Modern Geográfia
Vol. 20, Issue 2, 2025: 79–96
DOI: 10.15170/MG.2025.20.02.05

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Towards a Transformation of Gold Panning on the Tangonie Site, Burkina Faso

ABSTRACT

Mining in Burkina Faso is characterized by both industrial and artisanal mining, commonly referred to as gold panning. In recent years, gold panning has taken on a different form from that described in numerous scientific publications. This article describes and analyzes the transformations in the activity, based on data collected at the Tangonie site in the Boni commune of Burkina Faso. It relies primarily on secondary and field data. The data were collected between January and March 2020. Data processing and analysis reveal a trend towards gold scarcity at the site. Transformations mainly concern the use of chemicals and the role of women in gold panning. In the past, one kilogram of cyanide was used per cyanidation basin, but nowadays, gold miners use up to three kilograms of cyanide. Furthermore, mercury is used by some gold miners during ore grinding. Women no longer own the gold-processing sheds on the site, and their role has become the same as that of men. They now fetch gold ore from the extraction sites and process it in the same way as the men.

Keywords: Burkina Faso, women, gold panning, chemicals, Tangonia, processing

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INTRODUCTION

Artisanal gold mining has been an issue at the heart of African societies for two millennia and on several levels (Rubbers, 2013). The 1980s saw the emergence of artisanal mining outside traditional spheres in West Africa, more generally, and particularly in Burkina Faso (Ouédraogo, 2020). Indeed, there has been a shift in the frontier of this exploitation, which used to take place exclusively in the north due to drought in the Sahel and West African savannahs. Passing through the central areas of the country, the frontier reached the western and southern regions of the country in the late 1990s (United Nations Environment Programme, 2020; Werthmann, 2017). Since the 2000s, global exploitation of this resource has been booming (Petit-Roulet, 2023).

The country's economic activity is heavily dependent on a few sectors and production chains, such as cotton, livestock, and food crops, to which mining production must be added. However, agriculture and mining remain the flagship activities of the Burkinabe economy (Lankoande & Maradan, 2013). Agriculture, one of the main sources of foreign currency for the Burkinabe state thanks to cotton (cotton exports), is faced with two main difficulties, namely climatic hazards and fluctuating commodity prices, particularly those of cotton, which induce a production deficit (Gilles, 2016; Herrera & Ilboudo, 2012; Nana, 1992; UNITAR & UN Environment, 2018). In view of these difficulties, the population regularly looks for additional sources of income. Gold mining is therefore becoming an income-generating alternative for the population (Bohbot, 2017). Gold has become the country's main source of foreign currency and its leading export (UNEP, 2020). Globally, it is estimated that artisanal mining supports (or employs) over 16 million people worldwide. This is due to the fact that the price of gold quadrupled between 2002 and 2021. It indirectly ensures the survival of nearly 100 million people by creating jobs (UNITAR & UN Environment, 2018).

Artisanal gold mining is a rapidly expanding activity in West Africa (Keita, 2001). As such, it offers greater employment opportunities[3] (IRAM–PRODIG, 2024) and is a factor in territorial dynamics (Dessertine et al., 2022). In Burkina Faso, the mining sector is considered one of the most successful on the African continent. Indeed, according to the Organization for Capacity Building in Development (ORCAD, 2018), among African gold-producing countries, Burkina Faso ranks 4th. Yet several leading figures, including French President Georges Pompidou, have been pessimistic about the future of Burkina Faso's mining sector. The mineralogical history of Burkina Faso is consistent with that of the Paleoproterozoic province of West Africa, which is reputed to contain gold deposits (Le Metour et al., 2003). Outside this province, albites also serve as reservoirs containing gold-bearing fluids (Bamba, 1996; Bamba et al., 1997). Gold deposits and showings have been categorized into five groups in Burkina Faso: gold- and sulphide-mineralized shear zones in acid tuffaceous schists; quartz veins occasionally phosphatized; gold- and pyrite-bearing banded quartz and flint (cherts) horizons; Tarkwaïan paleoplacers (showing only); and hill placers or lateritic gold and/or alluvial accumulations (Sattran & Wenmenga, 2005). Gold is not found in the form most commonly seen, i.e., in nugget

[3] According to Traoré et al (2024), stakeholders can be divided into two categories: on the one hand, people in extreme poverty in need of income, and on other, people driven by calculated decisions seeking to become rich in the short term.

