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From Gold Ore to Bar: The Process and Challenges of Gold Smelting in Traditional Ghanaian Small-Scale Mining Settings

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Abstract

Smelting of gold is one of the most significant and oldest metallurgical processes in human history, and in Ghana, a major contributor to gold production in Africa, it is a major process for thousands of small and artisanal miners (galamsey operators), contributing to the nation's annual production. Ghana's traditional small-scale gold smelting involves the use of both technological and non-technological methods, such as improvised furnaces, hand-held crucibles, the use of simple flux, and the casting of gold into iron ingot moulds, a process that is not well documented in the academic literature due to its economic importance despite significant environmental and occupational health concerns. This article records and analyses the steps involved in the smelting process of small-scale gold miners in the traditional gold mining regions of Ghana, from the point of collecting the gold ores, dust, flakes, and grains to ore preparation, charging of the furnace, fluxing, smelting, removal of the smelting slag, casting, acid pickling, and production of gold bars. The article also explores the main problems of the small-scale smelters, such as equipment restrictions, flux management, mercury pollution, occupational health hazards, and limitations on product purity. The study is based on fieldwork observation, practitioner interviews, and literature review on artisanal and small-scale mining in Ghana and will provide a holistic and practically informed description of an aspect of Ghana's gold sector which has been little studied.

Keywords: crucible smelting, galamsey, Ghana, gold ingot, gold smelting

Introduction

For centuries, gold has had a unique place in the economic, cultural and political life of Ghana. The country's historical name as ‘Gold Coast' is a testament to its long tradition of gold mining and trading activities dating back over 1100 years ago, and Ghana today is among the top ten gold producing countries in the world, accounting for about 48% of total mineral revenues and about 6% of the GDP (Ghana Chamber of Mines, 2022) [5]. Although large-scale industrial mining is dominated by multinational companies like Gold Fields, Newmont and AngloGold Ashanti, artisanal and small-scale mining (ASM) is estimated to create 35-40% of Ghana's formal gold production (Hilson & Garforth, 2013) [7]. This sector, which directly employs 500,000 to one million people and indirectly supports the livelihoods of several million more people, is one of the largest informal sector activities in the country (Seccatore *et al*., 2014) [12].

The process from raw gold ore or alluvial gold material to a gold bar is a complex physical and chemical process. In industrial applications, these processes take place in a large-scale technologically advanced refinery where electrolytic refining, chemical leaching and automated assay systems are used to obtain 99.99% pure gold (World Gold Council, 2021) [14]. Ghanaian small-scale miners, in contrast, use rudimentary smelting technologies such as hand-crafted clay or steel furnaces, clay or graphite crucibles, basic fluxing agents, and cast-iron bar moulds, in an open-air or semi-enclosed workplace without safety infrastructure (Hilson, 2002) [6]. The gold that is produced in this process is commercially usable but usually has a purity level of 85-92%, and much toxic waste is produced from this process, such as the mercury vapour from previous amalgamation methods and acidic effluents from post smelting pickling processes (Aryee *et al*., 2003) [1].

Although small-scale gold smelting is an important activity in Ghana it has not been thoroughly documented in the scientific literature, especially in a systematic way. The research on ASM in Ghana has been geared towards the environmental impacts (Hilson, 2002; Aryee *et al*., 2003) [6, 1], legal and governance aspects (Teschner, 2012) [13], or social and gender issues (Baah-Acheamfour *et al*., 2021) [2]; and relatively few studies have attempted a detailed process level description of the ASM smelting operations themselves. This article aims to bridge that gap by documenting the sequential stages of traditional gold smelting as seen in small-scale gold mining in Ghana, and examining the technical, chemical and practical aspects of each stage, the main problems faced by small-scale gold smelters and comparing the traditional gold smelting process with industrial gold smelting operations. The eight process photographs in the article show the materiality of this process, which is often not described in detail in academic publications, while being taken at working small-scale smelting sites.

