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Fifth meeting
Geneva, 30 October–3 November 2023
Item 4 (c) of the provisional agenda*

Matters for consideration or action by the Conference of the Parties: artisanal and small-scale gold mining

Lessons learned from technology transfer activities in planetGOLD phase 1 projects

Note by the secretariat

The planetGOLD programme is funded by the Global Environment Facility to address mercury use in artisanal and small-scale gold mining within the framework of the financial mechanism of the Minamata Convention on Mercury, as provided for in article 13 of the Convention. The document entitled "Making mercury history in artisanal and small-scale gold mining: technology transfer experiences in the planetGOLD programme" was developed by the planetGOLD programme under the leadership of the United Nations Environment Programme. The document is reproduced in the annex to the present note, as received, without formal editing.

* UNEP/MC/COP.5/1.

Annex*

* The present annex has not been formally edited.

planetGOLD

MAKING MERCURY HISTORY IN ARTISANAL & SMALL-SCALE GOLD MINING

Technology Transfer Experiences in the planetGOLD Programme

Supported by: gef

Led by: UN environment programme

Background

When used properly, technologies and practices that reduce or eliminate the use of mercury in artisanal and small-scale gold mining (ASGM) can extract a greater amount of gold than traditional methods using mercury amalgamation—leading to more income for miners and their families and fewer risks to their health, their communities, and the environment. The appropriate technologies and processes depend on the ore type, available resources, and social and economic factors.

All projects that are part of the planetGOLD programme, funded by the Global Environment Facility and led by the UN Environment Programme, are promoting and piloting alternative technologies and processes with artisanal and small-scale gold miners. While every site is unique, the mercury-free production methods being piloted by the country projects usually involve improved crushing and milling techniques, improved gravity concentration tools such as sluicing and shaking tables, flotation, and/or chemical leaching. Projects also carry out training and capacity building activities to increase miners' knowledge of—and comfort with—mercury-free mining practices. As a result, project teams have made key advances toward helping miners undertake the transition to mercury-free methods.

This document provides an overview of the interventions that have been carried out across the planetGOLD programme as of June 2023 to advance responsible mining and eliminate mercury from the ASGM gold supply chain, through technology transfer, technical support, training, and sharing knowledge on best practices in mercury-free gold processing. For additional details on each country project's interventions, see the fact sheets in the **Annex**.

Building or expanding mercury-free processing capacity

Nine projects have introduced, or plan to introduce, improved gravity concentration equipment and methods at their mine sites as an alternative to mercury use (Burkina Faso, Colombia, Ecuador, Guyana, Indonesia, Kenya, Mongolia, Peru, and the Philippines). These systems use gravity to separate gold from other minerals in the ore, which have a lower density than gold. Examples of gravimetric equipment selected by planetGOLD projects include: shaking tables, centrifugal concentrators, sluice boxes, spiral gold concentrators, helicoidal concentrators, and vortex concentrators.

Project teams are also introducing machinery that crush or mill the ore to an appropriate grain size, such as ball mills, jaw crushers, and vibrating screens, before it is transferred to the gravimetric equipment. In addition to these gravity methods, some planetGOLD projects have also included chemical leaching processes such as cyanidation as elements of new or existing mercury-free circuits.

See the chemical-free method used in mobile plants developed by the planetGOLD Colombia project

In some cases the planetGOLD projects have undertaken efforts to build all-new mercury-free processing capacity, for use by miners and for training/demonstration. In others,

country teams took stock of existing gold processing facilities in their project areas and opted to expand these existing facilities' ability to process ore without mercury through capacity building and provision of mercury-free and other equipment.

To date, projects in six planetGOLD countries have developed or are in the process of developing new mercury-free processing systems: Burkina Faso, Colombia, Guyana, Indonesia, Peru, and the Philippines. These technology transfer activities fundamentally begin with sound preparatory activities, including for example prospecting studies, to establish the presence of economically viable gold deposits and laboratory analyses to characterize the nature of the ore. Analyzing the ore is a critical step, because understanding the type of ore helps determine which physical or chemical mercury-free processing methods are appropriate for the site.

Equally important, planetGOLD project teams consult with miner representatives at their project sites in an effort to ensure that any technical interventions meet the miners' needs and will be accepted and used by them. These activities are then followed by the identification of new technologies appropriate for each site/area, the procurement and commissioning of any new equipment, and finally the instruction of miners and gold processors on the operation and maintenance of the new technologies. Projects constructing these new facilities have developed plans for transfer of ownership and sustainability of the equipment after the project ends.

Projects in three countries (Ecuador, Mongolia, and the Philippines) have chosen the strategy to strengthen existing processing plants. In Ecuador, after increasing the capacity of existing processing plants with mercury-free equipment and practices, the planetGOLD partner project launched a communication campaign to encourage miners to sell their ore to these existing plants, instead of processing it themselves with mercury.

Overview of Ecuador project's sales strategy vs. miners' existing practices (click to view full size)

In the Philippines, after some community members at one of its project sites objected to the construction of a new leaching facility due to concerns about the use of chemicals, the project team pivoted to strengthening an existing facility with mercury-free equipment and improved processing practices. And facing significant regulatory barriers to constructing a new plant, the project in Mongolia similarly opted to introduce mercury-free processing systems in two existing processing plants.

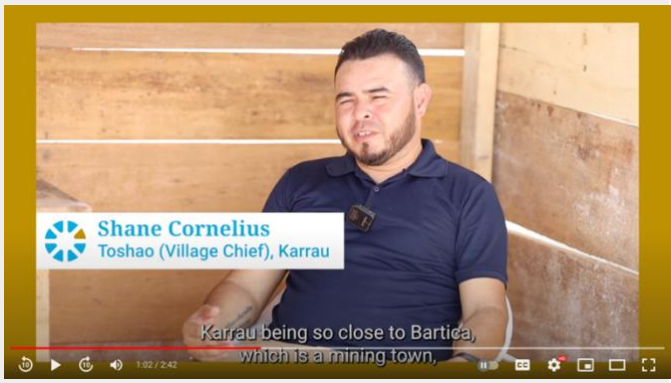
Mercury-free equipment as a persuasion tool

To achieve impact beyond sites where direct technical interventions take place, mercury-free processing systems can also be used as an awareness raising tool to educate and persuade miners that these systems can recover significantly larger amounts of gold than their conventional processes that use mercury.

The planetGOLD Guyana project's technology transfer approach included the establishment of three mercury-free demonstration sites, where more than 50 miners came to see for themselves how the technology resulted in more gold at a lower cost.

One of these demonstration sites was located alongside a parallel mining operation that continued to utilize mercury. By monitoring both operations side by side, the project was able to show the higher gold recovery rates of the mercury-free operation.

Take an interactive 360-degree tour of the mercury-free demonstration site near Mahdia



Hear why this Indigenous leader requested mercury-free mining technologies for his community after visiting a demonstration site

Training and improving awareness of better practices

To help foster the transition to mercury-free technology, projects across the planetGOLD programme have also provided technical assistance and have engaged miners and gold processors in trainings on how to utilize the mercury-free equipment. Projects have provided instruction on assembling and installing equipment in a proper and reliable way to ensure occupational safety, and on maintaining these systems to ensure their longevity. Technical training topics have included: improved crushing and size reduction operations, gravity concentration methods and equipment, chemical leaching and detoxification, smelting, and refining.

In places where planetGOLD projects have introduced leaching with chemicals that must be handled with great care, teams have educated miners on how to safely handle, use and store the chemicals, to avoid health and environmental concerns. Several project teams have also educated miners on additional techniques and technologies, including the proper management of mine tailings and techniques for removing mercury from existing tailings, such as the copper plate technique. In Indonesia, in addition to directly training miners on the equipment used in their processing plants, the project team also developed a

Meet Sugiyanti, a miner who participated in one of the Indonesia project's training programs

train-the-trainer program, equipping miners to transfer knowledge to others in their community on the proper use of equipment used in mercury-free gold recovery processes.

Beyond direct technology and training interventions, planetGOLD projects have also engaged in broader awareness raising and outreach activities to introduce additional skills and methods for reducing or eliminating mercury exposures in and around ASGM communities. In areas where miners are using what are considered by the Minamata Convention on Mercury to be the four worst practices in ASGM—whole ore amalgamation; open burning of amalgam or processed amalgam; burning of amalgam in residential areas; and cyanide leaching in sediment, ore, or tailings to which mercury has been added without first removing the mercury—projects promote adoption of better practices that can reduce the most harmful mercury exposures in a timely manner. These practices include using retorts to capture mercury vapor, carrying out gold processing in designated areas not in close proximity to others, and removing mercury from tailings.

Contributing to the global knowledge base on mercury-free methods

In addition to the planetGOLD country projects' capacity building efforts, the planetGOLD global coordination project supports sharing knowledge about mercury-free technical solutions with a wide range of international stakeholders engaged in improving the ASGM sector.

Click images above to view recordings from the 2022 Global Forum on ASGM

In 2021, the global project team organized Artisanal and Small-Scale Gold Production: Technology without Mercury, a virtual exhibit for dynamic conversations on new and emerging technologies involving planetGOLD project staff as well as external scientists, equipment engineers, and ASGM practitioners. During the virtual 2022 Global Forum on ASGM, planetGOLD hosted sessions on Mercury Free Gold Production and on Recovering Mercury from Tailings.

Seeing the rapidly growing number of small-scale cyanide processors in some ASGM countries, planetGOLD partnered with Pact to address the gap in applicable guidance by producing a report on managing the risks of cyanidation where national legal and regulatory frameworks permit its use to transition away from mercury use: Best Management Practices for Cyanide Use in the Small Scale Gold Mining Sector.

At the conclusion of its implementation, the planetGOLD programme aims to further expand the global knowledge base by producing a detailed analysis and comparison of all alternative technologies and technical interventions made across the life of the programme. In the meantime, for a broader picture of advances planetGOLD projects have made to help make mercury history in the ASGM sector, see the programme's most recent progress reports and visit planetgold.org for ongoing updates.

Quick Links:

- Artisanal and Small-Scale Gold Production: Technology without Mercury – planetGOLD Virtual Event Webpage
- Mercury Free Gold Production – 2022 planetGOLD Global Forum on ASGM Session Recording (available with interpretation in French and Spanish)
- Recovering Mercury from Tailings – 2022 planetGOLD Global Forum on ASGM Session Recording (available with interpretation in French and Spanish)
- Best management practices in the use of cyanide in artisanal and small-scale gold mining – planetGOLD Virtual Event Webpage
- Best Management Practices for Cyanide Use in the Small Scale Gold Mining Sector – planetGOLD/Pact Guidance Document (also available in French and Spanish)
- 360-Degree Tour of planetGOLD Guyana Mercury-Free Demonstration Site – planetGOLD Interactive Virtual Tour
- Demonstration of equipment for mercury-free mining in Guyana – planetGOLD Guyana Video
- Equipment for Responsible Mining – planetGOLD Guyana Booklet
- Curso Virtual Sobre Gestión Integrada del Mercurio | Modulo 6 Minería de Oro – planetGOLD Colombia Virtual Course
- Catálogo de proveedores de tecnologías para la MAPE (Primera edición) – planetGOLD Perú Catalogue
- Good Mining Practice Handbook for Small Scale Primary Gold Mining Sector – planetGOLD Indonesia Guideline Document
- Mercury-free ASGM curated collection – planetGOLD Resource Library
- Additional materials on mercury-free mining – planetGOLD Resource Library
- Blog articles on technical solutions – planetGOLD Website
- Dispatches From the Field: Burkina Faso – planetGOLD Video

Annex:
Country Project Technology Transfer Fact Sheets

FACT SHEET

planetGOLD Burkina Faso

Technology Transfer planetGOLD Burkina Faso

BACKGROUND

The planetGOLD Burkina Faso project is working toward eliminating mercury in the ASGM sector by improving the availability of mercury-free technologies, shortening the gold supply chain, and increasing artisanal and small-scale miners' direct access to the international market. In August 2022, the project officially opened its latest mercury-free processing plant in West Africa. The planetGOLD project taught local miners to process ore without resorting to mercury. The project is supported by government partners from the national agency supporting artisanal and semi-mechanized mines (ANEEMAS) and the Ministry of Environment, Green Economy, and Climate Change (MEEVCC), who have visited various sites located across the Southwestern and Cascades regions.

The project aims to showcase innovative and affordable mercury-free technologies while creating a socio-economic enabling environment to facilitate adoption and replication throughout Burkina Faso. To this end, the planetGOLD Burkina team is organizing various activities aimed at involving the many direct and indirect actors in the ASGM sector in Burkina, notably artisanal miners and their umbrella organizations, ministries and their agencies, and other organizations, all of whom have a role to play in the responsible development of the sector.

The mercury-free gold processing unit will bring three main benefits to the miners and their communities:

- It will increase miners' income by increasing gold recovery rates compared to the current practices and tools used (meaning more gold will be processed from the same number of rocks),
- It will decrease health risks by reducing miners' exposure to chemical and physical hazards, and
- It will eliminate the negative environmental impacts of using mercury for gold processing.

TECHNOLOGY DEPLOYED

The technology was selected based on a thorough site investigation to know the characteristics of the type of ores artisanal miners are dealing with for the extraction of gold. Based on the site selection process, it was revealed that the project sites have both alluvial and hard rock. The gold could be liberated with proper grinding and sizing for the latter. Therefore, the decision was made to choose a gravimetric circuit.