form. Instead, it is agglomerated with other rocks, in this case, quartz. This forces players in the gold sector to resort to tedious and polluting techniques to extract the gold (Bohbot, 2017). These techniques require the abusive use of chemical substances such as mercury, cyanide, and acids, in both the industrial and artisanal sectors. As a result, there is a body of laws and decrees governing the mining sector in Burkina Faso. These texts have been updated over the years in line with changes in the country's socio-political context. First, there was the 1997 mining code with law N°023/97/11/AN; then the 2003 mining code under law N°031-2003/AN; followed by law N°036-2015/CNT of 2015 and its application texts, forming a set of decrees. Finally, we have the mining code of 2024 with law N°016-2024/ALT. With this new Code, the country now has general legislation on mining activity, as well as the marketing of gold (The National Assembly of Burkina Faso, 1997; The National Council of the Transition of Burkina Faso, 2015, 2024).

In Burkina Faso, as elsewhere in West Africa, two types of gold mining have long coexisted: industrial and artisanal mining (Grégoire & Gagnol, 2017; Ministry of Mines and Energy, General Secretariat [PADSEM], 2014). The economic impact of artisanal mining is no longer in doubt (PADSEM, 2014). However, it faces serious difficulties and is the subject of debate, given its environmental and social consequences (Keita, 2001; Niang, 2014; Sawadogo, 2011; UNITAR & UN Environment, 2018; Tindano et al., 2024; Zongo & Zerbo, 2019). These impacts result from the digging of holes and the use of chemicals on the various gold sites. Taking these aspects into account, the National Agency for the Supervision of Artisanal and Semi-Mechanized Mining Operations (ANEEMAS) was created by decree N°2015-1420/PRES-TRANS/PM/MEF/MME of November 30, 2015. Its objective is the supervision of the artisanal mining sector. This article analyzes the changes and transformations taking place around artisanal gold mining at the Tangonie site. Before doing so, it highlights the forms of artisanal mining existing on the site, which reveal new data.

METHODS

Gold panning is an almost nationwide practice in Burkina Faso. It is practiced in 12 of the country's 13 regions. However, the activity is unevenly distributed across these different regions. Sites are concentrated in the North, South-West, Centre-North, and East regions. Gold panning is most prevalent in the North and extreme West of Burkina Faso (Institut National de la Statistique et de la Démographie, Direction des Statistiques et des Synthèses Économiques & Service des Comptes Économiques et des Analyses Macroéconomiques, 2017).

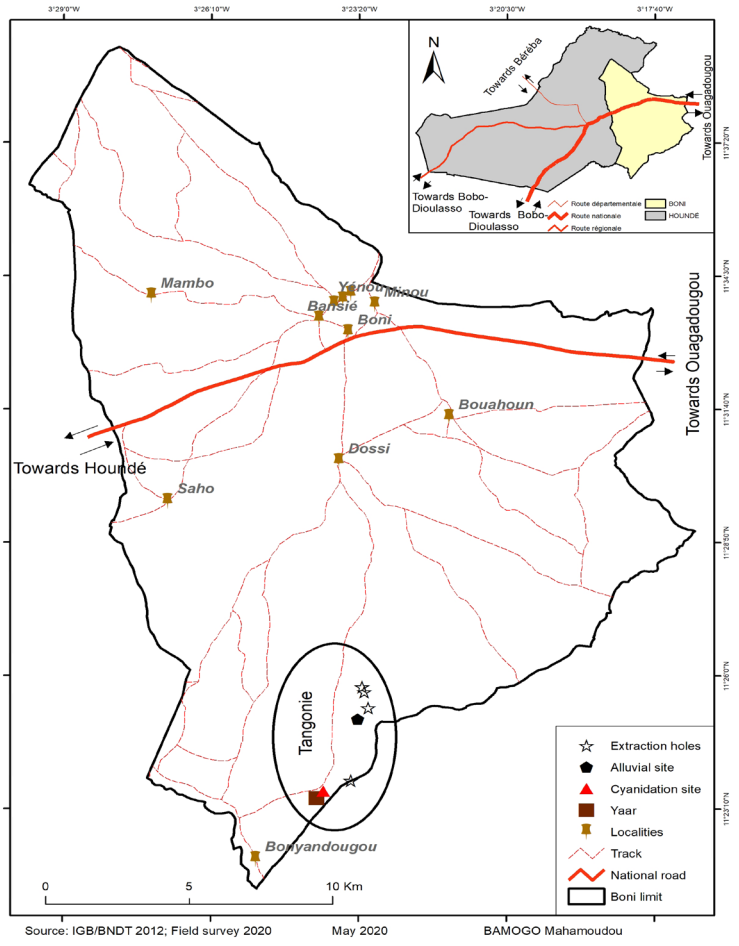
The commune of Boni was chosen as the site for several reasons. Firstly, the province of Tuy is home to several gold-panning sites. A closer analysis of the map of the Tuy province, whose capital is Houndé, and the mapping of gold-panning sites reveals that half of this province, particularly the entire southern and western part, is known for its gold-panning. However, with insecurity prevailing in the North, Sahel, and East of the country, most of the gold panners in these areas have migrated to the far West[4] All these factors combined led to the choice of Boni as the study area for this research