Historical and Economic Background of Gold Mining in Ghana

The history of gold mining in Ghana is one of the oldest and richest in Africa. Gold mining and trading in the area now known as Ghana has been traced back to at least the 8th century CE when trans-Saharan trade routes linked West African sites with gold with North African and Mediterranean ones (Boahen, 1986) [3]. The Akan Forest zone kingdoms of the forest, and the Ashanti in particular, evolved highly developed systems of gold production, weighing and trading, including the use of brass gold weights (abrammuo), which were used in a fully monetised economy centuries before European contact (Garrard, 1980) [4]. Gold was the main product that caught the interest of Europeans in the West African coast when Portuguese explorers came to the coast of Ghana in the 1470s and made it the trading post of Elmina, and the region became the colonial territory of the Gold Coast (Boahen, 1986) [3].

Under the colonial administration, the formalization of gold mining within Ghana led to the adoption of large-scale mechanised mining in the existing informal gold economy of the country. After independence in 1957, the Ghanaian government nationalised and restructured the mining industry by setting up the State Gold Mining Corporation to operate the large mines (Hilson & Garforth, 2013) [7]. The sector was opened to foreign investment since the 1980s, bringing in large foreign multinational mining companies, and at the same time prompting a massive growth of informal small-scale gold mining (galamsey) in rural mining areas of the Ashanti, Western, Eastern and Central regions (Teschner, 2012) [13].

The Small-Scale Gold Mining Law of 1989 (PNDC Law 218) legalised artisanal and small-scale mining activities, creating the Precious Minerals Marketing Company (PMMC) as the body for the government to buy and assay the mineral output of the small-scale miners (Minerals Commission, 2020) [10]. However, in reality, most of the small-scale gold mining continues to be processed in informal markets, such as by unlicensed itinerant gold buyers, and the difficulties of formalisation in a sector that is informal, mobile and lightly institutionalised (Hilson & Garforth, 2013) [7].

Raw Materials: Gold Ores, Dust, Flakes, and Grains

The raw materials used in the small-scale gold smelting process in Ghana can be classified by their character and origin to show that they are diverse, due to the variety of raw materials extraction methods used by the artisanal minors and the geological diversity of Gold-bearing formations in Ghana. Small-scale smelters treat four major categories of gold raw material.

Gold Ores

Primary gold ores consist of rocks that contain gold that is mineralogically bound to other minerals, mainly quartz veins, sulphide minerals (especially arsenopyrite and pyrite) and a variety of silicate gangue materials (Marsden & House, 2006) [9]. Gold is frequently associated with quartz vein systems and also in refractory Sulphide ore bodies in the gold major gold producing provinces in Ghana (Birimian Supergroup and Tarkwaian sedimentary sequences) where the gold needs to be liberated from the Sulphide mineralogical host for smelting to take place (Kesse, 1985) [8]. Small-scale miners working in primary ore deposits simply crush and grind the ore to free the gold particles (Figure 1), which are then concentrated using either gravity separation, amalgamation with mercury, or by simple sluicing (Aryee *et al*., 2003) [1].

Fig 1: Gold ores loaded in a crucible ready for smelting; spheroidal ore masses of varying sizes prepared for the furnace (Researcher's photograph, 2024)

Gold Dust, Flakes, and Grains

Gold from alluvial sources, from weathering and transport of primary ore deposits; is found in fine dust, flat flakes and rounded or irregular grains (Figure 2). Alluvial gold is found in the bed and banks of the rivers in Ghana (Offin, Pra, Birim and Ankobra river systems) and eluvial deposits are harvested from weathered laterite profiles (Kesse, 1985) [8].

Small-scale, alluvial miners use pan washing, a gravity concentration process that involves swirling lighter gangue minerals over the edge of the pan while heavier gold particles remain in the pan (Hilson, 2002) [6], and simple sluice boxes, as well as small-scale dredges (Hilson, 2002) [6] in more mechanised operations.

