



Guinea Conakry and Burkina Faso: Innovations at the Periphery

Cristiano Lanzano

13.1 INTRODUCTION

While operational definitions of ASGM usually emphasize the “simpler” or more “traditional” techniques employed—as opposed to those characterizing large-scale industrial mining—and the lower degree of mechanization, technological innovations are a central element for explaining socioeconomic change in artisanal mining areas. With the recent mining boom of the 2000s (and early 2010s), incentives for acceleration and intensification have reshaped both industrial and artisanal gold mining, as argued in part 1 of this volume. This chapter presents two cases of intense social and technological change that involved ASGM sites in two West African regions where gold mining has become central: eastern Guinea Conakry and western Burkina Faso. The case studies are based on ethnographic research I conducted in these regions together with several colleagues and collaborators¹ (Guinea in 2014, Burkina Faso between 2012 and 2017).

C. Lanzano (✉)
The Nordic Africa Institute, Uppsala, Sweden
e-mail: cristiano.lanzano@nai.uu.se

© The Author(s) 2020
B. Verbrugge and S. Geenen (eds.),
Global Gold Production Touching Ground,
https://doi.org/10.1007/978-3-030-38486-9_13

I start by describing how migrant miners from Burkina Faso have introduced extracting and processing techniques that target primary hard-rock deposits in the site of Tonso (Guinea), thus causing a reconfiguration of the authority previously exerted by the customary village institutions. Secondly, I analyze the impact of the expansion of cyanide-based processing techniques, which took place approximately in the same years, in western Burkina Faso. In the last section, I compare and discuss the two cases, reflecting on the social embeddedness of technological innovations and on the question whether they can be understood as a frontier with hybrid processes of adaptation and appropriation taking place at its margins.

13.2 DEEPENING EXTRACTION: THE “BURKINABE PITS” IN TONSO (GUINEA CONAKRY)

In eastern Guinea Conakry, gold mining is an established activity with a very long history. Early colonial written sources from the nineteenth century already document artisanal gold production in the placers located in the regions of Bouré and Siéké (or Séké), currently corresponding to the administrative units (*sous-préfectures*) around the towns of Kintinian and Doko (see Condé 2017). According to oral sources though, mining has been practiced well before the colonial era, shaping the pre-colonial economies and societies at both a local and trans-regional scale. The French colonial government attempted to control the intense extractive activities in the artisanal mines of Bouré (Luning et al. 2014) and started investing in large-scale operations in the region after the 1920s (Condé 2017). While, in general, the postcolonial Guinean economy has depended on mineral extraction—bauxite and iron ore in particular—to a significant extent, the importance of the gold industry has been more fluctuating, with a renewed interest in industrial mining in the region from the 1990s onwards.

In recent years, ASGM has undergone significant transformations. The region of Bouré and Siéké has inevitably been affected by the “mining boom” of the last two decades, which has provoked a rapid expansion of both industrial and artisanal gold mining in several West African countries, and more generally around the world as this volume demonstrates. The increased number of people willing to engage and invest in mining in the region has brought numerous (more or less) temporary migrants

from neighboring countries. New machines and new extracting or processing techniques—such as metal detectors (Dessertine 2016) or the so-called *laveries* or motorized sluice boxes (Arnaldi di Balme and Lanzano 2019)—have made their appearance, progressively transforming the existing modes of production and sometimes challenging previous regulatory and governance mechanisms. The expanding presence of industrial companies operating in the area also had important consequences, restricting the access of artisanal miners to the most profitable areas, creating patterns of company-community relations and schemes of compensation that have partly reshaped the local political arena (Bolay 2014; see also Luning 2012 for similar dynamics in Burkina Faso).

As a result of the recent processes of innovation, currently several gold mining crystallizations co-exist in the mining sites of Bouré and Siéké. The *bè*, often described as the most ancient or traditional way of mining, can still be observed in many locations. In this system, small teams of diggers—usually not more than five people for each pit—target underground alluvial deposits located at relatively superficial levels: The pits do not usually exceed a depth of 15 meters. Except for the occasional use of water pumps to empty the pits when diggers encounter the water table, or of air pumps to ventilate pits and underground tunnels, the degree of mechanization is limited and excavations are conducted through manual work. Yet, despite the apparent simplicity of this technique, the areas mined according to this system, themselves called *bè* or *be-kono* (“inside the *bè*” in Malinké), present an orderly and sophisticated structure, with small circular pits aligned in several rows at regular distance (no more than 5 meters) from each other. The different rows of pits are themselves positioned at a fixed distance from each other: This distance (10–20 meters) is greater than the one separating the pits and leaves space for underground horizontal tunnels to develop from each vertical pit in a perpendicular direction.