[5] https://lefaso.net/spip.php?article90571 consulted on 05/07/2019

(Figure 1).Secondary data were collected to assess the state of knowledge on the subject. These were progressively supplemented by primary data from field surveys, including a questionnaire and an interview guide. On the one hand, questionnaire surveys were carried out among hole-makers. On the other hand, interview guide surveys were conducted with women involved in alluvial gold mining, women owners of ore-washing sheds, and managers of *Yaar*.

Primary data processing differed depending on whether the data were collected using a questionnaire or an interview guide. Data collected via questionnaires were processed with the help of database software after the creation of an input mask. Recorded interviews were transcribed manually and processed using content analysis. Spatially referenced data were processed with the help of appropriate software.

Figure 1. Tangonie site location



RESULTS

Types of gold deposits and gold washing

Gold panning is the mining of gold-bearing alluvial deposits, and in Burkina Faso, it encompasses several types of mining. It includes the mining of gold-bearing alluvial deposits, which are particles of gold produced by the collection and washing of ore on the surface, as well as lode mining of gold in the subsoil. The study site is no exception, as both types of mining are encountered. Alluvial mining is the artisanal gold mining model favored by women. Lode mining, on the other hand, is a male-dominated activity. Alluvial gold mining will be analyzed first, followed by lode gold mining in Tangonie.

Alluvial gold mining at Tangonie

At Tangonie, as at other gold-mining sites, alluvial mining takes place in two phases: the extraction phase and the processing phase. The analysis of these two phases is the subject of this section.

As far as ore extraction is concerned, it is important to note that a test for the presence of gold in the ore is carried out beforehand. This involves taking a sample of the ore, winnowing or breading it, and washing it. Since alluvial mining is a surface activity, it does not necessarily require you to enter the holes and therefore requires less physical effort. The extraction process is relatively straightforward compared with vein mining. It consists of scooping or scraping the alluvium with tools such as dabas, plastic cups, cut-up oil cans[5], brooms, soap dishes and basins (Figure 2). The daba is used to dig the earth. Ore deemed profitable is recovered with cut-out oil cans and cups. Soap pans are used to separate the ore by particle size. Once the ore has been recovered with the drums and trays, it is placed in basins and transported to the ore processing area.

Ore from alluvial mining is processed differently, depending on whether it is dry or slightly damp. The tools used include basins and a few bowls. When the ore is dry, the women winnow and sieve it to obtain a concentration of ore (Figure 2). This concentration is stirred several times until the gold powder, if present, is obtained, and the rest is discarded on site. However, if the ore is a little damp, it undergoes panning (it may have been sieved long before) by the women and is then poured into a large dish or basin. After this stage, the ore is washed, and at this point, they can already see the gold flakes, which they carefully select and place either in a small bottle or in a corked jar (Figure 2). They are sold to buyers after several days' work, which can last around two weeks. Indeed, as Madame Apomè Safiatou points out: *"The work is not easy, it's complicated, you have to work and wait two (02) weeks to get something"* (A. Safiatou, personal communication, March 18, 2020)[6]. The women do not necessarily need to use mercury for gold extraction, apart from its use by a minority.

Washing the ore requires water, which the women bring to the extraction site. They have a technique that enables them to reuse the water through decantation. To do this, they use the fruit of a plant whose scientific name is *Cordia myxa*, commonly known as *petit cordia*. All they have to do is put the fruit

[6] These instruments are used to protect the fingers of gold miners from injury.
[7] Ms. Apomè Safiatou, alluvial ore operator.

of the plant into the dirty water they have already used and wait until the water is clear before reusing it. Other women take advantage of the water extracted from wells used for lode gold mining (Figure 2). They position themselves downstream on the water flow path. In this way, they do not need to constantly bring water to the gold processing sites.

Figure 2. Stages in alluvial gold mining

Note: a-b) Tools used by women in alluvial gold mining, c) Winnowing alluvial ore, d) Gold powder collected in a jar by a gold panner, e) Gold panner taking advantage of water from the lode gold mine.