- Design/workflow

  The gravimetric circuit consists of:

  - One (1) N2 jaw crusher (9x6"). Crushes large rocks.
  - Three (3) Rod mills for further size reduction after the jaw crusher. 1.00X0.80 m
  - One (1) Screen for classification
  - One (1) Mixing tank for a homogeneous slurry to the shaking table.
  - One (1) rougher Shaking table for coarse gravimetric separation of ore into two products (concentrate and intermediate tailings). Dimensions 1.5x3.50 m
  - One (1) cleaner shaking table for clean separation of concentrate from rough shaking table. There will be two basins (concentrate and residue).

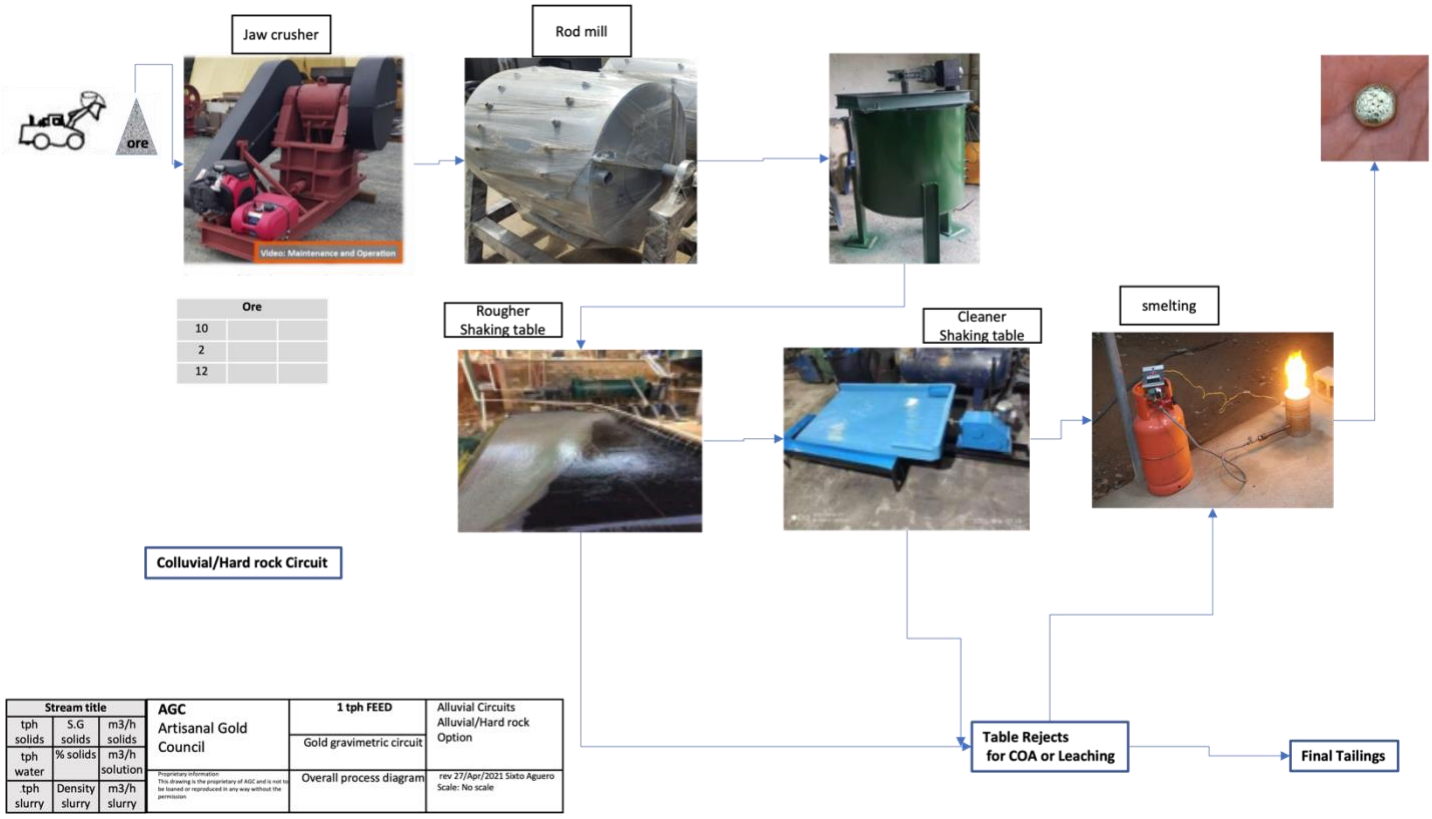


Figure 1: Workflow of the gravimetric circuit (click to view full size image)

- Costs

  As there was limited equipment available in-country at the time of purchase, equipment was imported from Colombia which amounted to 47,955.00 USD, and the shipping and importation cost an additional 9,398.98 USD, bringing the total to 57,353.98 USD.

- Improved gold recovery

  The equipment is still being tested to improve gold recovery with the adjustment of various parameters for efficiency and increased production:

  - Optimization of the grinding circuit
  - Proper engine to power the rod mill.
  - Smelting of the ore to remove impurities.

TECHNICAL TRAINING & DISSEMINATION

A training was conducted by the technical specialist Kader Sanou and had various steps as listed below:

- **STEP 1:** Crusher training - explanation of the crusher's purpose, i.e., to crush waste materials, and how to operate it.
- **STEP 2:** Introduction to and explanation of the grinding operation, its purpose i.e., the product and the type of grinding desired, which can result in a good p80 at the mill discharge and between 60% and 70% of ground material, this method reduces the circulatory load of the mill.
- **STEP 3:** Explanation of ore separation such as the role of the large shaking table, i.e., its role as a roughing machine, and how to make the various adjustments to obtain a good slope, i.e., 9 degrees.
- **STEP 4:** The gold concentrate purification table where advantages and disadvantages are explained:
  - Advantage: It purifies the concentrate, which must be smelted directly by adding fluxes such as borax and other reagents depending on the grade and purity of the ore.
  - Disadvantages: The table's vibration causes extremely fine gold to wash off in tailings, rather than be captured.

UPTAKE BY MINERS

The installed processing unit is very much appreciated by the miners, but the buy-in from this mining community is not yet at the level desired by the project team. Some miners are still skeptical about gold recovery by the processing equipment. Tests are ongoing to improve equipment efficiency and produce better processing results.

Numerous awareness-raising sessions have been held, with the aim of getting the entire mining community to help achieve the project's objectives by taking ownership of them and ensuring the optimum operation of the processing unit.

Figure 2: Machine operators work under the supervision of the technical specialist with ore brought in by some of the site's female miners.

Following training, artisanal miners are now able to:

- Conduct daily system checks of the equipment before starting operations to make sure oil and fuel are enough.
- Power all the equipment.
- Set the right angle of the shaking table for better recovery of gold.
- Know the proper sizing of the ore for optimal recovery of gold.

planetGOLD Colombia
Making a world of difference in small-scale gold mining.
A GEF Initiative

planetGOLD Colombia Clean Technologies Strategy

BACKGROUND

The project in Colombia aims to combine technical, financial and methodological efforts to implement actions that allow avoiding 20 tons of mercury from the environment with the technical, comprehensive and participatory assistance of 2,000 miners in Antioquia, Cauca and Sur de Bolívar. These actions seek, from a sustainable development approach, to reach the 2023 goal by contributing to a Mercury Free Colombia.

During the year 2020, the project developed a baseline to characterize the mining communities and identify the status of legality, formalization, use of mercury in mining activities, clean technology needs, their gold production capacity and the possibility of finding funding sources for the transition to new mercury-free techniques.

With this diagnostic information, a strategy adjusted to the needs of small miners and subsistence miners (artisanal miners) was designed based on "Knowledge Cycles" that is developed according to the appropriate technology: fixed plants, mobile plants for the gold beneficiation, and tools for the use of mercury-free techniques.

TECHNOLOGY DEPLOYED

The project selected the technology considering: first, the needs identified through the baseline developed at the beginning of the intervention. Second, doing laboratory analysis to study the size and shape of gold, petrography of thin sections, X-ray fluorescence analysis and atomic absorption analysis.

Accordingly, the project selected gravitational and magnetic separation methods to obtain coarse, medium and fine size gold. Some of the equipment and technologies implemented are: ball mill, concentrator table, separator table, centrifugal concentrator, sluice boxes and electric smelting furnaces. With this equipment, the technical assistance and the training of the miners, the recovery of gold is 80-90%, unlike the use of mercury, which only allowed them to recover between 20-40%.

1- Fixed plants: During the development of the project, intervention was made at the existing fixed plants of the La Gabriela Mine in the municipality of Tarazá (Antioquia), the Asominucol miners' association in the municipality of Caucasia (Antioquia) and the Cangrejo Mine in the municipality of Santa Rosa del Sur (Bolívar).

La Gabriela Mine

- Equipment delivered: separator table, centrifugal concentrator and furnace for gold smelting
- Costs: 45,000 USD

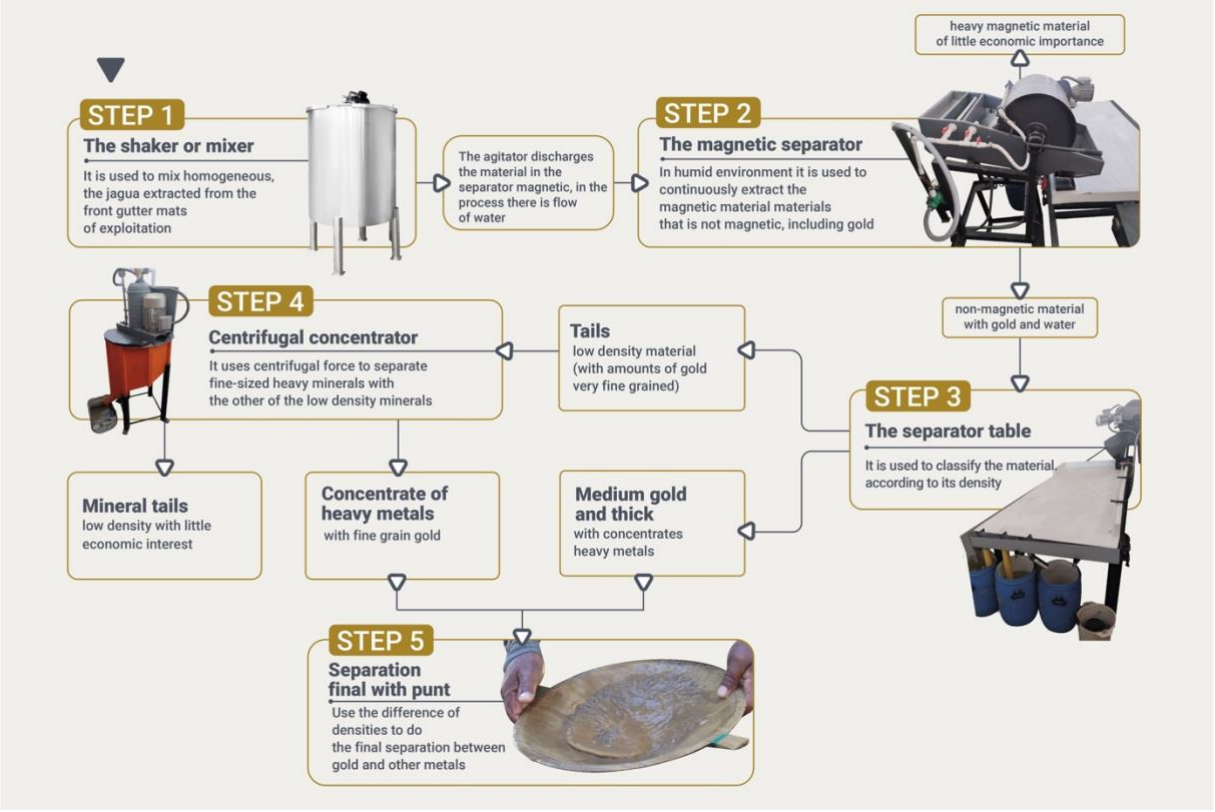
Mercury-free gold production plant – Tarazá, Antioquia

Design/Workflow fixed plant – La Gabriela Mine *(click image to view full size)*

Association of United Miners of Colombia – Asominucol

- Equipment delivered: agitator tank, magnetic separator, separator table, centrifugal concentrator, and furnace for gold smelting. Design and accompaniment in plant assembly
- Costs: 45,000 USD

Mercury-free gold production plant Asominucol – Caucasia Antioquia 2023



Design/Workflow fixed plant – Asominucol *(click image to view full size)*

2- Mobile plants: Starting in 2020, the project began the design and construction of mobile processing plants that would allow their transportation and operation in different areas of the country, in the project intervention areas. A mobile plant is a set of equipment and elements designed to benefit gold minerals, gold by-products, minerals that are in close league, associates and their concentrates.

This equipment is focused on training, on pilot trials and on small production; mercury-free, transportable, autonomous and scalable machine; supported by knowledge and technical control.

2.1 - **Mobile plant for the benefit of alluvial gold:** Plants for the gravitational separation of gold to increase the productivity of current processes without the use of mercury.

Plant model design

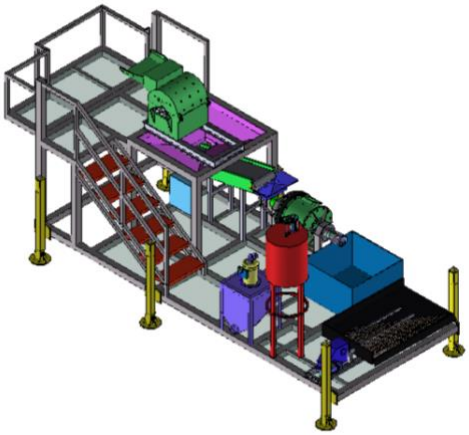
Mobile plant for training and pilot trials of alluvial gold. Caucasia, Antioquia

- Costs: 60,000 USD

[See video here]

2.2 - **Mobile plant for primary gold profit:** Plants with processes for the crushing of the material and gravitational separation of gold in stages without the use of mercury.