Fig 2: Gold grains and flakes recovered from a small-scale alluvial mining site, showing the characteristic irregular morphology and golden lustre of placer gold prior to smelting (Researcher's photograph, 2024)

The gold ratio of alluvial material is quite different from one place to another and from one concentration to the other, depending on geological sources and the efficiency of the concentration. Most of the pan concentrates from Ghanaian alluvial operations have gold with heavy mineral associates, such as ilmenite, magnetite, chromite and zircon, and also some silicate gangue. The concentrate is dried before smelting and, in many operations, is also passed through a mercury amalgamation step to produce a gold-mercury amalgam which is retorted to remove the mercury leaving a gold-rich sponge (Seccatore *et al*., 2014) [12]. The use of this amalgam retorting operation, which is very common but often carried out without proper mercury capture technology, is one of the greatest occupational and environmental risks in the small-scale mining industry (SSM) in Ghana (Hilson, 2002) [6].

Smelting Equipment: Furnaces, Crucibles, and Moulds

The Smelting Furnace

A furnace is the most crucial piece of equipment used in small scale gold smelting, it is used to create a steady high temperature environment that is needed to melt the gold and purify it from the impurities that are attached to it (Figure 3). The temperature range required for effective smelting (particularly of ore concentrates with the presence of refractory gangue minerals and sulphide phases) is normally 1,100°C-1,300°C (Marsden & House, 2006) [9]. The three main types of furnaces used in small-scale operations in Ghana are:

The most prevalent furnace used in artisanal production is the furnace improvised from clay or refractory brick by the smelter. The type of furnace is usually a cylinder made of clay, sand, and crushed refractory, about 30 to 50 cm in diameter and 40 to 60 cm tall. The fuel is either charcoal or wood with the combustion being forced by a bellows, which is normally operated by hand and is made from animal skin although electrically driven blowers are becoming more common, or from used motorcycle tyres that are foot-pumped (Aryee *et al*., 2003) [1]. These furnaces are made from a variety of materials, and the temperatures are not instrumented; they are only controlled by the operator on hand and his or her experience and judgement.

Fig 3: A traditional smelting furnace at a small-scale gold processing site in Ghana, showing the refractory crucible vessel at high temperature with tongs and crucible-holding frame alongside (Researcher's photograph, 2024)

The second type of furnace used is the propane or liquefied petroleum gas (LPG) torch, in which a high-temperature flame from a hand-held or mounted torch is blown into a refractory furnace chamber that contains the crucible. LPG torches can provide more control of the temperature than charcoal furnaces and start-up more rapidly, and are preferred by smelters who process larger quantities or whose operation is more demanding for faster turnaround (Hilson & Garforth, 2013) [7]. A third option is the electric muffle furnace, which is a furnace with electric heating elements contained in a refractory chamber that can be used to maintain the temperature precisely and steadily; they are mainly used in the facilities of licensed gold dealers, PMMC assay offices, and more formalised buying centres, not in field-based smelting operations.

The Crucible

The refractory vessel used for the melting and separation of gold and the flux in the crucible. Traditional small-scale smelting in Ghana uses crucibles of graphite clay composite material, where natural graphite, kaolin clay and other refractory additives are involved; a material with a high thermal conductivity and resistant to the corrosive fluxes employed in the smelting process (Marsden & House, 2006) [9]. The commercially available crucibles used in the small-scale mining operations are graphite-clay crucibles, which come in various sizes suitable to the number of ore being processed and are sold in the mining towns of Ghana such as Tarkwa, Obuasi and Konongo in the mineral supply market. Handmade, high silica refractory clay crucibles, dried and fired locally before use, are also commonly used, especially in less developed mining areas where it is difficult to obtain commercial crucibles (Aryee *et al*., 2003) [1].