Lode gold mining at Tangonie

Lode gold mining at Tangonie follows almost exactly the same stages as at other gold sites in Burkina Faso. The following plate shows the stages of gold mining at Tangonie. As shown in Figure 3, these operations include prospecting, sinking, crushing, grinding, washing, mercury, and cyanide recovery.

Prospecting, i.e., the search for a vein of gold, is generally carried out by experienced gold miners. The procedure involves going into the bush and searching for stones likely to contain gold. Judgment is made by eye and with instruments (small pickaxe, small shovel, cup, water, pestle, and mortar), with which they test these stones for the presence of gold (Figure 3). The next phase consists of digging the holes for the new site. Sinking is the process of digging a vertical hole in the ground, followed by horizontal drifts to reach the gold-bearing ore. Before drilling a hole, research is carried out[7]. The sinking stage is carried out in teams, with the hole leader choosing a team leader to take over in case of absence.

Somé (2004) emphasizes that the contract between the drillers and the hole leader is a verbal one. Remuneration consists of dividing the gold ore extracted in half. Holes are opened on the land or fields of landowners who accept the presence of the miners in exchange for a royalty. Generally, landowners demand 2,500 CFA francs before opening a hole, and for every ten (10) bags of gold ore extracted, one (01) bag is returned to the landowner. The role of the hole manager is to ensure that the work proceeds smoothly and that the hole is maintained (materials, catering, care, and minor needs of the workers).

[8] This scenario corresponds to former lode gold mining sites.

Figure 3. Stages in Gold Vein Mining

Note: a) Gold prospecting tools, b) Sinking/extraction, c) Crushing, d) Grinding, e) Washing, f) Chemical Treatment (cyanide).

Tools such as hammers, shovels, chisels, picks, ropes, torches, handmade pulleys, bags, pick hammers, dynamite, compressors, and wire are used during the jacking process. Equipment such as hammers, chisels, picks, and shovels are used as soon as sinking begins. At a certain depth, ropes and bags are used to extract the dead earth via the pulley system (Figure 3). The pulley is installed to facilitate manual pulling, while the torch is used to illuminate the galleries. The jackhammer is used if muscle power fails to overcome the hard rock in the hole. If the jackhammers fail to break through the rock, a compressor is used. The compressor helps create holes in the rock where dynamite, known as "Far Away", is placed. The person in charge of this task, paid 5,000 CFA francs per dynamite set, is referred to as a "Tempère"[8]. During the sinking process, the divers often encounter water, so they use a motor-driven pump to evacuate the water.

When digging a shaft, the hole is sometimes supported by wooden planks and wire to prevent it from collapsing, hence the role of "wedges". Once the pit boss has obtained the ore, a sack of ore is handed over to the caleur as payment. At a depth of around 20 meters, the hole needs to be aerated to lower the temperature and transport oxygen to the melters. For this purpose, they use a solar-powered stirring head and a very long black bag. This long bag connects the stirring head at the surface to the melters at depth (Figure 4).

The drillers first carry out tests to extract the gold-bearing ore from the hole. If the ore is deemed rich in gold and has a high market value after testing, they proceed with extraction. Not all extraction sites require gold-rich ore to be packed in 50 kg bags. In principle, according to the miners, gold is in short supply, which justifies the lack of interest in packaging it. Figure 4 shows a ventilation system

[9] Name given to those who carefully place dynamite(s) in the right places to explode hard rock in holes.

with an agitation head powered by a solar panel. Air is transported from the surface to the foundries via a long black bag.

Figure 4. The well ventilation system using an agitation head.

Once the ore has been extracted, it is transported to the yaar for processing by crushers. Their main role is to crush the ore to reduce the size of the rock before transporting it to the crushers. Crushing is done by the bag, so the cost of this service varies between 600, 700, or 1,000 CFA francs, depending on the strength of the ore. Crushing is generally carried out by children, and this activity takes place throughout the yaar. The tools used are bags that are rolled up, leaving a hole in the middle into which the ore is tapped.

The ore is tapped with a hammer on an anvil[9]. The rolled bag is a precautionary measure, as it enables crushers to protect their hands. The bag also minimizes the scattering of the ore. In terms of form, they make no use of any protective equipment (Figure 3) on the gold ore extraction site.