- Costs: 120,000 USD



Plant model design

Mobile plant for training and pilot trials of alluvial gold. Caucasia, Antioquia

[See the video]

2.3 - Metallurgical laboratory for mineral characterization: Mobile laboratories to monitor processes that ensure efficient and clean mineral production. Also, support laboratory techniques for analysis of quantity of gold, content, clean benefit methods. The project designed, built and implemented three laboratories for the intervention regions.

- Costs: 330,000 USD (110,000 each one)

Metallurgical laboratory model design

Metallurgical laboratory in action
El Bagre, Antioquia

See the video

2.4 - Sluice boxes and miner mosses: These equipment were designed to implement the clean technology strategy with subsistence mining communities and artisanal miners in the Guapi and Timbiquí, Caucasia, Cáceres, Tarazá and El Bagre regions. With these tools, miners can improve their practices and mine gold without using mercury.

This sluice box is made of aluminum, with a width of 40 centimeters and a total length of 4 meters. Once assembled, it is approximately 1.2 meters high and has an upper hopper that allows mining material to be loaded with the help of a shovel. The sluice box has a screen or inclined grid that allows the separation of mining material that has diameters greater than 2 centimeters, making a first selection of the material. In the process, the mineral is reduced until it becomes a finer material. The equipment is equipped with an irrigation system that allows the spraying of water to wash the material. The water recirculates to be reused.

- Costs: 2,000 USD (each one)

Women Miners using sluice box during partner visit in Tarazá, Antioquia

Artisanal miners training with sluice box and miner mosses
Guapi, Cauca

TECHNICAL TRAINING & DISSEMINATION

The clean technologies component of the project is a comprehensive knowledge strategy that integrates: awareness raising, technical assistance, equipment and learning tools. "*I know my mineral, I know my plant and I manage my plant*" seeks for mining communities to adopt the use of clean techniques without resorting to mercury through learning processes as follows:

- ***I know my mineral:*** in this phase, the miner knows the dangers of mercury in the environment and human health. Identifies the mining material, knows its mineral, recognizes the environmental conditions and the law that prohibits the use of this substance in mining practices.
- ***I know my plant:*** the miner identifies why it is important to use equipment that helps him make the transition to clean technologies and what is the best option to develop his mining activity. It recognizes that there is better recovery of your gold using non-mercury techniques. Understands how equipment is built, operated, and used.
- ***I control my plant:*** the miner is aware of sharing his knowledge with the communities. He manages his equipment to guarantee its operation. Track your operation with the tool. Turn your team into a community learning mechanism.

Currently, the project has trained 824 artisanal and small-scale miners in the use of clean technologies. Likewise, it has provided technical assistance to 2,372 people from mining communities with the aim of moving towards good practices that do not use mercury.

UPTAKE BY MINERS

In coordination with the *"Colombia Libre de Mercurio"* campaign, the project has developed a remembrance strategy with the miners. Each training includes an awareness kit that invites miners to appropriate the knowledge and share it with their communities. At the end of each training, the mining groups sign a commitment not to use mercury and to continue using clean technologies as a pact for the environment and human health.

The mining communities have shown interest in acquiring their equipment, seeking access to credit through the financial mechanism of the project. Today, mining groups in Antioquia and Cauca are consulting how to have their own sluice boxes.

Also, planetGOLD Colombia develops a line of didactic tools such as toys, to guarantee the implementation of the knowledge strategy *"I know my mineral, I know my plant and I manage my plant"* through project ambassadors in the territories.

Women Miners signed commitment in Tarazá, Antioquia

La Gabriela Mine signed commitment in Antioquia

planetGOLD Colombia

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planetGOLD Ecuador

Technology Transfer in Ecuador

BACKGROUND

Ecuador's National Action Plan, considered as the first formal diagnosis of quantities of mercury emitted from artisanal and small-scale gold mining (ASGM) in the country, determined that 10.1 tonnes of gold were obtained annually by amalgamation processes that used 29.6 tons of mercury. This makes ASGM the largest source of consumption of mercury in Ecuador.

To make the economic case for transitioning the sector away from mercury, in 2021 UNDP published a Targeted Scenario Analysis (TSA) for the ASGM sector in Ecuador, particularly in the Zaruma-Portovelo and Camilo Ponce Enríquez mining districts, which compared the likely economic and environmental costs of maintaining the same exploitation and processing practices (Business as Usual – BAU) with costs of a program to improve these processes (Programa de Beneficio Responsable – PBR). The study concluded that: "In terms of environmental impact, the intervention has the potential to achieve a decrease of more than 1 MT/year in mercury discharges. This reduction is significant and in turn represents a significant reduction in the costs borne by society as a result of mercury pollution."

Based on this analysis, a technology transfer strategy was implemented to encourage miners to abandon mercury amalgamation and instead sell their unprocessed ore to existing processing plants that do not use mercury in their gold recovery processes. This "ore sales" strategy had been successfully deployed in Peru and was considered suitable for adoption in Ecuador.

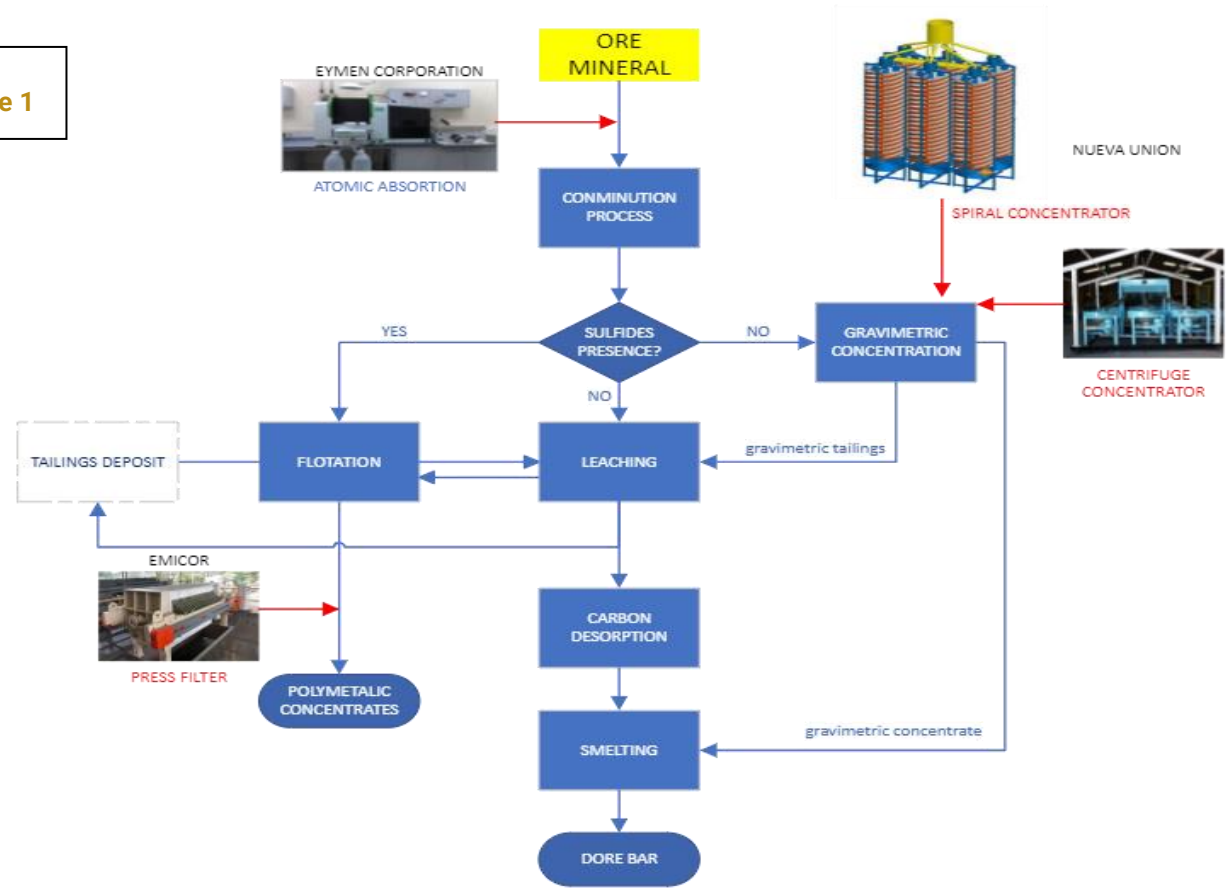
TECHNOLOGY DEPLOYED

The original project design envisioned constructing a new processing plant of 10 tons per day for miners to use but instead the project decided to increase capacity of existing processing plants and encourage miners to sell ore to those existing plants. This ore sales strategy means the miner becomes an ore supplier to the processing plants, where the price of the unprocessed ore is based on laboratory analysis of gold content. The lab analysis makes it possible to reach a fair price agreement between the miner and the processing plant. Since the plants process ore without the use of mercury, the use of mercury by the miner is prevented. Additionally, this strategy generates other benefits because generally the processing plant is more efficient at recovering gold, which increases profits.

To create an incentive for the plants to participate in the strategy, the project agreed to provide technical assistance and technology transfer to the plants. One of the plants required in-house laboratory equipment that allowed for the assaying of ore, which supported the strategy. (Other plants used existing commercial lab services.) Second, the project helped to increase the capacity and efficiency of the plants, so they could accommodate higher volumes of ore processing, which also supported the strategy.

The workflow shown in Figure 1 displays typical operations of the processing plants with which the project has implemented the ore sales strategy. For each plant, the project assisted with the selection of equipment to enhance their operations. To do so, an analysis of each process was conducted to identify the critical nodes that act as barriers to increasing production. The project worked with the plants' technicians to identify appropriate equipment and workflow to address these barriers, depending on type of ore processed (e.g., low- or high-sulphide) and other factors. For example, at the EMICOR plant, its critical node was the process of removing moisture from the concentrates; in this case, the plant was equipped with filter press equipment to make it possible to process more ore.

Figure 1



During the implementation of the ore selling strategy, another alternative for avoiding the use of mercury was identified. In addition to buying ore, the plants can also offer miners ore processing services. In this case, the miners own the resulting gold that is produced.

TECHNICAL TRAINING & DISSEMINATION

To implement and socialize the mineral sales strategy in the ASGM sector, many activities were carried out such as:

- Several socialization meetings have been held with mining stakeholders (artisanal miners, small miners and jancheras), owners of mineral processing plants and officials of sectoral ministries.
- Promotional activities have been carried out in the mining sectors through community events.
- Advertising in the media and social networks has been undertaken.

The strategy of selling ore to the processing plants offers the ASGM miners mercury-free gold recovery, which is environmentally friendly and more efficient, which generates a win-win system for both the miner and the processing plant. Since the beginning of the implementation of the strategy, 30 purchases of ore have been made by the plants from miners in the Camilo Ponce Enríquez and Zaruma-Portovelo sectors. It is hoped that in the coming months the number of miners agreeing to be part of the ore sale strategy will increase and that this new alternative will become common practice in these areas.

FACT SHEET

PlanetGOLD Guyana Technology Transfer

BACKGROUND

Guyana's Artisanal, Small and Medium-scale Gold Mining (ASGM) sector has been in existence for over one hundred years. Under the Mining Act (1989) mining activities have been fully legalized. The ASGM sector accounts for 70 percent of the country's gold production where mercury is widely used in the final stage of the gold extraction process.

The planetGOLD Guyana technology transfer approach included both demonstration of prospecting and exploration technologies for ASGM and establishing mercury-free demonstration sites.

TECHNOLOGY DEPLOYED

Prior to establishing a mercury free circuit, prospecting studies were conducted at the selected mining area to establish the presence of economically viable gold deposits as well as to characterize the nature of the ore, which facilitated selection of appropriate technology. This involved the following activities:

- Initial assessment to ensure conformity with project criteria for establishing a demonstration site.
- Rapid Environmental and Social Impact Assessment to determine any risk of significant effects on biodiversity or nearby communities.
- Prospecting to determine if the area holds economically viable amounts of gold deposits.

