number of artisanal miners is 10,000, at least 3 times as many people are directly impacted by artisanal mining activities, with countless others indirectly impacted by downstream pollution, deforestation and general environmental degradation.

The project site in particular is the Kedougou Prefecture located in the southeastern corner of Tambacounda, bordered by Guinea and Mali about 700 km from Dakar. Kedougou is approximately 18 square kilometers, comprised of 4 districts and 10 rural communities of about 70,000 people. Estimated gold reserves in this region are about 30 tonnes.

Most mining in this region is conducted from November through May by village men, women and children participating in every activity from excavating rock to grinding ore and burning amalgam. Although the rainy season from June to October makes gold mining very difficult for artisanal miners, pressure from state and formal sector mines has lead to increased activity during the winter months. The weak rate of extraction combined with the informal distribution chain of artisanal gold, compromises not only the health of the miners and their families, but comminuty security and equality as well. Even worse, this pressure is quickly leading to a tragedy of the commons with regard to the environment.

Project Strategy

Pr. Amadou Diouf, a toxicologist with the University of Dakar, Kali Niang, a sociologist, also with the University of Dakar and Meredith Block, Africa Projects Coordinator for the Blacksmith Institute conducted a preliminary assessment in June 2006 that revealed unsafe uses of mercury by the ASGM communities in this region.

		
Woman using mercury to create amalgam, Tenkoto Village 2006	*Amalgam*	*Burning of Amalgam*

In Tenkoto Village, it was observed that after the ore is milled and pounded by women using a large mortar-pestle system, it is combined with elemental mercury, to bond to gold particles, creating an amalgam. The activity of creating the amalgam was exclusively dont by the women, with no protections for their skin. About five minutes after the amalgam pictured above was made, the same woman was breast feeding her child. After the amalgamation process, a battery powered coal stove stationed at a storefront was used to burn the amalgam. The heat caused the mercury to evaporate into the open air, completely uncovered, leaving behind a small piece of gold. No safety precautions were taken, and children often observe this process, as mercury emissions escape into the air.

As in the other artisanal gold mining communities Blacksmith Institute has worked with, a simple tool, known as a retort, can be introduced into the community to curb mercury emissions, protecting both the miners and the environment. The retort can be manufactured from local materials at minimal cost, and labor. As a result, the strategy to solving this problem is centered around an appropriate technologies training program for the mining communities of the Tambacounda region.

The Blacksmith Institute together with the GEF/UNDP/UNIDO Global Mercury Project, and USEPA sponsored the mission of technical expert Olivier Savornin to investigate the use of mercury in artisanal mining operations and to transfer knowledge about controlling mercury in the gold mining industry to local authorities, NGOs and leaders of the mining communities of Kedougou. Olivier conducted a training program in the use and construction of retorts as well other methods of improving gold yields. After this initial train-the trainers session, the participants are now charged with disseminating the new technology throughout the community, staying onsite and acting as a local resource. This group includes authorities from all of the larger mining villages who will remain a permanent resource for those

communities, as well as regional authorities who will move between villages providing additional support to the local staff.

Blacksmith's Dakar representation, Africaclean partnered with local health NGOs, La Lumiere and Wula Nafa, who are already engaged with the affected communities. Both organizations are invested in helping sustain the impact of the train-the-trainers program, by providing staff and space in their office to provide additional resources for the community. These organizations that work closely with Oxfam International on a wide rage of issues from health to education, AIDS awareness and women's rights.

The training program occurred in 2 separate stages; Training the Trainers and Training the Miners.

II. Training the Trainers

This exercise was held in a one day long seminar and workshop in the center of Kedougou Prefecture, a central location within the Tambacounda region that could be easily accessed by the would-be trainers and local authorities. The point of this first training session was to train people who will continue to spread appropriate methodologies for extracting gold once the technical expert has left.

Among those at the training, community leaders were present from the villages of Tenkoto, Khossanto, and Kanoumering as well as representatives from La Lumiere and Wula Nafa health centers, two NGOs who work in the region. Aliou Bakhoum from the NGO la Lumière and Mouhamadou Sellou Diallo, the director of the local health administration for Kedougou, were designated as the principal trainers who will continue to carry out field training activities over the duration of the project. In total, 15 people attended this workshop.