The regularity in the spatial organization reflects the centralized control exerted by the authorities of the neighboring villages. In each village—or, more rarely, a grouping of villages—the council of the elders and the *damantigi* (a respected personality in charge of the symbolic and material control of mining areas) decide upon and supervise the mining activities taking place in the territorial domain of their competence. More particularly, they are responsible for both spatial and temporal limits imposed on gold digging. Through divination, they are expected to determine at the beginning of each mining season which specific areas will host

the mining pits and which areas will be left to rest. In fact, the geographical location of alluvial gold deposits is commonly known, but this procedure establishes an alternation that gives sites the time to rest, somehow evoking the principle of field rotation in fallow agriculture. The duration of the mining season is also decided in advance, and start and end dates as well as mandatory rest days are established centrally and enforced. In order to enforce these regulations, the elders nominate a committee called *tomboloma*, composed by male adults (usually in their 40s or 50s) who are experienced in mining and represent the main autochthonous lineages of the village. The members of *tomboloma* are charged with the daily supervision of mining activities in the *bè* and the enforcement of the *damantigi*'s and the elders' decisions. For example, they trace the exact limits of the broader area where excavations are allowed and mark the location of the individual pits; they also supervise the attribution of pits to each mining team and reserve some pits for notable village personalities or for mining investors and teams coming from other regions. Furthermore, members of the *tomboloma* can facilitate the resolution of conflicts and collect rents and informal taxes from miners, traders and other economic actors operating in the site. On the one hand, the *bè* is a production system that relies on the relative autonomy of mining teams and service providers, and that keeps entry barriers at a relatively low level in order to attract migrant workers and traders from other regions (see also Bolay 2014). On the other hand, its functioning is based on a centralized system of—informal, or rather customary—governance that enforces predictable regulations on, and extracts rents from, all economic actors active in the site.

While some of the practices and institutions described above are still observable and active at some level in most mining sites around Bouré and Siéké, the *bè* is no longer the dominant system of gold production. It currently cohabits with different and new techniques, social arrangements and patterns of work organization. Near the village of Tonso (in the *sous-préfecture* of Doko, at the heart of the Siéké region), for example, new techniques have been adopted since approximately 2012. These have transformed both digging operations, with deeper pits targeting primary hard-rock gold deposits, and processing methods, with a more sophisticated chain involving several phases of ore crushing and washing as well as the use of mercury. These innovations corresponded to an intensified presence of migrant miners coming from neighboring countries like Burkina Faso, where hard-rock mining had been practiced for a longer time and mercury was widely employed. In fact, the shafts targeting hard-rock

deposits—which in 2014, at the time of my fieldwork, were predominant in the mining site of Tonso—were often referred to as “the Burkinabe pits.” Migrant miners from Mali and Burkina Faso constituted the majority of the teams active in these shafts, although they often worked side by side with local miners and had to reach arrangements and sharing agreements with the customary authorities of the village of Tonso.

The “Burkinabe pits” targeting primary deposits reached variable but generally significant levels of depth (up to 30 meters or more). Their excavation required the use of new techniques and machines: Resort to explosives was common, and the construction of internal wooden scaffolding structures in the pits became necessary in order to facilitate the descent of miners and to prevent collapse. The geological characteristics of hard-rock deposits also required new forms of knowledge—such as the ability to identify the “gold vein” and extract the rock from it—and imposed new working routines or forms of specialization among laborers. Maybe even more importantly, they transformed the processing phase: Compared to the kind of rock usually extracted in the *bè*, the ore coming from primary deposits is usually harder and manual processing techniques are not effective. The rock coming from the “Burkinabe pits” first had to be crushed with mechanical tools, usually engine mills readapted to the task. After the crushing, the pulverized ore was “washed,” i.e., mixed with water on sluice boxes—which were found quite rarely in the *bè* system—to facilitate the precipitation of the heaviest parts, and later treated with small quantities of mercury to facilitate the isolation and aggregation of gold particles. Together with the intensification of extraction and the partial mechanization of processing work, the appearance of mercury in the site of Tonso was one of the most dramatic changes in gold mining practices that could be observed in the whole area of Bouré-Siéké around 2012–2015.

The innovations brought by Burkinabe migrant miners posed multiple challenges to mining practices associated with the socio-technical system of the *bè* and to the local institutions that played a major role in it. While in the case of secondary deposits, there was a shared knowledge concerning the geographical position of placers—that had been mined repeatedly over the years—and miners could assume a relatively homogenous degree of soil mineralization in those locations, the situation changed when new excavations started targeting primary deposits. Uncertainty over the identification and localization of gold deposits became much higher, and miners had to rely on fortuitous findings and tests performed on the surface.