The deployment of equipment involved:

- Land preparation exclusive of forest clearance
- Circuit set-up with consideration for water supply and tailings management
- Testing of equipment (water then ore)

Fig. 1 Aerial View of Mahdia, Region 8 Mercury-free Site

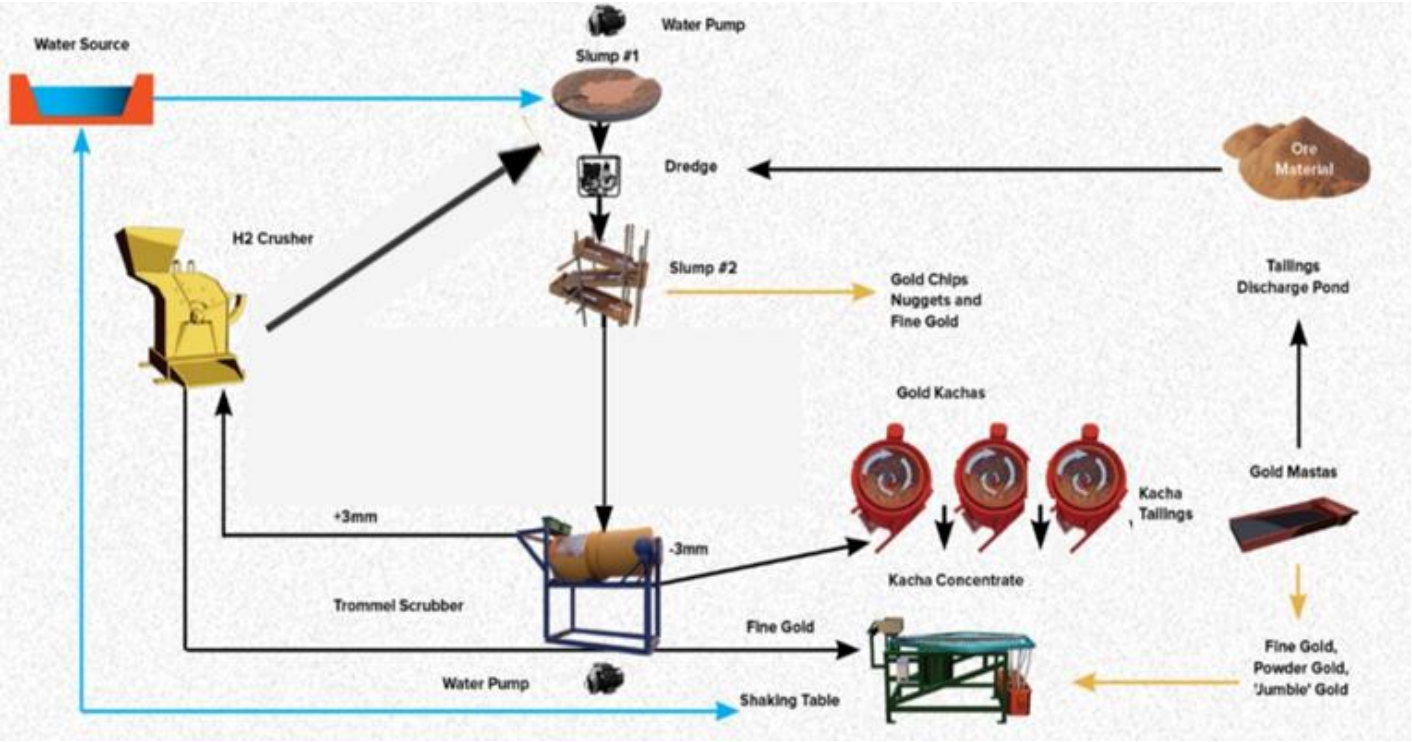


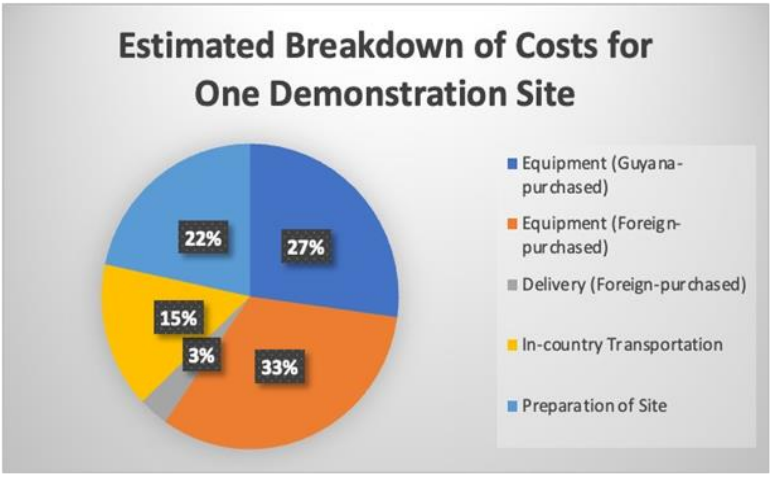
Fig. 2 Schematic of Mercury-free Mining Circuit

The project aimed to persuade miners that mercury-free gold processing circuits can lead to higher recovery of gold in amounts and at costs that compare favourably with gold processes that include mercury use. This was done through regular tracking of gold present in the material moving along the mercury-free circuit over a given period, and comparing that to data from a site nearby that continued to use mercury. The analysis of the data generated confirmed the expectation that the recovery rates of mercury-free processing ranged from 95% to 99% in comparison with the 35% to 40% recovery rate of the parallel circuit that utilised mercury.

Costs

The sluice box has been part of the mining operation of most small- and medium-scale operations for many years and though variations in terms of design, all are constructed by the miners using mainly wood with the addition of matting for lining the box. As part of the demonstration site circuit, the sluice box is Z-shaped with specific angles, again built by the mining crew. Thus, the cost was entirely each Concessionaire's responsibility.

The total approximate cost of establishing each demonstration site is $160K USD. Note that location of operation influences costs, with $25K-$40K USD required for domestic transportation.



TECHNICAL TRAINING & DISSEMINATION

Soon after circuits were in place, demonstrations were organized and miners from nearby operations were invited to see the mercury-free operations. At each operation, training commenced with the Concessionaire and/or Mine Manager and their workers, led by Guyana Geology & Mines Commission (GGMC) representatives and the planetGOLD Guyana Project Technical Officer. Demonstrations, once started, attracted miners from nearby operations as well as those from significant distances away.

Apart from the scheduled demonstrations at each site, there were occasions when miners requested to visit the mercury-free operations, having heard of the impressive gold recovery as reported by others. Such subsequent visits at each site were conducted either by the Mine Manager or the Project Technical Officer. This continued over the life of each mining operation and depended entirely on the willingness of the Site Manager to accommodate interested parties.

UPTAKE BY MINERS

After witnessing the demonstrations, miners reported making changes at their own operations. Groups of miners from the indigenous village of Karrau witnessed the demonstrations at Puruni and Mahdia. Village leaders then approached the project, requesting the establishment of a mercury-free site on village land. While a Karrau site was not originally a planned output, the project agreed to this request. The site was completed in the closing months of project implementation through collaboration with GGMC and the CI-Guyana, NORAD-Funded project that focuses on improving the livelihoods of Indigenous Villages in specific regions.

FACT SHEET

June 2023

planetGOLD Indonesia

Developing Micro-Leaching Tank of Mercury-Free Technology for ASGM in Indonesia

Introduction

The Government of Indonesia has undertaken significant steps toward the reduction and elimination of mercury in the artisanal and small-scale gold mining (ASGM) sector. Since the Government formally banned the use of mercury in 2017 and committed to reduce/eliminate mercury use in ASGM by 2025, there has been an increasing number of cyanidation processing plants built by miners in mining sites around Indonesia. This is an indication that due to very limited access to mercury supply, the miners have been shifting to a mercury-free technique to sustain their livelihood as gold miners.

As part of its objective to increase the capacity of mining communities for mercury-free ASGM through the technical assistance and technology transfer, the project aimed to provide a prototype of a small mobile plant with mercury-free gold processing equipment to be implemented with miners, particularly for locations like Hulawa Village where 100% of miners are still using the amalgamation system. This fact sheet focuses on the process the project team underwent to develop, test, and train miners on a newly designed, mobile leaching tank for use in artisanal gold mining.

Development of a micro-leaching tank

The project design envisioned that the the project would establish a small mobile plant that could be used to teach artisanal miners to improve processing techniques and to help miners make economic calculations and comparisons of mercury versus non-mercury processing methods. At the end of the project, the intention was to transfer ownership of the mobile plants from credible lenders to mining cooperatives or community groups in a *lease-to-own-program* so that the miners can continue mercury-free processing and train new miners in its use.

The process of establishing small-scale mercury-free processing plant

Looking at the recent technology built by the project's Implementing Partners (i.e. BRIN and MoEF), which have a capacity of 2 tonnes, the small-scale miners doubted that the scale and the system of the processing plant could be implemented and replicated by most of the miners, because most of the miners do not have enough capital to procure the 2 tonne capacity system.

In terms of the cost, building the facility is expensive, furthermore the miners are doubtful that they will easily get a loan from financial entities.

Thus the project team found it necessary to down-scale the technology for the miners in a way that would make it more affordable for miners and manageable in terms of tailing issues and permit requirements. This is in line with the project's assessment report recommending developing a micro-scale individual processing plant. It is important and urgently needed that the project must be able to provide a prototype of a small-mobile plant with mercury-free gold processing equipment to be implemented with miners. This prototype is required to be designed in a laboratory, built and tested directly at a mining site, resulting in a Detail Engineering Design (DED) that can be adopted by miners in order to reduce mercury use.

Responding to the concern, the project developed an option for a "Micro-processing plant for an individual miner who have small amount ore (250 kg) with low capital (<3000 USD)". The trommel owned by miners will still be used for grinding the gold ore with an effort on optimizing the particle size to less than 0.2mm so the sludge can be further processed by the micro-processing plant. This step is for reducing the cost of a new mercury-free processing plant.

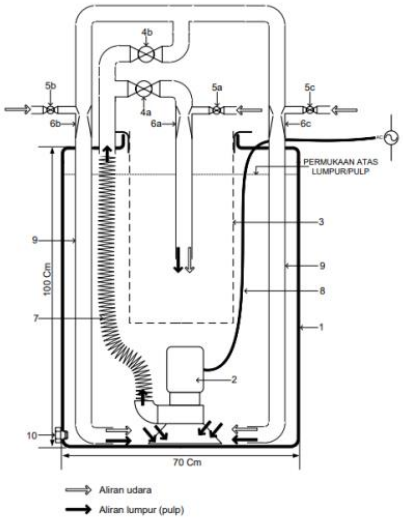
FACT SHEET

June 2023

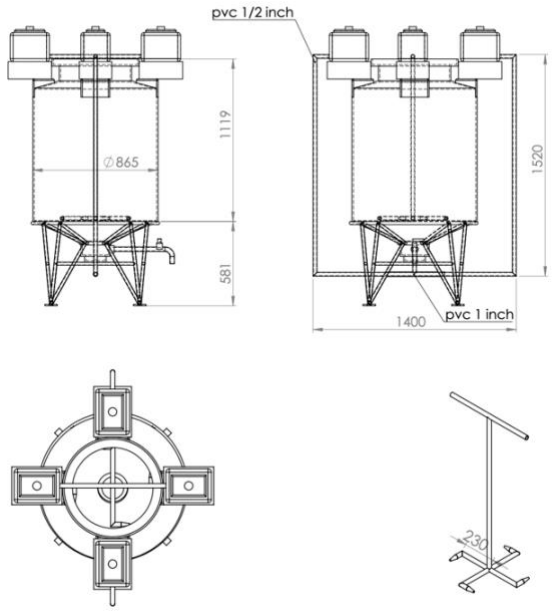
planetGOLD Indonesia

To find this final model of “Micro-processing plant for an individual miner” there were steps that have been conducted by project:

1. Developing DED of “ISMIA Micro-processing plant for an individual miner”.



2. Following the implementing of this equipment, some miners are still skeptical of the results, thus the project has conducted optimalization of the equipment. The adjustment parts are:
   - The shape of the barrel from flat bottom changed to cone shape bottom.
   - Machine attached to the barrel.



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The new design of equipment has been tested in Anggai Village - Obi Island on 31 January – 10 February 2021 with an aim to:

1. Introduce the alternative mercury-free technology
2. Provide information of fundamental mercury - free processing plant
3. Provide information of the dangers of mercury used and comparison of mercury versus mercury-free technology

The training involved the trainers from BRIN, local government personnel to miners. The training on producing Micro-Scale Mercury-Free Gold Processing Equipment used an adult learning approach. This was based on the premise that the participants already had knowledge and experience of ASGM practices, particularly gold processing using cyanide. Therefore, the methods used in the training include presentations, group discussions, simulations, demonstrations, actions, and questions and answers. The combination of these methods spurred the participants to understand more

easily how to make equipment and how to use it in the future. An atmosphere of competition is also presented for individuals and groups.

Training process

1. The main topics of the training included procedures for processing mercury-free gold and managing its waste: (1) Assembling micro-scale mercury-free gold processing equipment (2) Carbon Dissolving and Absorption; (3) Carbon Washing and Burning; (4) Carbon Ash Smelting; (5) Cyanidation Waste Treatment; (6) Measurement of Free Cyanide Levels. These topics can be used as a source of reference and information in strengthening the capacity of miners in the ASGM sector, particularly in processing primary gold ore and waste management.

2. Assembly has been carried out first on one of the tanks before the miners assembled the second tank so that they could identify tank that lacked and have precise measurements so that miners can use them as an example for the second tank assembly. Tank assembly by the miners ran smoothly, there were only a few assembly techniques that still require accuracy in the process so that tank assembly can be more effective and efficient and there was equipment that was lacking at the time of assembly and would be evaluated in the future. It was hoped that this assembly technique can be understood by miners so that miners could assemble their own micro-scale mercury-free gold equipment.

3. The micro-scale mercury-free gold processing used a volume of 200 liters of water for each tank, then 90 kg of ore was added to each tank. As much as 500 grams of lime was dissolved and added to the tank to increase the pH to pH 10.5. Cyanide added in the form of Sodium Cyanide (NaCN) was added as much as 700 grams to get a cyanide concentration (CN-) in the tank of 1200 ppm. This gold dissolving process lasts for 48 hours. The 7 kg of carbon will be added after 6 hours of cyanide entering the tank.