Thermal shock of frequent heating and cooling, chemical attack from the molten flux to the crucible, and handling mechanical damage are common reasons for the short crucible lifetime in small-scale operations, often measured in mere two to five smelt cycles. The expense of replacing crucibles is a continuous operating expense for a small-scale smelter, while if a crucible fails (during a smelt) releasing molten gold, it not only costs the smelter money, but it also poses a serious safety risk.

The Ingot Mould

After smelting the gold and removing the slag, the molten gold is poured into an ingot mould to form the gold bar. In small-scale Ghanaian operations, ingot moulds are usually made from iron, either from commercially made bar moulds, or from locally made moulds created by blacksmiths following the smelter's specifications (Figure 4). The gold bars produced by the moulds are divided into three types, each of which has different dimensions and proportions depending on the volume of material processed: bars produced by small-scale smelters can have a mass of a few grams up to several hundred grams, the dimensions and proportions of which depend on the shape of the mould cavity, and do not comply with any standardised dimensions (PMMC, 2020).

Fig 4: Gold bar freshly cast in iron ingot moulds, showing the characteristic surface texture and form of small-scale smelted gold prior to acid pickling (Researcher's photograph, 2024)

The Smelting Process: Sequential Stages

Crucible Charging and Flux Addition

The smelting process starts by loading (or 'charging') the crucible with the prepared gold concentrate or amalgam retort sponge. The material is carefully loaded into the crucible and flux is added to help the separation of the metallic gold and accompanying gangue minerals, oxides and impurities. Flux selection and application are among the most technically challenging aspects of the small-scale smelting process, and the experience and expertise of the smelter are the most important factors in determining the quality of the flux management.

Borax, also known as sodium tetraborate, $Na_2B_4O_7 \cdot 10H_2O$ is the most commonly used flux in the small-scale gold smelting industry in Ghana, and is an excellent fluxing agent as it dissolves silicate gangue minerals, iron oxides and other impurities to produce a fluid glassy slag which readily separates from the molten gold (Marsden & House, 2006) [9]. In Ghana the mining towns, Borax is traded and sold under the local name 'soda' and is used at 10 % to 30 % of the weight of the charge, depending on the operator's experience combined with the type of gangue mineral in the charge and the amount of impurity in the raw material. Soda ash (sodium carbonate, Na_2CO_3) is often added to the flux in the form of a secondary flux, being used with borax to provide extra alkali to neutralise the acidic gangue minerals and so aid slag fluidity (Hilson & Garforth, 2013) [7]. When there is a shortage of silica in the charge, a small amount of silica sand can be added as a flux modifier. Traditionally, materials locally available such as wood ash, a source of both potassium and sodium carbonate, are added to the flux, partially replacing it, but the chemical composition of these materials varies and so does their fluxing efficiency (Aryee *et al*., 2003) [1].

Furnace Heating and Melting

Having loaded the crucible and added the flux, the crucible is then put in the furnace and the temperature is increased gradually until the gold charge is completely melted. Careful control of the heat up stage is necessary in order to prevent thermal shock to the crucible, as well as to prevent flux dissolution and the formation of slags before the gold has completely melted. In charcoal furnaces, the smelter works by modifying the draught and fuel loading to manage the rate of temperature rise, based on a visual inspection of the crucible and charge (including colour and fluidity of the developing slag) to determine the melting progress (Marsden & House, 2006) [9].

The melting point of gold is 1,064°C, and as temperatures approach and reach this value, the molten gold flows to the bottom of the crucible due to gravity while the lighter slag (which may be gangue minerals dissolved in the molten metal, flux residues and oxidised impurities) float to the top of the molten gold pool (Figure 5). The smelter checks the molten charge by looking through the furnace opening to see the colour, flow and nature of the slag layer. Fluid, mobile slag which flows evenly out of the crucible means good flux action, whereas a viscous sticky slag means insufficient flux or too low a temperature. Further borax can be supplied at this point by pouring it through the furnace opening to aid in the fluidity of the slag.