Furthermore, they built the pits and shafts in order to “follow the gold vein,” in accordance with the direction “taken by” the ore. The uniform distribution of excavations over space, decided centrally by village authorities in the case of the *bè*, could not work anymore in this new system, and the mining teams became more autonomous in deciding where to start their digging operations and how to solve competition over the same portions of land and of the underground. Similarly, the intensification of extraction and the increased competition between mining teams, feverishly busy with reaching hard-rock deposits in the shortest possible time or with identifying new locations to dig, made it impossible to abide by previous regulations and limitations concerning the appropriate time—for example, the rhythms, the duration and the starting and ending dates—for mining work (Lanzano 2018).

These changes in the organization of work and production reconfigured the governance roles of village institutions and of *tomboloma* in particular. Its members retained their role as gatekeepers, managing the access of migrant miners and traders to mining sites, and as security enforcers, mediating in cases of conflicts. On the other hand, they generally lost most of the control they had over choices concerning spatial—location, distance, form and direction of the shafts—and temporal—duration and rhythms of the operation—aspects of mining. This decline of the centralized governance that characterized the *bè* seems to have been compensated, in a way, by an increased level of informal taxation. Along with the imposition of local rentiers—representing the different lineages that compose the population of the village—for each pit mined by a team of outsiders (a practice that existed in the *bè* system as well), additional daily financial contributions were established. The *tomboloma* would collect these contributions and channel most of the income to the *damantigi* or the council of elders, who were in charge of final decisions about the destination of mining revenues. In the new socio-technical system of gold mining brought by Burkinabe miners, local authorities shifted from their regulatory function to the—less central but somewhat more profitable—extraction of rents and imposition of informal taxation (for a more detailed description of these processes, see Lanzano and Arnaldi di Balme 2017).

However, the “Burkinabe pits” in Tonso were a relatively short-lived phenomenon, since a good number of foreign migrants were forcibly evicted from the mining sites and repatriated between 2015 and 2016. In a more recent fieldwork in the area (February 2019), most mining

activities in Tonso had gone back to targeting alluvial deposits, although often through more mechanized techniques than those usually associated with the *bè*. Yet, the knowledge and the technologies related to deeper hard-rock mining have not disappeared from the region and can occasionally be found in other locations of the Bouré–Siéké.

13.3 TURNING RESIDUES INTO THE CORE PRODUCT: CYANIDATION IN WESTERN BURKINA FASO

While there is some debate around how far gold panning in the region can be traced back in time (see, e.g., Werthmann 2007), Burkina Faso has become a mining economy in much more recent times than Guinea. Attempts to develop industrial mining during colonial and postcolonial times were relatively short-lived, and it was only during the first decade of the twenty-first century that growing foreign investments led to the opening of several industrial mines, turning gold into the first source of export earnings since 2009. Underground ASGM made its first appearance in the early 1980s in the northern and central regions of the country, and then began to expand, reaching western and southwestern regions between the late 1990s and the early 2000s, in correspondence with the positive trend in global gold prices. In that period and until very recently, the opening of new ASGM sites was mostly associated with the mobility of migrant miners coming originally from northern and central Burkina Faso, where gold mining had developed first. Bringing their knowledge, techniques, and even professional and commercial networks, these miners contributed to the diffusion of ASGM across most of the country and to its emergence, in a short span of time, as a booming sector and a policy problem in the public debate—raising concerns, for example, about its lack of formal regulation and its contribution to social conflicts.

Given the recent character of ASGM expansion, life and production in gold sites are not regulated through an established system of practices and norms rooted in traditional law and customary institutions, as in the Guinean case. Instead, the informal governance of mining sites involves a multitude of actors—miners and their leaders, representatives from both customary and formal local authorities, private investors and companies holding official mining permits—who collaborate in precarious arrangements that can vary significantly according to the location, and evolve in time. In western Burkina Faso, gold mining crystallizations

are specifically influenced by the fact that mining activities are still dominated by migrant miners and traders who reside only temporarily in the area, and eventually move somewhere else (or return to their homes). Relations between locals (i.e., those who belong to the ethnic groups considered as *autochthones*) and outsiders (or *étrangers*, belonging to non-autochthonous ethnic groups) oscillate between conflict and collaboration (see Werthmann 2006). In most cases, in order to succeed, miners need to obtain some form of support from the *autochthones* or—at least some of—their representatives, and the involvement of local landowners and traditional institutions range from rent extraction and informal taxation imposed on migrants' activities to a more active and direct engagement in the gold economy.