The workshop consisted of two main segments; Mercury Education and Appropriate Technologies Construction and Application

1. Mercury Education

The following is a brief summary of the topics as they were presented to give the participants a better understanding and urgency of the problem

a. Mercury and its toxicity

Mercury is a metal, which is liquid in normal conditions of temperature and pressure. It exists mainly in two chemical forms, elemental mercury (Hg) and the methyl mercury (CH3Hg). Mercury is a heavy metal and is highly toxic.

Frequent consequences of intoxication from elemental mercury vapors.

- Neurological impairment
- Blurred vision
- Memory loss
- Shaking
- Chronic fatigue
- Vomiting
- Impulse and co-ordination problems
- Bronchitis
- Kidney problems

Frequent consequences of intoxication from methyl mercury ingestion

- Neurological impairment
- Leg numbness
- Paralysis
- Severe in-utero neurological damage

- Convulsions
- Death

b. The Use of Mercury in Gold Mining

Elemental mercury has amalgamating properties. Essentially, this means that when you mix the finely powdered gold-bearing rock with some mercury, the gold within the rock dissolves and forms what's called a gold amalgam. The mercury can catch the gold particles while separating them from the other minerals in sand to create a pure mercury-gold amalgam. After being crushed, grinded and screened, then passed through the sluice box, the concentrated ore is combined with mercury, to make the amalgam. The amalgam is called “Sanou Deggo” in Malinké, which means cake.

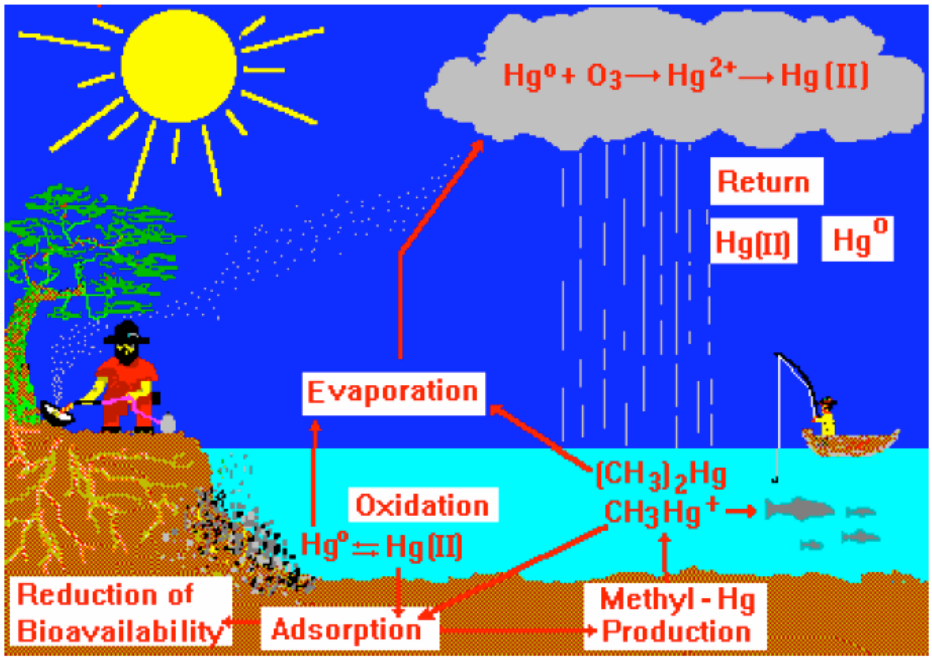
c. Contamination Risks from Elemental Mercury

Miners burn the amalgam to retrieve the gold. The mercury becomes a vapor, leaving the gold in its solid form. This process is highly toxic and poses serious risks for those who burn the amalgam, as well as those in close proximity. The entire village can be at risk of poisoning. Mercury is very toxic in its vapor form especially since inhaling can expose people upwards of 80%. Alternately, only 1% of liquid mercury touched by people is absorbed by the body.

d. Contamination Risks from Methyl Mercury

Anaerobic bacteria transform elemental mercury into methyl mercury, one of the most toxic elements on earth. When elemental mercury reaches river sediments, bacteria transform it into methyl mercury through digestion. The higher the trophic level of the organism, the greater the contamination.

Methyl mercury is eaten by small organisms, eaten themselves by small fish. Every time a contaminated fish is eaten by an other one, the concentration of methyl mercury increases exponentially in the predator organism, because methyl mercury is hard to remove from the body. When big carnivorous fish are finally eaten by people, they are consuming dangerous levels of methyl mercury. These big fish can travel long distances. Contaminated fish can be found as far as 100km from a contaminated spot. It is for this reason that people living on the Gambia River can be intoxicated by methyl mercury, even if they are not miners.