Fig 5: Smelted gold in a crucible as removed from the furnace, showing the characteristic incandescent orange-white glow of molten gold at approximately 1,100°C surrounded by slag residue (Researcher's photograph, 2024)

Slag Removal

When the gold is completely melted and the slag has become fluid, the smelter grabs the crucible with long-handled tongs (usually made from mild steel rod at a local blacksmith shop) and carefully tips the crucible to pour out the floating slag into a waste container. The slag-skimming operation is very skillful and physically stable because the furnace is very hot, usually around 1100-1300°C and any instability will cause the molten gold to spill. In practice, several slag skimming operations can be carried out at the same smelt and the crucible returned to the furnace between skims to maintain smelting temperature, to the extent that the operator considers the size of the slag has been reduced to an acceptable level and the underlying gold is sufficiently clean (Hilson, 2002) [6].

Discarded slag consists of minerals that are characteristic of the original charge. Slags from sulphide ore concentrates are characterized by higher amounts of iron silicates, iron oxides and remaining sulphur compounds, while alluvial slags consist mainly of silicate and aluminosilicate phases from the heavy mineral gangue associated with the alluvial ore. In most small-scale smelters, slags are collected and periodically smelted to recover the metal values that were trapped in the slag matrix during the initial smelting operation, which is an important recovery step since the metal is valuable and single-smelting operations do not always recover all the metal (Aryee *et al*., 2003) [1].

Casting: Pouring Molten Gold into the Ingot Mould

The furnace with the purified molten gold is lifted after slagging the product and the molten gold is poured into the pre-heated ingot mould, which is made of iron (Figure 6). The mould is usually pre-heated by setting it close to or into the furnace before casting so as to avoid the thermal shock of the contact between the molten gold and the cold mould and to prevent premature solidification or the occurrence of mould surface cracks. The mould can also be lightly coated with a release agent, usually the carbon black (soot) or a thin casting bar refractory slurry, to help prevent the cast bar from sticking to the mould walls (Marsden & House, 2006) [9].

Fig 6: Pouring molten gold from a crucible into an iron ingot mould, showing the incandescent orange stream of liquid gold and the two-cavity mould configuration used in small-scale operations (Researcher's photograph, 2024)

The pouring operation must be carried out at a steady, controlled pouring rate, to minimise turbulence, which may result in gas bubbles and oxidised inclusions in the solidifying bar, and to enable the mould cavity to be completely filled. The molten gold solidifies very quickly when it comes in contact with the cold mould; usually in 30 to 120 seconds depending upon the volume of the bars and the temperature of the mould. After solidification, the bar shrinks slightly from the mould walls allowing easy removal. The cast bar is partially cooled before being knocked from the mould, by either inverting the mould or tapping the mould walls with a metal rod to loosen the bar.

Acid Pickling: Cleaning and Surface Purification

Remove dirt and contaminants from the surfaces using acid pickle solution (Figure 7). The freshly cast gold bar, although mostly gold, is covered with a layer of oxidised impurities, slag inclusions, and flux residues which reduce the visual appearance of the gold and can also impact the purity of the gold when assayed. Small-scale smelters will immerse the cooled bar in a weak acid solution, known as acid pickling, which dissolves the surface oxides and any base metal inclusions without significantly attacking the gold (Marsden & House, 2006) [9].

Fig 7: Acid pickling of a gold bar in a dilute acid solution, with the immersed bar visible at the bottom of the container alongside tongs used for handling — the dark green solution indicates the presence of dissolved copper and base metal impurities (Researcher's photograph, 2024)

Typically, acid used in small-scale Ghanaian operations is dilute nitric acid (HNO_3) or, more commonly, dilute hydrochloric acid (HCl) which can dissolve iron, copper, silver, and other base metals, while leaving gold untouched. Acid solution is poured into the bar (in a plastic bucket or ceramic container) and left to sit there for anywhere from a few minutes to a few hours, depending on the amount of contamination on the surface and the concentration of the acid. During an immersion, wooden tongs or plastic tools should be used to handle the product, since metal tools will interact with the acid. The dark green or blue-green colour of pickling solution is due to the dissolution of copper and iron compounds from the surface of the bar. After pickling, the bar is removed, washed clean with water and dried, leaving a shiny bright gold surface (Figure 8) that is typical of a polished bar (Hilson & Garforth, 2013) [7].