The next step is to grind the ore into powder. This facilitates washing for better recovery of the gold powder (Sawadogo, 2011). For ore grinding[10], ore owners who do not have mills for grinding turn to mill owners for grinding. The instruments used for this purpose are grinding wheels and barrels filled with water to cool the mills simultaneously. In Tangonia, they have introduced a new machine they call the "wonbyaaré"[11] (Figure 3). With this machine, the ore is not ground three times before washing, but twice. After the ore has passed through the "wonbyaaré", it is supposed to be ground twice, and the mill (Figure 3) does the final grinding. However, after a first wash, some people decide to grind the washed and slightly concentrated ore a third time to wash it again. The mill shown in Figure 3 is used for this third grinding operation. For the third grinding operation, those who decide to grind their ore again pay the sum of 5,000 CFA francs per flat of ore.

On the site, crushing is no longer done by the sack, as on other sites, but by the barrel, and the price of the crushed barrel varies according to the strength of the rock. The price ranges from 7,500 to 10,000 CFA francs per barrel of ore. This applies to the first two stages of ore crushing.

[9] The anvil here is a large granite stone.
[10] At this level, sometimes the go-getters and the hole leader are no longer together.
[11] In Moré, this term means "crush everything".

The grinding phase prepares the ore for washing. The crushed ore is transported to the washing sheds, where the ore is washed to concentrate the gold. According to Sawadogo (2011), concentration is achieved by gravimetric sluice separation. A variety of ore washing methods are used on-site. The instruments used for the various washings are virtually the same, with a few differences. Ore washing methods differ in the number of times the ore is washed. In addition, the decision to further grind the ore retained after washing in the belts and/or add mercury prior to grinding also constitutes a level of differentiation. Ultimately, the composition of the sluice used for washing also differs.

The instruments used include large bowls, water barrels, sluices, and soap pots. Once in the washing sheds, the ore is mixed with water in large bowls to form a slurry. Gradually, the washer removes this slurry with the soap pot and, using the water in a bowl, adds water and washes the ore over the top of the sluice. The sluice has a top section (Figure 3), which is inclined thanks to a barrel on which this section rests. During washing, the light material is carried down to a hole where it is collected. In the hole, this light matter forms a sludge called "gneika" or "garaga". It may or may not be sold to cyanidation processors. In any case, most gold miners prefer to do the cyanidation themselves or make arrangements with cyanidation site managers. The bottom of the sluice is then lined with black plastic, on which cloth or wool mats are laid. The purpose of these cloth mats is to retain the heavy elements, which are blocked by two or three pieces of iron. This covering is used during the first and second washings.

The first wash takes place just after the first two ore crushings. During this phase, the ore collected in the belts is placed in a cup to be dried. After drying, the ore is ground a third time in a mill they call a "belt-noor machine"[12], before being washed once more. The composition of the sieve is always the same as that of the first wash. Therefore, with this second wash, the ore retained in the mats is put back into a cup. However, the quantity of ore is significantly reduced. This concentrated ore is breaded with pans to further concentrate it by adding the mercury known as "Med"[13]. At this stage of preparation, the ore is kneaded by the goldsmith's bare hands to obtain the gold-mercury amalgam that will be burned later.

The other washing technique consists of introducing a small quantity of mercury into the ore retained in the mats before grinding it a third time. The ore is washed again, and the final result is a black plastic sheet with no mat. The reason for this change in process is that the mercury mixed with the gold makes it heavier. During washing, the gold-mercury mixture and other materials, such as iron filings, remain on the tarpaulin. At the end of the washing process, the contents of the tarpaulin are scraped into a dish. The gold miners add mercury to the contents of the dish before rubbing it down, then compress the mixture with their bare hands so that it sticks together. At the end of the operation, the resulting mixture is placed in a cloth and compressed to remove most of the mercury. Excess mercury is recovered for later use. At this stage, the gold appears white and is burned to obtain spongy gold. This technique was described following an informal interview.

Well before starting the washing process on the sluice, some gold miners decide to mix detergent with the ore to remove the machine oils that have followed the crushed ore. However, in order to reuse

[12] In Moré, this term refers to the machine that crushes the ore held in the belts.
[13] Local name for mercury.

the water used in the first wash[14], other miners do not add detergent and decide to wash the ore in this way. During the second wash, miners typically choose to add detergent. Although this method is not universally adopted, it is the most common practice at the site. According to the miners, it is the most effective technique for achieving better gold recovery, particularly given the rarity of gold and its presence in powder form.

Some gold miners, after crushing the ore a second time and washing it, opt to introduce mercury directly into the ore without proceeding to a third crushing or washing. This approach is generally used when miners believe that the gold recovered without a third wash is sufficiently profitable. The ore residues obtained at this stage are often sold to others who add mercury to the ore before conducting a third grinding and wash, as described earlier.