Oxidation of mercury into methyl mercury (source M. Veiga)

Not only can evaporated mercury rain down into rivers, but mercury that is thrown on the ground with the non-amalgamated ore can run off into the rivers as well.

e. Where Does Elemental Mercury Come From ?

Mercury is a natural resource which is extracted from mines. Nowadays, mercury mostly comes from the recycling of batteries, lamps and most electronic products that come from industrialized countries. It comes to Senegal and Mali for use by dentists and doctors, before being sold on the black market to the miners.

Miners in Senegal buy mercury between 1000 and 1500 Fcfa (US$2 to US$3) for 10g, whereas doctors buy it at 1400 Fcfa (US$2.8). Taxes on importation in Senegal are higher than in Mali, so mercury can be cheaper on the black market from Mali than in Senegal at normal market prices.

Kali Niang explaining the dangers of mercury

Olivier Savornin explaining retorts

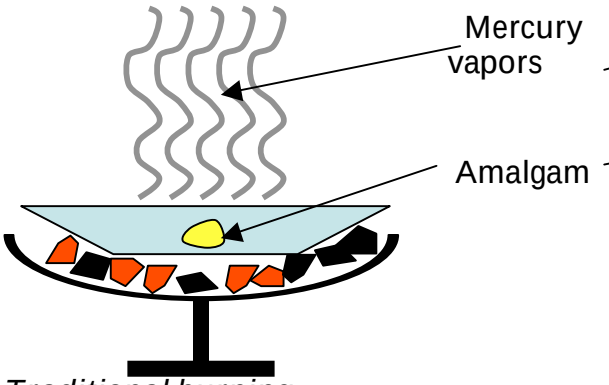
2. Appropriate Technologies Construction and Application

a. Current Practices in the Tambacounda Region

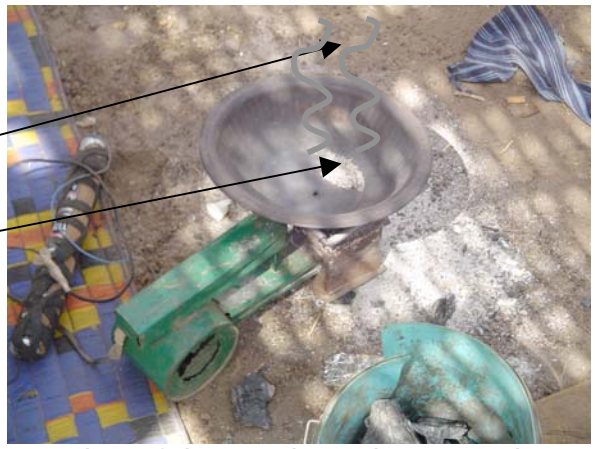
After the amalgamation process, women and men use a either a coal pit or battery powered coal stove to burn the amalgam. The heat causes the mercury to evaporate into the open air, completely uncovered, while the gold is left behind. There are no safety precautions, and children often observe this process, as mercury emissions escape into the air.

b. Retorts

There are a number of cleaner technology alternatives to current methods of mercury amalgamation. The use of retorts during the mercury burn-off stage is a simple and cost-effective way to decrease the occupational exposure to mercury and minimize its release into the environment. Retorts allow for the efficient capture and reuse of mercury. Retorts are inexpensive to manufacture and can be made out of local materials. Two kinds of retorts were taught to the participants in this training exercise: closed retorts and retorts with a pipe or tubing.