During the process, miners assisted to determine pH and Dissolved Oxygen to be able to understand the process parameters that must be maintained so that dissolving gold takes place effectively. The miners also had to determine free cyanide using the titration method. This was done so that miners can determine their own pH, Dissolved Oxygen, and free cyanide in the future after this technical training is completed. Determination of these process parameters should be carried out in the first 6 hours before carbon enters to determine whether the process is going well or not.

The following is a table of parameters measure during the training:

Time	Tank No. 1			Tank No. 2		
	CN- (ppm)	pH	DO (ppm)	CN- (ppm)	pH	DO (ppm)
Hour -0	1192	10.65	7.1	1192	10.68	6.8
Hour -1	1139	10.61	7	1126	10.65	7.2
Hour -2	1086	10.56	6.8	1099	10.61	7.1
Hour -3	1060	10.54	7.1	980	10.55	6.8
Hour -6	1060	10.40	6.9	954	10.41	7.0
Hour -24	795	10.20	6.8	821	10.18	6.7
Hour -28	768	10.50	6.8	795	10.47	6.8

After 48 hours, the carbon was removed and washed first. The collected carbon will be burned and smelted elsewhere because the equipment used is difficult to move to the training location. The final result was gold weighing 1.14 gram.

From this equipment for fully functioning used, it is estimated that the amounts of mercury avoided are as follows:

Item	Anggai Village, South Halmahera
Number of micro-processing tanks (unit)	2
Average tank capacity (kg)	150
Number batch processed per month	9
Total ore processed per month (kg)	2700
Total Hg avoided feed per month (kg)	67.5
Total Hg avoided loss to environment per month (kg)	0.44
Total mercury-free gold produced per month (kg)	0.06
Total Hg avoided loss to environment per year (kg)	5.28
Total mercury-free gold produced per year (kg)	0.72

4. Gold processing produced cyanide waste with high concentrations, and it is forbidden to dispose of it into the environment, so the cyanide waste must be treated. In this training, Copper sulfate was used as a detoxification catalyst as much as 50 grams per tank and Sodium Metabisulfite (SMBS) as a detoxification agent as much as 5 kg per tank. Detoxification lasted for 3 hours and free cyanide was determined using a Spectrometer. The remaining 1.4 ppm of free cyanide from detoxification can then be disposed of. It was hoped that this training on waste processing could be understood and

implemented by the miners because before the training was carried out, the miners immediately disposed of cyanide waste without carrying out detoxification, thereby polluting the environment and endangering health. This understanding will make miners aware of the dangers of discarded waste and will carry out waste treatment before disposal.

5. During the training, pre-test and post-test was also conducted with results showing that the knowledge level of the majority of participants (30 out of 37 participants) had developed from the beginning to the end of the training. The mean score increased from 30.95 to 46.35; so that the average percentage increase is 49.78%. This indicates that the training is running effectively so that participants can receive learning well.

Lessons-learned

1. From the positive result of the Angga Village training, the project continued introducing 6 units of the equipment to Hulawa Village and 4 units provided to Sekotong Regency.
2. The equipment can be used not only for male miners but also for the women, as the size of the tank is manageable for women.
3. From all the site, understanding pH is important for miners and they must invest a small amount in buying the pH measurement i.e. pH paper or pH meter.
4. Miners understand the important concept of waste management, however miners need other simple chemical process to reduce the CN toxicity in a short time period, i.e adding the chemical directly onto the tailing pond. In addition, availability of the chemical ingredient is not easy to find and buy in the sites.

Written by Baiq Dewi Krisnayanti (National Project Manager)

FACT SHEET

planetGOLD Kenya Technology Transfer

BACKGROUND

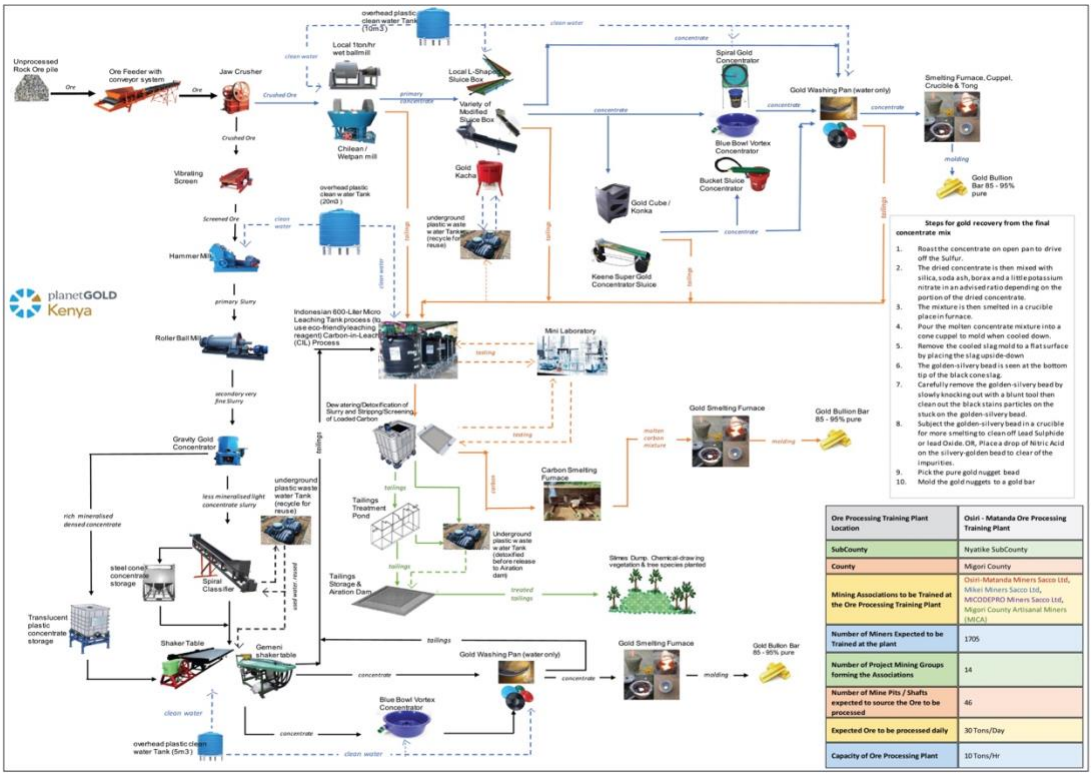
planetGOLD Kenya is set to put up ore processing and gravimetric demonstration / training plants where mining groups will increase their capacities for mercury-free ASGM through provision of technical assistance and technology transfer. At mercury free training plants, miners will engage in hands-on mineral process on their own upon attainment of training by the project technical team.

Ore processing training plant will be setup at Osiri-Matanda project location situated in Migori County. It will have a full-scale ore process line, a gravimetric process line and a micro-leaching process line. The Osiri ore processing plant is expected to train at least 1705 miners belonging to four (4) mining associations; comprising of 14 mining groups and ore from approximately 46 active mine shafts/pits. Approximately 30 Tons of ore will be processed per day at the training plant. The proposed processing system lines can optimally run a continuous crushed and concentrate slurry flow rate of 10 Ton/hr.

Gravimetric training plants will be setup at Rosterman and Bushiangala (in Kakamega County), Chavakali-Vyalo and Kamlembe (in Vihiga County), Kehancha (in Migori County) and Lolgorian (in Narok County).

Design / Workflow Diagram at the Ore Processing Training Plant

Click to see full size image

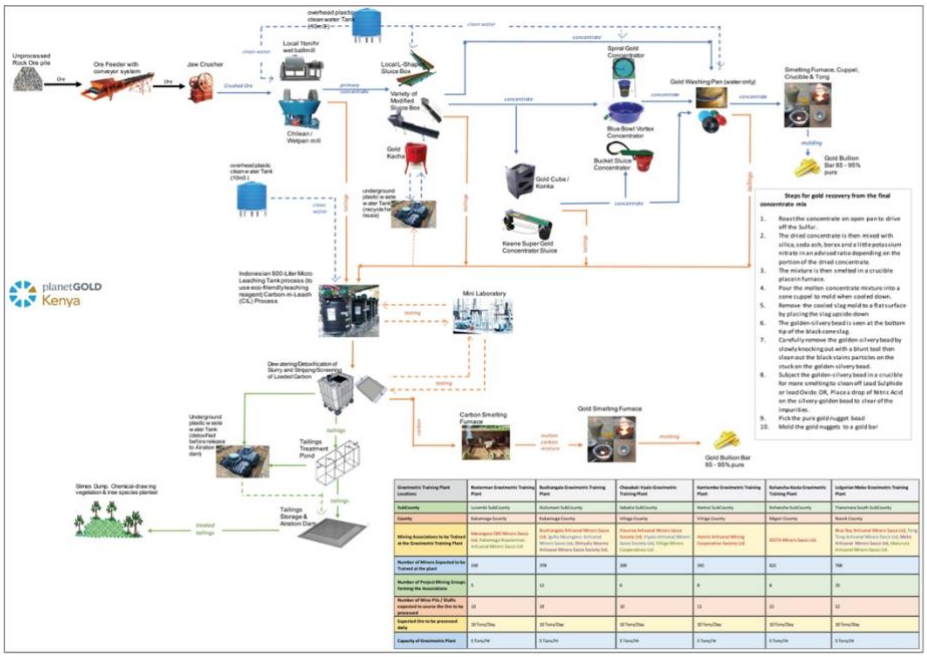


The gravimetric plants expect to train miners' population ranging between 230 to 768, comprising of 5 to 15 mining associations and operating mine shafts/pits numbering 10 to 52. Expected ore to the gravimetric plants by respective mining associations is 10 Tons per day of ore for demonstrations and processing. All Gravimetric plants comprise process lines for both gravimetric equipment line and micro-leaching with an optimal continuous crushed and concentrate slurry flow rate of 5 Ton/hr.

Layout for the planetGOLD Kenya mercury-free training plants' have an elaborate waste management and tailing management plans. The project will ensure that only tested and approved eco-friendly leaching chemical and reagents are used.

Design /Workflow Diagram at the Gravimetric Training Plants

Click to see full size image



TECHNOLOGY DEPLOYED

planetGOLD Kenya technology handbook proposes mercury-free processes at Ore Liberation, Ore Crushing, Ore Screening, Ore Milling, Ore Concentration, Gold Amalgamation, Chemical Leaching, Tailing Waste Management and Mine Closure Management.

Processes	Equipment & Technology
Ore Liberation	a small ball mill, mortar and pestle, sledge hammer, a clock, a bucket, a washing basin or pond, sieves (5mm, 2mm, 1mm, 0.5mm, 0.1mm) and a weigh scale (up to 200kg).
Ore Crushing	Ore Feeder & Hopper, Jaw Crusher
Ore Screening	Single Deck Vibrating Screen
Ore Milling	Hammer Mill, Roller Ball Mill, Wet Ball Mill, Wet Pan Mill/Chilean Mill, Spiral Classifier
Ore Concentration	Gravity Gold Concentrator, Gold Kacha, Shaker Table, Gemeni Shaker Table, Modified Sluice Boxes, Gold Cube / Konka, Spiral Gold Concentrator, Keene Super Gold Concentrator Sluice, Bucket Sluice Concentrator, Blue Bowl Vortex Concentrator
Gold Amalgamation	Gold Washing Pan & Gold Pan Kits, Crucibles & Tongs & Gold Molds, Gold Concentrate Smelting Furnace, Charcoal Briquette Machine, Carbon Smelting Furnace,
Chemical Leaching	Assortment of laboratory Apparatus, Tools and Equipment, Indonesian 600-Liter Micro Leaching Tank and complete with part assembly, Detoxification Tank, Carbon Screen for Detoxification Tank, Air Compressor for Smelting, Booster Water Pump, Fresh Water Pump, Booster Water Submersible Pump, Aerator, Sump Box, Leached Tailing Treatment Pond.
Tailing Waste Management and Mine Closure Management	Septic underground plastic Waste-Water Tank, Tailings Storage & Aeration Dam, Slimes Dump. Chemical-drawing vegetation & tree species planted

SELECTION OF TECHNOLOGY

Selection of technology was consultative with the mining communities. Key considerations for technology selection include: - Cost of technology, Availability of technology, Acceptability of technology, Economies of scale, Scalability of technology, Useability of the technology, Cultural factors of the mining community and Efficiency of Gold Recoverability in the technology.