Fig 8: Stack of completed gold bars produced by small-scale smelting operations, showing the characteristic form, surface texture, and golden colour of artisanal gold bars following smelting, casting, and acid pickling (Researcher's photograph, 2024)

Challenges in Small-Scale Gold Smelting

Equipment Limitations and Temperature Control

Small-scale smelting equipment in Ghana is not standardised, which poses problems for operations. Since there are no thermocouples or pyrometers to keep an eye on the furnace temperatures, the smelters have to depend upon empirical judgment of the furnace colour, charge behaviour and slag fluidity to determine whether or not optimum smelting conditions have been reached. This reliance on operation experience creates a situation where smelting results are often very inconsistent and less experienced operators often fail to obtain the desired temperatures or fail to hold the temperature for long enough, leading to an inadequate separation of the slag and gold and lower gold recovery (Hilson, 2002) [6]. Additional operational instability is caused by the short working life of improvised clay crucibles: a smelt failure can lead to loss of charge, and burn injury hazards.

Mercury Contamination

In operations where the gold concentration step is mercury amalgamation prior to smelting, which is still highly prevalent in the small-scale alluvial gold mining sector in Ghana despite its outlawing by the Mercury Act of 2016, the retorting of amalgam to drive off mercury is often not adequately contained. Mercury vaporises at 357°C and when retorting takes place over an open flame, without a closed retort vessel and condenser, mercury vapour is emitted directly into the retorting environment (Hilson, 2002) [6]. The workers involved in amalgam retorting have a high risk of acute and chronic mercury poisoning, and the surrounding soil, water and air is contaminated with mercury that remains in the environment for decades (Aryee *et al*., 2003) [1]. Although some smaller-scale mercury-free smelting operations exist, the use of amalgam is still common, perhaps due in part to the success of this method and the lack of knowledge about its alternatives among many miners.

Flux Management and Purity Limitations

Selection and dosing of flux is an empirical and experience-based process carried out by most of artisanal smelters, which often leads to suboptimal results to achieve good gold recovery and purity.

Over-fluxing – adding too much borax for the amount of gangue – results in the loss of precious flux, and causes the slags to be too fluid, which can result in the entrainment of gold droplets.

Under-fluxing – adding too little borax – causes the slags to be viscous, incompletely dissolved slags, leaving an unacceptable amount of gold in the discarded slag matrix (Marsden & House, 2006) [9].

Since laboratory assay testing is unavailable to measure the mineralogical makeup of the charge, smelters are unable to make informed flux calculations, and gold recovery during small scale operation is correspondingly lower than that of the industrial smelting operation which is well-managed. The gold purity of the bars produced by small-scale smelters in Ghana is generally in the range of 85–92% (PMMC, 2020), which is far from the minimum standard of 99.5% required for London Good Delivery bars, and can have a significant impact on the price which gold buyers receive per gram of gold.

Occupational Safety and Health

Small-scale gold smelting in Ghana is done with very little personal protective equipment (PPE) and in places where the workers are at risk of being exposed to several serious hazards. Thermal hazards pertain to contact with the hot crucible, furnace, molten gold and cast bars, and to radiant heat stress from extended exposure to high temperature furnace environments. Chemical hazards include inhalation of mercury vapour from amalgam retorting, inhalation of fumes from the decomposition of the flux (borax and soda ash), and acid pickling solution skin and eye contact.