The ore obtained from the second or third wash is further concentrated using a pan. Once the concentration process is complete, mercury is added. The miners knead the mixture with their bare hands, combining the gold, mercury, and iron filings in a dish. They rub and compress the mixture in the dish to form an amalgam. The next step involves pressing the amalgam in a cloth to extract the gold. Following this, the gold is heated using a torch, gas flame, or charcoal. This process causes the mercury to evaporate, leaving behind spongy gold. The gold is then transported to Houndé for melting.

Cyanidation marks the final stage in the recovery of artisanally-mined gold. This process involves adding cyanide to the sludge from the various washing stages. On the study site, cyanidation takes place at specialized locations outside the yaar. These sites are privately owned, often by anonymous individuals[15]. Like mercury amalgamation, cyanidation is a process performed only by individuals with expertise in the field. However, as noted by several authors (Kouadio, 2016; Roamba, 2014; Sawadogo, 2011), it is increasingly uncommon for individuals to purchase sludge from various washing processes to carry out cyanidation themselves.

Owners of cyanidation sites occasionally buy sludge for this purpose, but on the Tangonie site, such transactions are rare. According to gold miners, the scarcity of gold at the site makes this practice less viable. Instead, sludge owners without cyanidation expertise or their own cyanidation facilities negotiate directly with cyanidation site owners. These negotiations typically concern the rental of cyanidation basins, with prices ranging from 7,500 to 10,000 CFA francs per basin.

The materials required for cyanidation include potassium cyanide, zinc, nitric acid, and sulfuric acid, which are provided by the sludge owner. For the process, two large basins are excavated, each measuring 2 meters in length, 1.5 meters in width, and 80 centimeters in depth. Between these basins, a smaller basin is dug, measuring 90 centimeters in length and width and 1.5 meters in depth. The larger basins are lined with a watertight tarpaulin to prevent seepage, while the smaller basin is coated with cement.

Before cyanidation, the sludge undergoes drying and is then pounded or rammed with wooden tools to achieve a finer consistency. Proper drying is crucial for the sludge to be accepted at cyanidation

[14] The water used for the first wash is recovered in the basin, which is also used to collect light materials.
[15] They are anonymous for outsiders, i.e. for those who are not from the Tangonie site.

sites. The prepared sludge is transported to the sites using tricycles[16]. Upon arrival at the cyanidation sites, the ore is deposited into large basins, each capable of holding the contents of two full tricycles. Four barrels of water are added to each basin, along with 2 kilograms of cyanide, which is securely bound in bags (Figure 3). The mixture is left to stand for 12 hours.

After this period, the openings connecting the two large basins to the smaller basin are unsealed, allowing the cyanide-gold solution to flow into the small basin. Inside the small basin, a U-shaped tube is fitted with zinc shavings that capture the gold dissolved during the leaching process. The cyanidation process continues until miners observe no further changes in the color of the zinc shavings. At this point, they declare that the "hole is dead". If the zinc shavings in the tube are insufficient to capture all the gold, additional shavings are introduced.

The shavings that have absorbed the gold are then collected and placed in a pan. Sulfuric acid is poured over them to remove impurities, particularly iron. This reaction produces a liquid, which is immediately ignited to create a white powder. This powder is then mixed with nitric acid, which dissolves the bronze and leaves behind gold in powder form. The gold is subsequently sent to the foundry in Houndé for further processing. Before reaching this advanced stage of gold transformation, miners have introduced various modifications to their traditional gold panning techniques. But what are these transformations?

Possible transformations and explanations

To address the gold shortage in Tangonie, miners have implemented a series of changes referred to as transformations. These adjustments primarily concern gold processing methods and the evolving role of women on the mining sites. The following sections outline these transformations and the factors that have driven these modifications in Tangonie.

Transformations

According to gold miners, the scarcity of gold has prompted significant transformations, including the incorporation of chemicals in specific processing stages, an increase in the quantity of chemicals used, and an expanded role for women in gold extraction activities. In response to the ongoing gold shortage at the Tangonie site, various stakeholders have pointed to the pervasive issue of gold scarcity as the primary challenge. Kouama Bouba and Zoun Aminata expressed their perspectives, which were further supported by Bougma Kassoum, the drilling manager, who elaborated on the situation:

> *"[...] the fact that there's not much gold in the ore, there's no theft, there's nothing to worry about...". "...before, we didn't use mercury; for processing, we simply blew the ore to get the gold nuggets. The fact that there are gold nuggets, the little grains are left behind"*[17] (K. Bougma, personal communication, February 18, 2020; B. Traoré, personal communication, March 5, 2020).