APPROXIMATE COSTS

Item #	Description	UOM	Quantity	Unit Cost (USD)	Total Cost (USD)
A	Ore Processing Line	LS	1	38,950	38,950
B	Gravimetric Line	LS	7	21,750	152,250
C	Micro-Leaching Line	LS	7	14,975	104,825
D	Additional Set-up Costs	LS	1	4,000	4,000
	GRAND TOTAL				**300,025**

EXPECTED TECHNICAL TRAINING, DISSEMINATION & UPTAKE BY MINERS

At Ore Processing Plant

Ore Processing Training Plant Location	**Osiri - Matanda Ore Processing Training Plant**
SubCounty	Nyatike SubCounty
County	Migori County
Mining Associations to be Trained at the Ore Processing Training Plant	Osiri-Matanda Miners Sacco Ltd, Mikei Miners Sacco Ltd, MICODEPRO Miners Sacco Ltd, Migori County Artisanal Miners (MICA)
Number of Miners Expected to be Trained at the plant	1705
Number of Project Mining Groups forming the Associations	14
Number of Mine Pits / Shafts expected to source the Ore to be processed	46
Expected Ore to be processed daily	40 Tons/Day
Capacity of Ore Processing Plant	10 Tons/Hr

At Gravimetric Plant

Gravimetric Training Plant Locations	Rosterman Gravimetric Training Plant	Bushiangala Gravimetric Training Plant	Chavakali-Vyalo Gravimetric Training Plant	Kamlembe Gravimetric Training Plant	Kehancha-Kesta Gravimetric Training Plant	Lolgorian Meko Gravimetric Training Plant
SubCounty	Lurambi SubCounty	Ikolomani SubCounty	Sabatia SubCounty	Hamisi SubCounty	Kehancha SubCounty	Transmara South SubCounty
County	Kakamega County	Kakamega County	Vihiga County	Vihiga County	Migori County	Narok County
Mining Associations to be Trained at the Gravimetric Training Plant	Mwangaza CBO Miners Sacco Ltd, Kakamega Roasterman Artisanal Miners Sacco Ltd	Bushiangala Artisanal Miners Sacco Ltd, Iguhu Muungano Artisanal Miners Sacco Ltd, Shinyalu-Neema Artisanal Miners Sacco Society Ltd,	Elwunza Artisanal Miners Sacco Society Ltd, Viyalo Artisanal Miners Sacco Society Ltd, Vihiga Miners Cooperatives Ltd	Hamisi Artisanal Mining Cooperative Society Ltd	KESTA Miners Sacco Ltd.	Blue Ray Artisanal Miners Sacco Ltd, Teng Teng Artisanal Miners Sacco Ltd, Meko Artisanal Miners Sacco Ltd, Masurura Artisanal Miners Sacco Ltd.
Number of Miners Expected to be Trained at the plant	230	378	200	242	622	768
Number of Project Mining Groups forming the Associations	5	12	6	8	8	15
Number of Mine Pits / Shafts expected to source the Ore to be processed	10	19	10	11	22	52
Expected Ore to be processed daily	10 Tons/Day	10 Tons/Day	10 Tons/Day	10 Tons/Day	10 Tons/Day	10 Tons/Day
Capacity of Gravimetric Plant	5 Tons/Hr	5 Tons/Hr	5 Tons/Hr	5 Tons/Hr	5 Tons/Hr	5 Tons/Hr

FACT SHEET

planetGOLD Mongolia

Professionalizing ASGM processing in Mongolia

BACKGROUND

Mongolia's mining sector is dominated by the large-scale extraction of coal, copper, fluorite, gold, and iron ore. Gold is the main commodity mined on an artisanal and small-scale with 83% of the sector's workforce operating in 15 provinces out of 21 provinces in Mongolia making it an important livelihood activity across the country. (NSO 2021). An estimated 60,000 people directly engage in ASM in Mongolia, and approximately 240,000 are dependent on the sector for their livelihood.

The ASM was officially recognized by the State in 2010 with inclusions in the Minerals Law and approval of the ASM Regulation. Since then, there have been two revisions of the Regulation in 2017 and 2022 reflecting the ongoing needs and changes in the ASM sector. ASM gold processing is heavily regulated with more than 40 official documents required. The application and approval process for these documents is lengthy and costly, which exacerbates the informality of the sector. As of 2023, there are only two processing plants with proper operational permits in the whole country. Furthermore, this contributes to the lack of availability of processing facilities which drives the miners to use banned chemical substances such as mercury.

The planetGOLD project has estimated around 12 processing plants operating in the country with various levels of operations and equipment.

Then the project team chose a collaborative approach to partner with an existing processing plant which offers the opportunity to test another model for the implementation of mercury-free technologies in the ASGM sector.

Through a competitive selection process, the project selected the two ASGM processing facilities to introduce mercury-free processing systems (MFPS), with consideration of the criteria including availability of ore resources, existing infrastructure, production capacity, formalization, potential ASGM beneficiaries and willingness to work responsibly and sustainably with the project.

Common challenges faced by ASGM processing plants in Mongolia

In addition to the MFPS, the project sees an opportunity to promote the formalization of plant operations by supporting the acquisition of missing permits, as well as to implement due diligence standards in extraction, processing and trading of the mineral.

TECHNOLOGY DEPLOYED

In order to identify environmentally friendly and clean technologies adapted to the local condition, the planetGOLD project conducted extensive research and laboratory tests on the ore reserves, ore grade, the existing technologies and equipment, and the latest gold recovery methods in the ASGM sector.

Flotation and gravimetric laboratory experiment were conducted with representative ore sampled from ASGM sites. Based on research the new processing system is designed as 100% gravimetric technology without using any chemicals and has the capacity to concentrate 3 (MFPS-1)-5 (MFPS-2) metric tons of hard rock gold deposit ore per day.

Based on the results and implementation viability within the project timeline, the planetGOLD project decided to introduce an enhanced gravity processing circuit that will increase the gold recovery rate and production. The new systems are designed as 100% gravimetric technology without using any chemicals with capacities to process a total of 8 metric tons of ore per day.

Table 1: Recovery rates of the experiment

Processing equipment	Recovery rate
Froth flotation	39.7%
Centrifugal concentrator	57.1%
Shaking table	64.4%

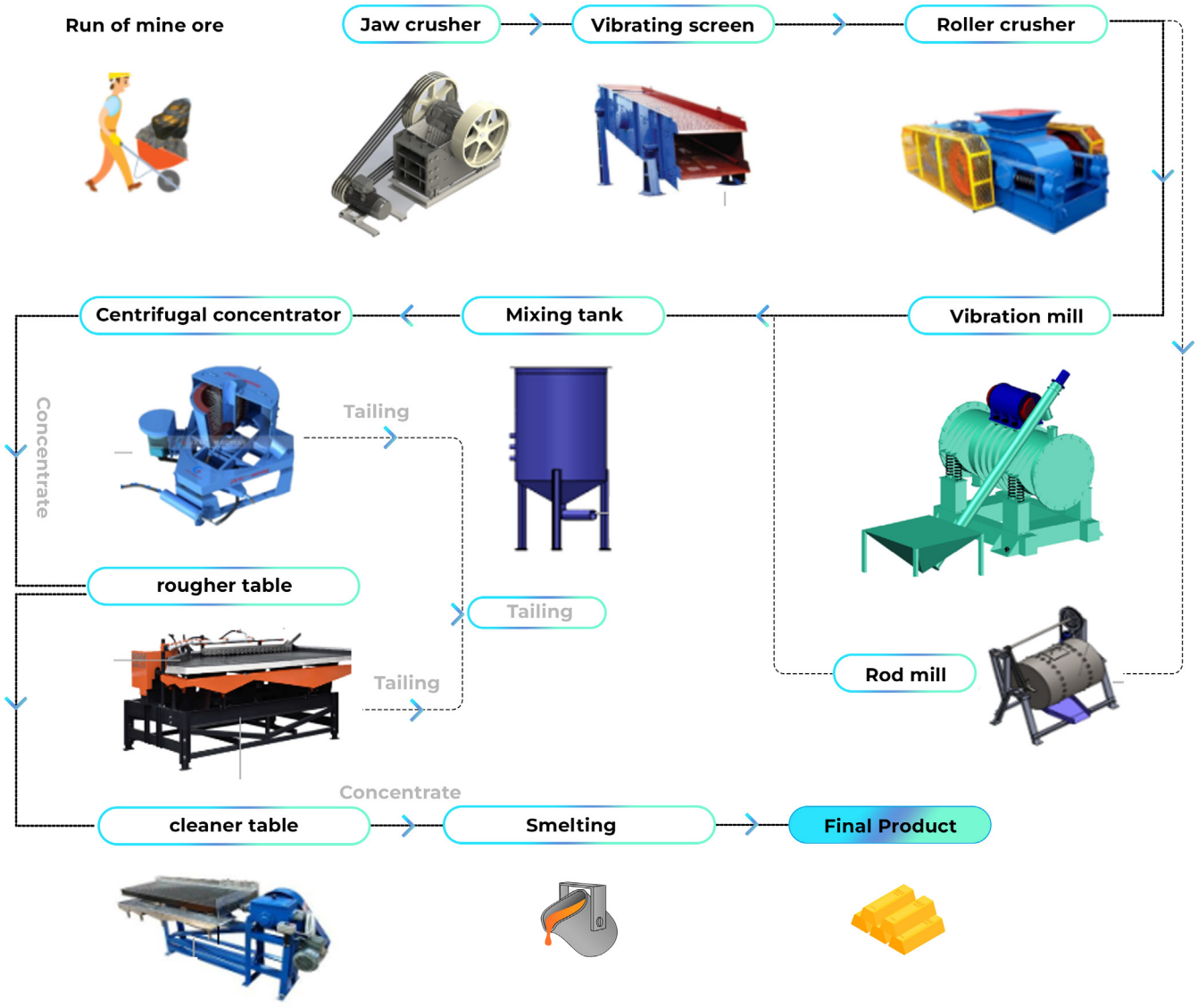


Figure 1: planetGOLD MFPS simplified diagram

The key equipment in determining the processing capacity is a grinding mill as it is the most time-consuming part in the processing cycle. Therefore, the planetGOLD project introduced a dry grinding vibration mill for the first MFPS and ball mill for the second MFPS to improve gold particle liberation rate by both of dry and wet grinding and to compare efficiency of the mills. Current recovery rate is 30-50% using wet pan mill and sluice. The planetGOLD circuit is projected to recover 60-70% of total gold.

Table 2: Key parameters for planetGOLD Mongolia MFPSs

Key parameters	MFPS-1	MFPS-2
Capacity	3 tonnes of gold ore per day	5 tonnes of gold ore per day
Raw ore gold grade	16.74 g/t	28.8 g/t
Expected recovery rate	60-70%	60-70%
Expected gold production	30-35 grams	86.4-100.8 grams

The tailings management facility will act as a holding cell for gravimetric tailings that will contain upwards of 30-40% of the total gold. This is because the gravimetric system is limited to only recovering free gold, so further gold recovery can only be achieved by using additional mineral processing technologies involving chemicals such as leaching or flotation. The "tailings" are therefore not final waste material and must be treated as a material of value. This low-medium grade material will be stockpiled until a suitable solution is arranged, such as an off-site processing at a third-party cyanidation facility.

The planetGOLD project estimates the total cost for both MFPSs to be USD 350,000. This includes manufacturing, import, taxation, as well as construction and infrastructure development. High logistics cost as a landlocked country and construction cost for the harsh winter climate are key factors behind the high cost. The onerous permitting process increases the cost further.

TECHNICAL TRAINING AND DISSEMINATION

The planetGOLD project conducted operations and maintenance trainings during the installation and commissioning of the MFPS to familiarize the participants with equipment assembly and functions. All staff of the processing plants who will operate and the miners who will be served by the MFPS took part in the training. The training was conducted in the form of on-the-job training where the participants learned to assemble and install the equipment in a proper and reliable way to ensure their own safety.

Figure 2. On-site training on rod mill and shaking table

The training imparted knowledge and skills on preventive maintenance schedule making, equipment maintenance and operation procedures, and the safety of the work environment whereas the online part delivered about the smelting system, fluxes, basic operating principles, and grinding efficiency as well. The importance of safety, operational procedures, and record keeping such as maintenance logs were reemphasized to the trainees who recognized and embraced the value of these principles. The project plans to conduct regular training as a refresher course every 3-6 months to ensure the safe operation of MFPS technologies. Furthermore, the project will develop a manual on operational procedures for the MFPSs, equipment inspection sheets, and a regular maintenance book.

PHOTO GALLERY

Figure 3. Progress of installation, testing, and on-site training

planetGOLD Mongolia
Supported by: gef
Led by: UN environment programme
In partnership with: UNIDO United Nations Industrial Development Organization; Government of Mongolia Ministry of Environment and Tourism; AGC

FACTSHEET

planetGOLD Perú

Technology transfer activities in Peru

Background

In Peru, there are around 300,000 artisanal miners who have been working in this activity in the 25 regions of the country. The government, through Legislative Decree 1293, declared the formalization of artisanal and small-scale mining (ASM) activities to be of national interest, creating the Comprehensive Mining Formalization Process, where 88,000 miners (between individuals and legal entities) decided to register and start their process of formalization. To date, there are more than 10,000 miners who have achieved formality, however, these Peruvian entrepreneurs must still take on the challenge of being sustainable with this economic activity and improving their environmental and mining practices, as well as strengthening their management capacity business, for which accessing to the services offered by the financial system represents an opportunity to invest in technologies and equipment that allows them to stop using mercury and increase their profitability.

According to figures from the Ministry of Energy and Mines, the small-scale and artisanal mining sector contributes 20% (20 tons) of gold volume to the national gold production (150 tons). Arequipa, Puno, Piura and Madre de Dios are the regions that contribute with the greatest volume of production. This volume places Peru as the first gold producer in South America and sixth worldwide.

Alluvial gold mining and underground mining are practiced in Peru's ASM. Alluvial gold mining is an economic activity that takes advantage of detrital gold deposited in terraces, placers, plains, riverbeds, etc. This geological condition allows artisanal miners to obtain gold-bearing material more easily, using rudimentary technology and low-skilled labor.

On the other hand, underground gold mining is an economic activity that involves the use of gold veins or veins found within the subsoil, which are difficult to access and require greater investment. However, artisanal miners carry out this activity in conditions of risk to health and the environment, with limited technical assistance, lack of financing and rudimentary or adapted technologies, known as "hechizos".

It is estimated that 80% of the miners registered with REINFO (Integral Mining Formalization Registry) work in areas where undergroung mining is practiced, while the other 20% practice alluvial mining. The topographic and geological conditions of Peru make primary deposits predominate, making it necessary to carry out underground mining to access the resource with empirical exploitation techniques and where mineral processing with mercury predominates.