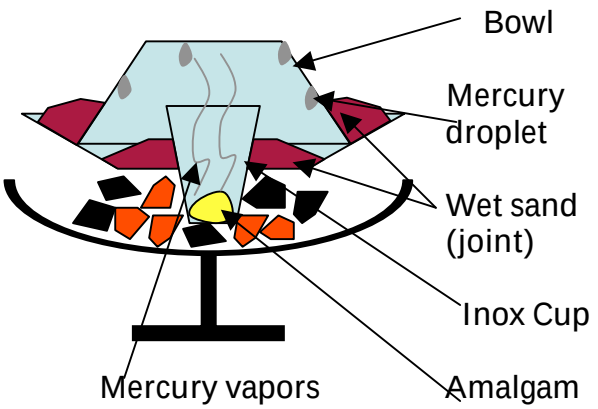


Traditional burning


Burning of the amalgam in Bantanko

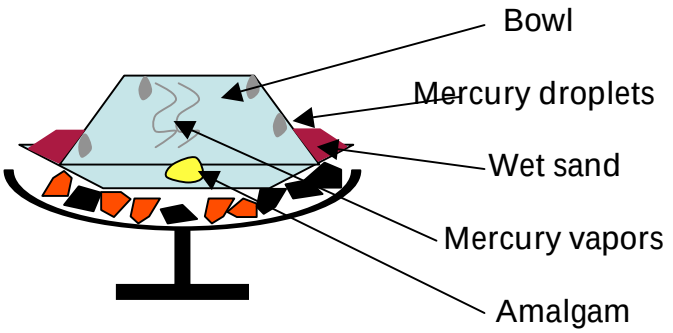
C. Closed retorts

These retorts are hermetically sealed to prevent mercury vapors from escaping. They can also to be opened after burning to collect the gold. The mercury that collects in the sand can be panned briefly to be recovered.



Closed retort with cup *Retort in Sabodala*

This retort is made by a bowl, a plate, a cup and wet sand. It gives the opportunity to get back gold and prevent mercury from falling back in the cup, thus recombining with the gold. The cup also enables the amalgam to be placed in the heart of the fire, burning more efficiently. As a result the mercury evaporates quicker and more completely. This retort requires more assembly time because the cup needs to be welded inside of the plate. One of the advantage of this retort is that is can burn large amalgams, upwards of 100g. This retort cost 2000 Fcfa ($4) to make.



Basic retort *Retort in Bantanko*

This second retort is based on the same principle, but is cheaper because there is no cup or additional modification to the plate. This retort however, is not as energy efficient because the amalgam is farther away from the center of the fire and needs a bit more time to heat for full evaporation of the mercury. Occasionally the sand can melt with the gold. This retort costs 1250 Fcfa ($2.5).

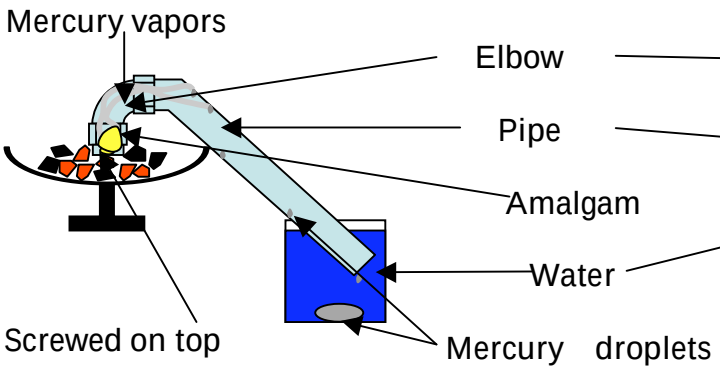
These two retorts can be modified easily depending on which items miners can find in each villages. A bowl can replace by a cup, and to see what is really happening

in the retort, a transparent bowl, ideally Pyrex brand can also be used. Thinner glass bowls can break. None were found in Dakar, or in Kédougou.

To use these retorts, it is recommended to let the amalgam burn for at least 15 minutes, to be sure that the sublimation of mercury has been done completely. These retorts also require that the metals be stainless steel or another non-oxidized metal. Copper and iron should never be used, as the mercury can also bond to those metals.

d. Retorts with a Pipe

These retorts are not hermetically sealed. They are open on one end of an extremity, usually a pipe, which is far away enough from the heating source to let the mercury vapors liquefy in water. With these retorts, it is possible recover mercury in its liquid form, and then to reuse it indefinitely in the amalgamation process.



Pipe retort

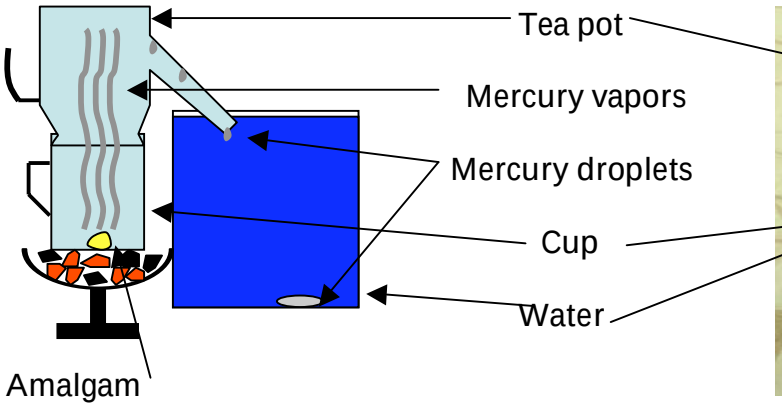

Retort in Sabodala

This retort is the easiest easy to make, efficient and inexpensive. It had the most success with the miners during the field training sessions. The small contact surface area that touches the fire, leads to a high exchange of heat and the sublimation of mercury is accelerated. Because each item used is a plumbing item, they can be screwed together creating a very tight seal. This captures the mercury vapors really well.