[16] The tricycles are called "Noda Tan" on site.
[17] Traoré Bila, gold prospector at the Tangonie site.

In the past, gold miners did not rely on chemicals to process ore and extract gold. They simply blew the ore to retrieve the gold, but this practice has now become obsolete. For miners, the scarcity of gold poses a significant obstacle to the smooth running of their operations. However, they offer no concrete explanation for the underlying causes of this scarcity. These challenges have triggered a series of changes to adapt to the new reality.

The transformations at the Tangonie gold site are evident on several fronts. Foremost among these is the increasingly aggressive use of chemicals. Previously, miners would wait until the ore had been fully washed after grinding before adding mercury. Today, however, the amalgamation method has evolved at Tangonie. Miners now add mercury to the ore immediately after washing for more efficient concentration. After drying the ore, they add additional mercury to facilitate crushing before amalgamating it during a subsequent washing stage.

Telmer and Stapper (2012) identified two modes of mercury use at gold panning sites. According to their findings, miners either add mercury directly to the raw ore, a method they termed Amalgamation du Minerai Brut (AMB), or mix mercury with ore only after it has been concentrated using a washing table or sluice, known as Concentrated Ore Amalgamation (CMA). At Tangonie, the Amalgamation of Concentrated Ore (AMC) process is employed. This approach applies to all in-situ washing methods, as these require the ore to be pre-concentrated. However, the level and quantity of concentrated ore vary depending on the washing technique.

One variant of this method involves adding mercury to the ore before a third milling stage, following the drying process. This approach necessitates a substantial volume of mercury due to the larger quantity of concentrated ore involved.

Similar practices have been documented at other gold-mining sites in Burkina Faso. For instance, Sawadogo (2011) describes mercury usage at the Fafora site. Here, miners process two concentrations of waste rock, which are washed at the edges of pits. The first step involves separating out larger elements, such as wood fragments and stones. The resulting concentrate is dried and then mixed with rejects from amalgamated ore and additional mercury. Once crushed, this mixture is further concentrated by beating to recover the gold-mercury amalgam.

In the Sanmatenga region, miners mix waste rock from panning and ore from sinking with mercury before crushing. This method is used to improve their chances of recovering more gold (Zongo, 2020).

The changes are not limited to the use of mercury as a chemical agent. Cyanide has also become a key component of these transformations, with its dosage increasing in proportion to the concentration of gold powder measured in grams[18]. For ore with a sufficient gold content, the cyanidation process typically uses 1 kilogram of cyanide per basin, with each basin holding the equivalent of two tricycle loads of ore. For ore with minimal or no detectable gold content, the cyanide dose increases to 3 kilograms per basin. However, on other sites, only 1 kilogram of cyanide is needed to process three full tricycles of ore (Kouadio, 2016; Roamba, 2014).

In addition to increased cyanide use, some pit managers now opt to repeat the cyanidation process—a departure from earlier practices when a single cyanidation was the standard. The scarcity of

[18] This is the ore that has undergone the various processing phases (crushing, grinding, washing, amalgamation).

gold has necessitated this second cyanidation phase to recover any remaining gold particles that may have escaped during the first treatment. Consequently, the amount of cyanide used in the first phase is doubled for the second cyanidation.

Not all miners on the site proceed to the cyanidation stage; some limit their efforts to mercury recovery. However, the trend at the Tangonie site shows that most miners are now shifting toward completing the entire cyanidation process, as it represents the final recovery phase. This shift is aimed at minimizing potential gold losses, given the scarcity of gold at the site.

Finally, one of the most significant transformations concerns the role of women on the mining site. In addition to men, women also play an active and substantial role in gold panning activities. Women constitute 40% to 50% of the workforce on these sites (Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development [IGF], 2017). Their involvement extends beyond their traditional roles as housewives (Leclerc-Olive et al., 2023)[19], Women are heavily involved in both alluvial and lode gold mining. Their contributions are particularly notable in the maintenance and management of gold ore washing sheds, where men come to wash their ore. This significant role has been highlighted by several authors (Mégret, 2009; Ouédraogo, 2020; Sawadogo, 2011; Sawadogo, 2021; Sawadogo & Da†, 2021; Zongo, 2020). However, Ouédraogo (2020) also documented the emergence of competition between men and women over control of the washing sheds. This rivalry stems from disputes over the ownership of residues and sludge produced during ore washing.