Description of technology deployed

In order to identify clean and environmentally friendly technologies adapted to local conditions, planetGOLD Peru carries out, as a **first step**, the *technical diagnosis* of the artisanal mining operation, both in terms of extraction and metallurgical processing.

As a **second step**, a *topographic survey* is conducted inside the mine and geological sampling is performed.

As a **third step**, the *samples are analyzed in the laboratory* to determine the type of ore (oxidized, sulfide, or mixed), particle size distribution, reserve, and grade.

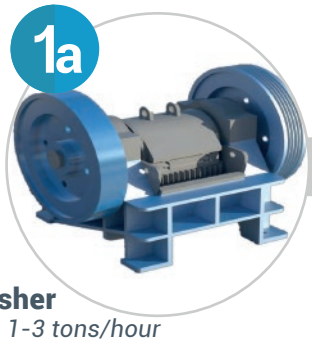
Finally, as a **fourth step**, after conducting some *tests and evaluation the feasibility of ore recovery* through clean processes, the implementation of a metallurgical processing circuit based on gravity separation is recommended.

The implemented technology is suitable for both alluvial mining and underground mining, as shown in the following flowchart. The key is to liberate the gold and allow the material to enter the agitation tank with the ideal mineral size according to the type of deposit. For example, we recommend that for alluvial mining, the material should be up to 165 microns (mesh 90), and for underground mining, it should be up to 106 microns (mesh 140).

planetGOLD Perú

UNDERGROUND MINING

1a



6" x 8" Jaw Crusher
Crushing capacity: 1-3 tons/hour
USD 9,500

2a

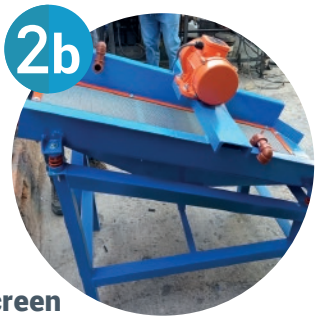
3' x 3' Ball Mill
Grinding capacity: 0.4 tons/hour
USD 9,500

ALLUVIAL MINING

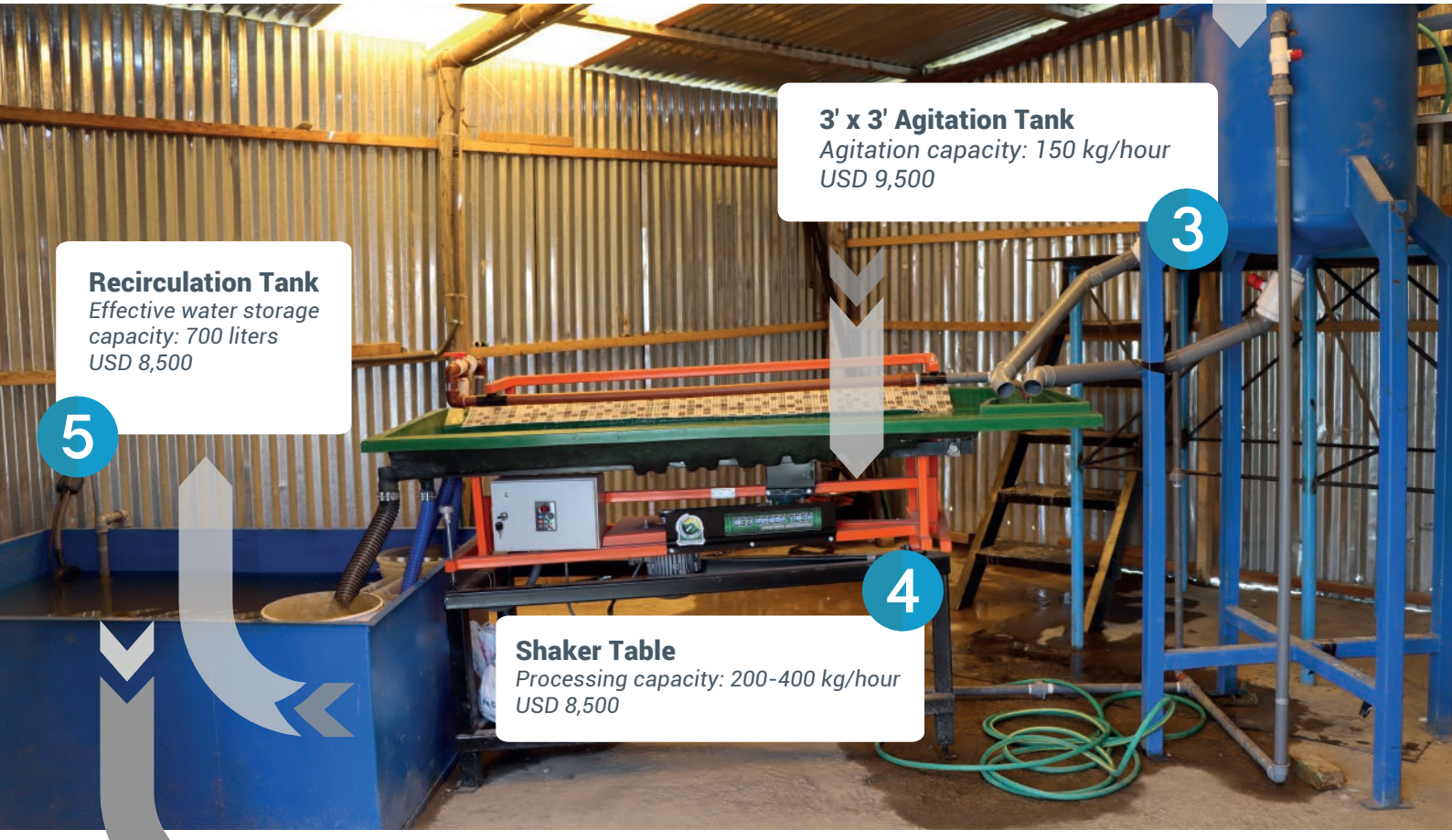
1b

Sluice box

2b



Vibrating Screen
USD 4,000



3' x 3' Agitation Tank
Agitation capacity: 150 kg/hour
USD 9,500

3

Recirculation Tank
Effective water storage capacity: 700 liters
USD 8,500

5

4

Shaker Table
Processing capacity: 200-400 kg/hour
USD 8,500

Smelting

6

7

Final product

FLOWCHART OF A GRAVITY PLANT FOR THE RECOVERY OF GOLD WITHOUT MERCURY

Equipment function description

1a **Jaw Crusher:** Reduces the size of the extracted mineral rock from the underground tunnel so that it can pass into the mill.

2a **Ball Mill:** It liberates the gold, and it is recommended that the mineral be reduced to 106 microns and pass through a 140-mesh screen.

2b **Vibrating Screen:** Used for alluvial mining. The pre-concentrated mineral from the sluice box is separated, and a 165-micron mineral that passes through a 90-mesh screen is obtained. This concentrate then goes to the agitation tank to form the pulp.

3 **Agitation Tank:** The tank homogenizes the mineral pulp that will enter the gravity table. It works by generating a vortex-like movement, created by a shaft attached to the paddles that allow the movement of the pulp. To regulate the intensity of the movement force, it has a frequency regulator (VR) and a gearbox, which adds force to the work being done.

4 **Shaker Table:** The table utilizes the physical properties of minerals to selectively separate them and obtain gold and reject material. The table vibrates longitudinally through its mechanism, using a slow leftward stroke and a quick rightward return, causing mineral particles to slowly drag along the deck in the direction of the slower movement.

5 **Recirculation Tank:** This tank, a quadrilateral structure, stores water from the gravity table. It serves as the water supply for the table using a water pump, creating a closed circuit and improving water utilization, which can be reused. It receives the 4 ports from the gravity table where the concentrated gold that will go to the smelter is collected.

The equipment implementation involves a process of adaptation and calibration by the miners with the assistance of an metallurgical engineer. This system has demonstrated an **average gold recovery efficiency of 90%**, and any unrecoverable mineral is sold to a cyanidation plant, in this way no tailings are generated.

It is worth noting that the metallurgical equipment transferred by the project is co-financed by the miner ally. This investment covers civil works, electrical supplies, equipment coverage, and security. This co-financing reflects the level of commitment of artisanal miners towards technological change, a progressive mechanization process.

Summary of training and dissemination activities to encourage uptake by miners

To date, 9 gravity plants have been transferred in the regions of Puno and Arequipa, with 6 more plants pending transfer in 2023. Undoubtedly, technical support is crucial for the proper use and management of the metallurgical equipment, considering variables such as:

- Type of mineral.
- Association with other minerals.
- Shape and size of gold particles.
- Density and viscosity of the pulp.
- Equipment cost.
- Availability of spare parts.
- Access to energy and water resources.

Map of plants and equipments delivered by planetGOLD Peru until june 2023.

The project, in collaboration with regional governments, provides training to artisanal miners, university students, and professionals in ASM, demonstrating that gravity plants are a viable option for the recovery of gold without mercury. In this way, the project contributes to the multisectoral national policy for artisanal and small-scale mining, which aims to promote the use of clean technologies.

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FACT SHEET

planetGOLD Philippines

Technology Transfer in the Philippines

BACKGROUND

In the Philippines, the planetGOLD Project is executed by the Artisanal Gold Council (AGC) and implemented by the United Nations Industrial Development Organization (UNIDO) and the United Nations Environment Program (UNEP). In partnership with the Department of Environment and Natural Resources (DENR) and the Mines and Geosciences Bureau (MGB), the Project is being carried out in two (2) project sites– Sagada, Mountain Province and Paracale, Camarines Norte.

Under the better technologies and techniques component of the Project, a Mercury-Free Processing System (MFPS) is currently being constructed in the *Minahang Bayan* (or People's Small-Scale Mining Area) in Paracale, and is progressing towards completion. While in Sagada, improvements to the existing systems and processes of the miners are intended to commence.

TECHNOLOGY DEPLOYED

▸ Technology Selection

To have a good understanding of the Artisanal and Small-Scale Gold Mining (ASGM) sector in the project sites, a baselining study and mineral resource assessment were conducted. These studies provided the data needed to develop the design of the MFPS, ensuring that it is tailored to the ore characteristics in the sites and the specific needs and conditions of the respective mining communities.

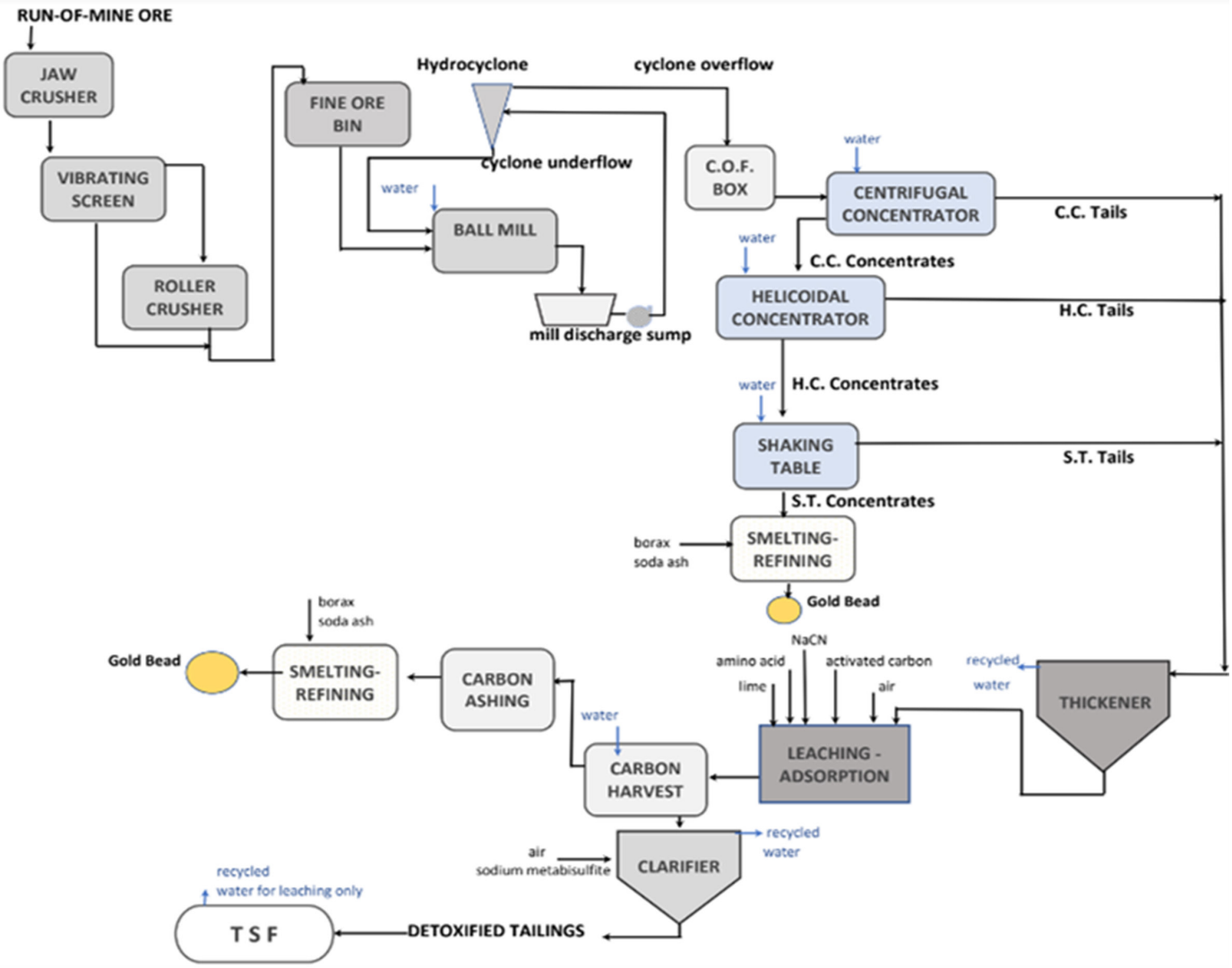
The complete circuit of the Paracale MFPS is composed of gravity concentration methods and chemical leaching which are widely used by large-scale mining industries in the Philippines and around the world recovering gold from ores with the same mineral characteristics.