Structural hazards include collapse of furnace and potential for molten gold spills (Hilson, 2002) [6]. In acid pickling, sometimes basic eye protection and rubber gloves are worn, but heat-resistant gloves, respiratory protection or proper fume extraction is usually not used. In Ghanaian small-scale mining communities, higher levels of respiratory disease, neurological symptoms associated with mercury exposure, and burn injuries have been recorded among the small-scale smelting operators (Aryee *et al*., 2003) [1].

Legal and Regulatory Challenges

Most of the small-scale gold smelting in Ghana is not licensed. The Minerals and Mining Act of 2006 (Act 703) and subsequent regulations and guidelines for the licensing of small-scale mining, and the compulsory sale of gold through the PMMC, have not been fully enforced, while most small-scale gold mining is sold to itinerant buyers who may purchase the gold through unofficial channels (Teschner, 2012) [13]. The sector has continued to be stunted by intermittent crackdowns by the government on informal mining, such as the well-publicized army-organised operations of Operation Vanguard and Operation Halt, which have temporarily hindered informal smelting operations without formalising the sector or diverting smelting through official channels (Baah-Acheamfour *et al*., 2021) [2]. There is no formal regulation, so most small-scale smelting activities do not have environmental or safety guidelines that are enforced.

Recommendations for Improving Small-Scale Gold Smelting in Ghana

The issues described in this article suggest that a more comprehensive range of practical and policy measures might be implemented to significantly enhance the effectiveness, safety, environmental impacts and profitability of small-scale gold smelting in Ghana. A first step is the development of knowledge on flux management, which can be achieved by specific training programmes offered by the Minerals Commission, PMMC and the local mining associations. These efforts should be accompanied by readily available assay services, to allow the smelters to properly characterize the feed material before processing. At the same time, investments in mercury-free concentration technologies (more effective gravity concentrators, shaking tables, direct smelting of concentrates) should be promoted by providing subsidised equipment and a dedicated extension service. With the help of electric furnaces, fume extraction, and trained personnel, centralised and well-equipped communal smelting facilities in key mining centres would also enable small-scale operators to achieve a higher level of purity and return in addition to reducing health and environmental risks. All government and NGO programmes should include basic provision of personal protective equipment and rigorous safety training. Finally, formalisation incentives to lower regulatory requirements and provide formal gold-buying opportunities based on assays will help regulate a greater proportion of production, while reducing the risks of informal smelting.

Conclusion

This article has recorded and analyzed the sequential process of gold smelting as carried out by the small-scale miners in the traditional environment of Ghana, from the stage of gathering gold ores, gold dust, flakes and grains up to the furnaces charging, fluxing, smelting, extracting the gold slags, casting and gold pickling in acids to the finished gold bar. The process is deceptively simple, but is very technically complex and demands extensive practical expertise and experience of the operator. Small-scale smelting operations in Ghana are characterised by a lack of well-designed equipment, empirical flux management, non-existent temperature control instrumentation, and poor environmental and safety infrastructure, leading to gold purities of 85-92% significantly below the gold purity obtained in industrial refineries – and serious thermal, chemical and toxicological risks for the workers.

It can't get any different between a small-scale smelter and an industrial gold refinery! In Ghana, small-scale gold smelters, which are in much greater and relative numbers, have largely no instrumentation, safety equipment, environmental controls, or access to assay services that would allow them to characterize and improve their product in a way that produces gold of 99.99% purity in comparative safety. This purity gap has economic costs which are largely borne by the miner, who is paid less than the gold value of the bar.

A multi-sectoral approach, that is government policy, institutional capacity, technical training and investment in infrastructure is needed to address this gap. In this article, the recommendations; from the promotion of mercury-free technology, the adoption of better flux training methods, establishment of communal smelting facilities, provision of PPE, and incentives for formalization can be seen as a realistic agenda for the improvement of the results in a sector that is not only a major informal economic activity in Ghana but the sector that offers the least technical assistance and regulatory protection for its activities. The information presented herein, along with original photographic documentation from current smelting operations, is a step in the right direction toward developing the documentation and analysis required for designing and implementing these improvements effectively.

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