If the pipe or tube is not able to be screwed together with the end-piece, it can be welded to the elbow piece. It is very important to remember that the open end of the pipe must be entirely under the water, even when the retort is taken off the fire.

This retort costs 2000 Fcfa ($4) in Dakar and Kédougou.

The team also tried another retort, developed on the project site based on the same principles of both the closed retort and the pipe retort. The idea was to use a teapot, which is a common item in Muslims countries where generally people drink a lot of tea.



tea pot retort

Tea pot retort at the training session in Kédougou

During the construction, the joint between the teapot and the cup was thought to have been tightly sealed. Unfortunately this was not the case as very little mercury was recovered in the water or condensed along the side of the teapot. This might be able to work if some sand or mud is added. This retort costs 2250 Fcfa ($4.5).

Miners discussing retorts while observing the burning process.

Even this though the teapot retort didn't work, a list of criteria were developed and taught to the participants so if they want to experiment with other materials, they have guidelines to adhere to.

To be efficient, a retort MUST :

- **Be <u>hermetically closed</u> to prevent all mercury vapors from escaping.**
- **Retorts are efficient only <u>if every burner uses retorts</u>. Although intoxication is higher just around the burning sites, the team noted that mercury intoxication was present throughout every village that was visited in the field training exercises.**
- **Retorts cannot be made with thin glass, nor with copper or iron materials. (amalgamation can happen between mercury/copper and mercury/iron). They are best made with stainless steel/**
- **Retorts must be used for <u>burning amalgam only</u>. The items used in making the retort are not to be used in cooking, storage or any other application for health reasons.**

III. TRAINING THE TRAINERS – Field Activities

After the training of the trainers workshop, the participants visited three of the main mining villages in the area: Sabodala, Bantanko and Khossanto. An additional 15 head miners in Sabodala, around 12 more miners in Bantanko, and 4 in Khossanto were trained by the new trainers with supervision from the GMP technical expert, Olivier Savornin, so he could ensure that it was being done correctly. Not only did the newly trained miners explain retort construction and maintenance but were fervently explaining the risks of mercury with an emphasis on trying to at least keep children and pregnant women away from the burning areas at all times.

In each village, the training was enthusiastically accepted, as the miners soon understood that they could conserve mercury with the retorts. All materials for the construction of pipe retorts and closed bowl retorts were easily available.

Each village in the region has at least one retort, and a trained representative to explain and share the technology.

Trained miners explaining retorts to other miners

Sara Cissoko, the chief of Sabodala village taking the retorts to his village after the training

Participants in Kédougou Training (15)	**Villages trained by miners**
Tenkoto	Bantanko
Kanoumering	Sabodala
Khossanto	Khossanto
NGO La lumière	
NGO Wula Nafa	
Hygiene service	
Kédougou Health centre	
Professional and technical officials	

IV. FOLLOW-UP ACTIVITIES

2 organizations based in Kédougou will be providing follow-up services to ensure the ongoing field training activities. Aliou Bakhoum from the NGO la Lumière and Mouhamadou Sellou Diallo who is the director of the local health ministry will lead field training activities for the duration of the project. They both had an exceptional enthusiasm for the issue and understood the information quite well. During the first year, M. Bakhoum and M. Diallo will travel to each of the 10 main villages twice a month, with a focus on the smaller villages in year two.

Each mine pit is operated by one owner or "Diourtigui"

In each village the trainers will assemble the local authorities, as well as representatives of the mining communities including the owners of the different mining sites. Depending on the size of the plot of land, the plot owners known as "Diouratigui", employ between 10 and 40 miners to work one small pit or a series of small pits, depending on the estimated yield. These owners will be a targeted group to train as they tend to supply the mercury to their workers.

There will be trimester reports sent from the local trainers to Blacksmith Institute documenting how many people have been trained, how well the technology and health information is being understood, as well as how many retorts are active within each village.