As for Sagada, several community consultations were organized by the project team to discuss the proposed MFPS. However, some community members did not give their consent to construct a leaching facility for the small-scale miners due to concerns on the effects of chemical use on the environment. This is despite the thorough explanation of the project team and its government partners on the proper management and disposal systems which will be in place. As a result, system improvements to the current process plants of Sagada miners will be implemented instead of a complete gold processing circuit similar to Paracale.

A miner uses an axe to break the ore into smaller pieces before feeding into the ball mill.

▸ Design / Workflow

1. Municipality of Paracale, Camarines Norte



Process Design for Paracale MFPS

Crushing and Screening

Run-of-mine (ROM) ore packed in bags will be received by the facility and the wet weight of ores in kilograms will be recorded. Samples will be subjected to percent moisture determination. ROM ores will be fed into a primary crusher where 80% of the particles are targeted to be reduced below 12 mm (P80 = 12 mm). The classification system will consist of a vibrating screen, with oversized material fed into a secondary crusher to produce the final, desired particle size. Crushed materials will then be stored in the fine ore bin (FOB).

Grinding

Crushed ore inside the FOB will then be gradually fed into the ball mill at a controlled rate. The target cyclone overflow (COF) is designed for P80 = 75 µm or 200 mesh. The cyclone underflow (CUF), normally consisting of a coarser size fraction, will be recirculated back into the mill for regrinding before being fed into the hydrocyclone again in a closed circuit. The COF will be directed to the COF box to advance to the next stage.

Gravity Concentration Process (Centrifugal Concentrator, Helicoidal Concentrator, and Shaking Table), Smelting, and Gold Bead Production

The COF slurry (mixture of ore and water) will be charged to the centrifugal concentrator (CC) at a controlled rate. Fresh or clean water will also be added to the CC to achieve the desired percent solids. The CC concentrates will then be collected and further upgraded by use of the helicoidal concentrator (HC). The HC concentrates will be subjected to the shaking table (ST) for further upgrading. The final concentrates (shaking table concentrates) will then be dried and smelted in a furnace or a traditional clay pot with the appropriate fluxing agents such as borax, niter, soda ash, and/or silica, to produce a doré, which is a metal alloy of primarily gold and silver. Meanwhile, the CC/HC/ST tailings (or process waste) will be collectively stored in the thickener or settling tank for the next processing stage which is leaching.

Paracale MFPS as of June 09, 2023

Leaching, Carbon Ashing, Smelting, and Gold Bead Production

The CC/HC/ST tailings will be thickened to achieve a range of 38-40% solids slurry while the clarified water will be recycled for upstream reuse. Lime will be added to ensure a pH of 10.5 to 11.0, eliminating the risks of toxic hydrogen cyanide (HCN) gas evolution. The thickened slurry will be placed into a carbon-in-leach (CIL) tank wherein the remaining gold will be dissolved via the leaching process followed by the uptake of dissolved gold by way of activated carbon adsorption. After the 36-hour leaching process, the gold-loaded carbon will be harvested through a screen during the discharge of contents of the CIL tank.

A mixture of sodium cyanide and an amino acid will act as the lixiviant or leaching agent. Results using ore from Sagada reveal that the use of amino acid in leaching can achieve a significant gold extraction with decreased cyanide dosage or consumption.

Harvested gold-loaded carbon will undergo washing with water for the removal of unwanted materials before charging to the burner for carbon ashing. After the carbon ashing process, the burner will be cooled down to ensure that it is safe enough for the collection of “matte-like” products. Unburned carbon will be charged back to the next carbon ashing batch. The “matte-like” materials will be collected and will be charged to a furnace for smelting using appropriate fluxing agents to produce doré. To further improve the purity of gold metal products, refining techniques, i.e. use of acids, may be applied.

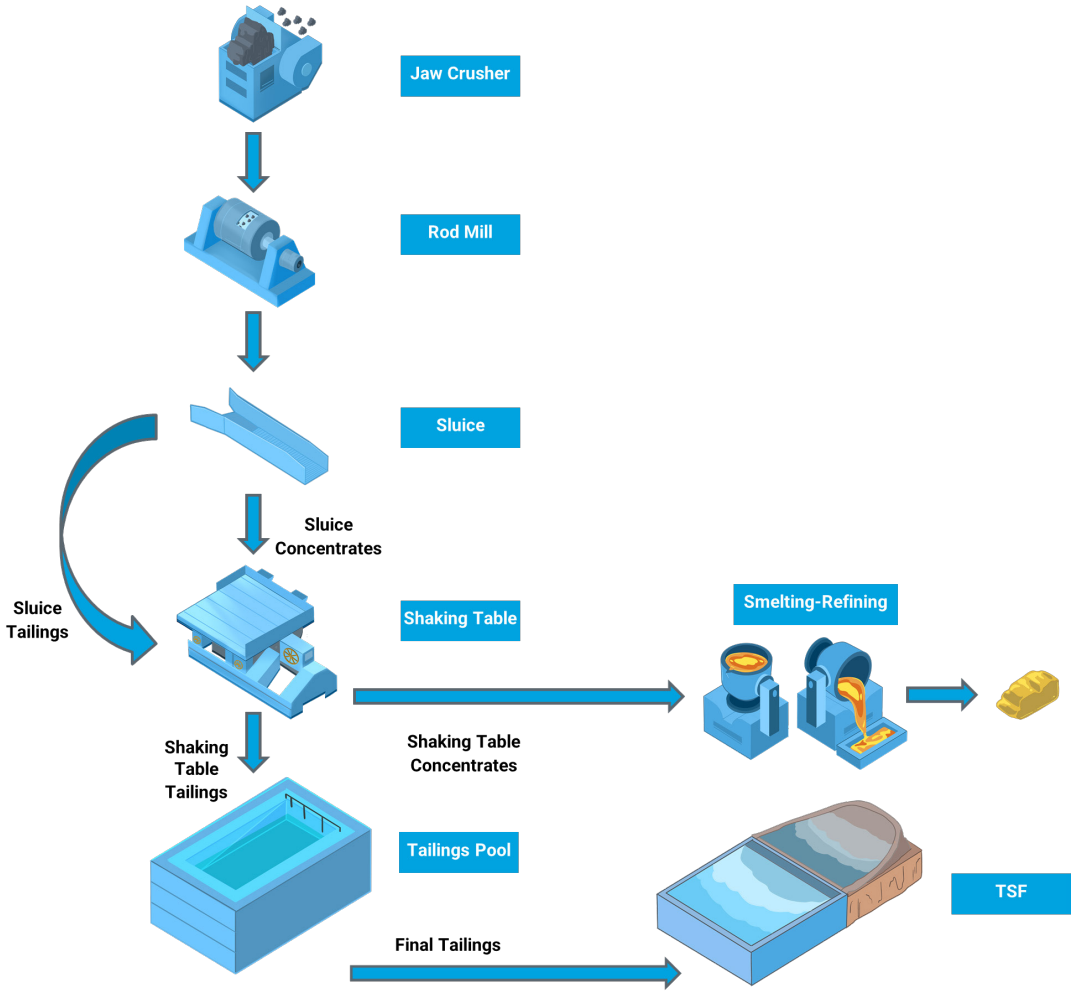
Cyanide Detoxification and Tailings Disposal to Tailings Storage Facility (TSF)

The leached tailings will be subjected to a detoxification process using either sodium metabisulfite ($Na_2S_2O_5 \cdot xH_2O$) or hydrogen peroxide (H_2O_2) inside the clarifier or thickener. After ensuring the compliance for free cyanide effluent regulation, it will then be impounded to the TSF or the tailings storage starter pond. Water in the TSF may also be reused for processing purposes only.

2. Municipality of Sagada, Mt. Province

The system improvement in Sagada is summarized in the in the table below.

Activities	Rationale / Benefits
Installation of jaw crusher	Increased throughput and/or production rate by replacing manual crushing of ores which requires more energy and labor
Installation of sluice boxes	Increased gravity concentration efficiency and gold recovery rates through improvements of sluicing performance
Installation of shaking table	Increased gold recovery rates by capturing gold particles not captured by sluice boxes
Optimization of process control	Improved profit margins by reducing operational expenses
Construction of common TSF	Reduced environmental impact by proper disposal of tailings
Technical training — mineral processing capacity building	Increased efficiencies throughout with better process control to monitor and improve general system performance



Gold Processing System Improvement Design for Sagada

Meanwhile, the final tailings from the MFPS will be sent to a cyanide leaching facility in Itogon, Benguet which is a five (5)-hour drive from Sagada, Mountain Province. AGC will partner with the Loacan Itogon Pocket Miners Association (LIPMA) to install cyanidation tanks that will process gravimetric tailings to recover gold that is not recoverable by gravity concentration methods.

▸ Cost

MFPS-related expenses

Project Site	Description	Total Cost[a], PHP	Total Cost, USD[b]
MFPS-1: Paracale, Camarines Norte	Complete circuit	32,258,653	576,047
MFPS-2: Sagada, Mountain Province	System improvement	8,207,942	146,570
MFPS-2: Itogon, Benguet	Leaching tanks installation	2,800,000	50,000

[a]Total cost includes expenses on building construction and engineering works, equipment purchase and transport, permit acquisition, power installation, water supply works, commissioning, reagents, supplies, consumables, labor, setting up of training center for Paracale, operations and maintenance before turnover, among others.

[b]1 USD = 56 PHP

▸ Improved Gold Recovery

Current estimated gold recovery

Project Site	Current Gold Recovery	Equivalent Gold Amount (Current)	Estimated Gold Recovery	Equivalent Gold Amount (Estimated)
Paracale, Camarines Norte	<50%[c]	25.77 kg	>85%[e]	54.76 kg[g]
Sagada, Mountain Province	<50%[d]	6.04 kg	60%[f]	9.06 kg[h]

[c]Recovery of gold using amalgamation is 30-50%.

[d]Based on the analysis of samples obtained from Sagada, at least 50% of gold is still remaining in the tailings.

[e]Recovery of cyanide leaching can reach up to 95%

[f]Free gold recovery only (MFPS-2: Sagada system improvement) but can reach up to at least 85% (additional recovery by cyanide leaching facility in Itogon, Benguet)

[g]Total annual gold recovered if MFPS-1 can process/accommodate the whole Paracale *Minahang Bayan* ore production

[h]Assumptions and calculations: annual gold production based on the whole *Minahang Bayan* production (if every tunnel will process their ores in the MFPS-2 (system improvement))

TECHNICAL TRAINING & DISSEMINATION

In order to equip miners, plant workers, and other stakeholders with the necessary knowledge and skills related to mercury-free processing technologies, the following training sessions were conducted at the project sites:

▸ Technical Lecture on Operations and Maintenance of the MFPS

The objective of the training was to prepare the miners for the efficient and effective operation of the MFPS. By the end of the seminar, participants were expected to achieve the following outcomes: (a) understand and differentiate different metallurgical concepts and processes; (b) demonstrate knowledge of various metallurgical equipment; and, (c) discuss the flow diagram of the MFPS. The training sessions encompassed a wide range of topics related to mercury-free processing technologies including size reduction operations, gravity concentration methods and equipment, chemical leaching, detoxification, smelting, refining, fire assay, tailings storage facility, and tailings management.

Number of Attendees

Project Site	Number of Male Trainees	Number of Female Trainees	Total Attendees Per Site
Paracale, Camarines Norte	18	17	35
Sagada, Mountain Province	14	11	25

▸ Workshop on Mineral Processor's License Application and Environmental Compliance Certificate

A workshop was organized specifically for the officers and key members of the partner mining associations in both project sites with the aim of enhancing their understanding and capacity to comply with formalization and environmental compliance standards and requirements.

Number of Attendees

Project Site	Number of Male Trainees	Number of Female Trainees	Total Attendees Per Site
Paracale, Camarines Norte	4	9	13
Sagada, Mountain Province	9	4	13

Hands-on Training on Operations and Management of MFPS

Once the commissioning of the MFPS is completed, the project beneficiaries will undergo hands-on training (scheduled in October 2023 for Paracale and February 2024 for Sagada). This training will focus on the actual operation, troubleshooting, and maintenance of the equipment and processes involved in the MFPS. It aims to ensure that the associations are well-prepared in terms of managing the plant upon turnover.

UPTAKE BY MINERS

"Our small-scale mining association, SMBC, is very lucky that of all the mining sites assessed by the planetGOLD Project, we were one of those selected as beneficiaries of a mercury-free processing facility.

We are very thankful to planetGOLD Philippines for choosing to build a processing plant that will greatly help us miners improve our health because we will no longer use mercury. We will learn to recover gold without the use of mercury."

Cherry Almeda
Miner
Paracale, Camarines Norte

"We are hoping that the processing plant being constructed by the planetGOLD Philippines Project will be completed soon so that miners in Paracale like me can already avoid using mercury."

Edgardo San Juan
Miner
Paracale, Camarines Norte

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Executed by: AGC