At the Tangonie site, women no longer fulfill this role, as men have chosen to manage their own washing sheds within the yaar compound. Gold miners interviewed explained that this shift is driven by the scarcity of gold at the site and a desire to minimize potential losses. As one gold panner, Mme Zoun Aminata, remarked: *"The men no longer wash the gold here. If there is gold, the mud is for the women; if there is no gold, it's difficult for the mud to return to the women"*[20] (A. Zoun, personal communication, March 18, 2020). Kouama Bouba also testifies that: *"There's not much gold left. Often, crushing and washing can be done without the initial investment. We need to get to cyanide so that it responds well and makes a profit"* (K. Bougma, personal communication, February 18, 2020). This explains why so few women own ore washing sheds; on the Tangonie site, only two women are reported to have such ownership.

This shift has driven women to become more directly involved in lode gold mining. They now visit mining sites to purchase ore clandestinely, which they trade with team leaders. This practice is facilitated by two factors. First, women collaborate with team leaders in the absence of the hole leaders. Second, they also buy ore directly from the hole leaders. The latter are often willing to sell ore due to a lack of financial and human resources to effectively manage their operations. However, the ore sold to women is often considered by men to be of lower gold content. Long before the extraction of gold-rich ore, portions of it are mixed with earthy gangue. It is this mixed ore that is typically sold to women.

In their study conducted in Noumbiel province, Dah and Somda (2023) observed women who own wells and collaborate with other men to manage them. Additionally, some women have taken

[19] There are gold miners living with their families on the Tangonia yaar.
[20] Mrs. Zoun Aminata, gold digger managing an ore washing shed,.

ownership of mills and grinders. The same is true in Sanmatenga[21], where some women take on most of the expenses of a well, but prefer to leave the management to their partner (husband). In this way, women participate discreetly (Zongo, 2020). These cases were not reported during the field surveys, although it is important to note that this role is intentionally concealed by the women themselves.

Some possible explanations for the changes brought to the region by gold prospectors

Explaining the transformations carried out by miners is an arduous and complex task. This is due to the lack of data to corroborate their statements. Nevertheless, we have tried to find plausible reasons for these changes. The reasons for the evolution of changes or variations in gold processing methods were also the subject of our study. To this end, we needed to determine whether the transformations were linked to the extraction methods used by artisanal miners or whether they were related to the physical characteristics of the gold (nugget, inclusion, lode, or fine gold). Additional information was sought from ANEEMAS and the Burkina Faso Bureau of Mines and Geology (BUMIGEB), given the scarcity of data.

The primary objective of miners—and even industrialists—is to make maximum profit with minimum investment. They will take all appropriate measures to ensure a substantial return on investment. Gold miners carry out processing without any prior field study. They are either former industrial mine workers, friends of geologists or BUMIGEB agents, or have observed processing methods at other sites. This justifies their immersion in the business of clandestine gold processing and marketing. In the same vein, Zongo (2020, p. 444) mentions that: *"The movement of people from one gold panning site to another is accompanied by a strong mobility of mining and processing techniques, and a transfer of know-how"*. In the same vein, Traoré (2023, p. 8) states: *"In the course of their travels, gold miners come into contact and work with other miners from different regions or nationalities, from whom they gain experience. This has always been a feature of gold panning in West Africa.*

The goldsmith may find that other goldsmiths on a particular gold panning site are processing the ore in a special way and decide to imitate it on his own site without expertise. It is this latter reason that drives gold miners to use other gold extraction methods in addition to those that existed according to the state of the art of ore processing methods.

Thus, with the new processing methods certainly observed on the sites, these changes are also observed on the Tangonie site. They can be seen in the variations in gold processing methods. The scarcity of this mineral resource may explain the changing role of women on gold panning sites. These women, lacking customers, are obliged to go to different extraction sites and buy the raw ore to mine it themselves.

[21] Sanmatenga is one of Burkina Faso's provinces in the Centre-Nord region.

CONCLUSIONS

Artisanal gold mining is becoming increasingly widespread in Burkina Faso against a backdrop of dwindling natural resources. The situation is much the same in other countries of the sub-region. Gold is mined in two (02) ways: lode mining and alluvial mining. Lode mining rigorously follows a multi-phase mining scheme (prospecting, sinking, crushing, grinding, washing, and recovery with mercury and cyanide). In response to the increasing scarcity of gold, certain transformations are taking place in the gold panning industry. These changes are reflected in the quantity and use of mercury and cyanide by gold miners. They are also accompanied by changes in the role of women on all gold panning sites.

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