In these informal and precarious arrangements governing ASGM sites, an important role has been played by the private *comptoirs*: These locally owned companies have multiplied after the mid-2000s, when the previously operating Comptoir Burkinabè des Métaux Précieux—the state-owned marketing board for minerals—was dismantled and the new mining legislation created room for local private investors. A few entrepreneurs started then competing for artisanal mining permits delivered by the ministry and often made an instrumental use of their status of *concessionnaires* in their competition to control mining in a certain region or site, rather than respecting literally the temporal or territorial validity of their permits (Arnaldi di Balme and Lanzano 2013; Côte and Korf 2018). In a first phase, though, these private *comptoirs* mostly acted as (wannabe) monopsonists, i.e., trying to enforce their position as exclusive *concessionnaires* for the final purchase of the gold produced in a certain site. Even when they held a mining permit (such as an *autorisation d'exploitation artisanale et traditionnelle*), they left the actual extractive and processing activities to self-organized miners' teams and their informal arrangements with traders and service providers. Besides, their investment was mostly indirect, for example, by injecting money in the value chain through the network of individual buyers that depended financially on the *comptoir*.

The increased competition between the private *comptoirs* is one of the key explanations for the socio-technical change that has affected the sector in recent years (see Chapter 3 in this volume on scarcity). The growing presence—since the mid- to late 2000s—of international companies investing in new industrial mining sites pushed many private *comptoirs* operating in ASGM to rush for all the permits they could obtain from the ministry. In this way, they hoped to maintain their dominant position

in the locations where they already operated and to outdo competitors in opening new ASGM sites. Space became quickly saturated, with the large majority of known deposits covered by some—industrial or artisanal—mining permit by around 2012–2013. With less and less land accessible, increasing the intensity of gold mining became a necessity even for ASGM miners and investors.

The main opportunity for intensification came from a technique that was already in use but had remained relatively marginal in ASGM, i.e., the processing of tailings and final residues with cyanide. Until that time, mercury was the main chemical substance employed in processing the gold ore. Similarly to what happened in the “Burkinabe pits” of Tonso described above, miners would process their share of rock—usually distributed among the members of the mining team after extraction, according to fixed arrangements—individually, crushing it mechanically, “washing” it in the sluice boxes and finally using small quantities of mercury to aggregate gold particles. The different by-products created during this procedure were usually left aside for later reprocessing. In some cases, like the final residues of the washing phase accumulating at the bottom of the sluice boxes, they were used as a compensation in kind for the owners of the washing stalls. The latter—a large majority of which were women (Ouédraogo 2014; Arnaldi di Balme and Lanzano 2016)—could then reprocess their piles of “mud” (often referred to as *boue*, the French word for mud, or locally called *garga* or *nyeka*) again with water and mercury. Another option was to sell them to itinerant buyers especially interested in residues and “muds,” who would then bring them to areas specialized in cyanidation, located outside of the mining sites. There, the remaining content of gold could be more easily isolated and extracted.

As we have seen, cyanide-based techniques were already practiced, but they were described as less accessible and residual: Cyanidation areas were scarce and usually located far away from mining sites, and most miners did not have the necessary knowledge to extract gold from residues and “muds.” In fact, both the miners working in the pits and the representatives of the *comptoirs* seemed to remain focused on mercury-based processing, which distinguished between more valuable products—the heaviest portions of the pulverized rock, isolated during the washing on the sluice box and then processed with mercury—and more residual ones. Progressively, though, cyanidation techniques spread, and new areas dedicated to processing the final residues—often in a very rudimentary way—were created, making this technique more and more visible. The higher

prices many buyers were willing to pay for the piles of mud accumulating at the bottom of the sluice boxes signaled that cyanide-based techniques could significantly increase the profit made on every unit of extracted ore, possibly outdoing the previously dominating techniques.

From 2013 on, the national press gave some coverage to a few conflicts arising in different mining sites and involving representatives of the private *comptoirs*, on one side, and groups of artisanal miners and women active in the processing of gold ore, on the other. Conflicts pertained to the ownership of the different outputs of the production taking place in the sites—particularly of the final residues that would be processed with cyanide—and to the right of the *comptoirs* to appropriate them. In July 2013, for example, the newspaper Sidwaya reported the declarations of Adama Pafadnam, one of the most successful investors in ASGM, concerning a conflict with the women of Nicéo (near the town of Diébougou), where he had established a *comptoir*:

The comptoir belongs to us. The piles of mud [the final residues] too. Women do not have the right to sell them to anyone else until we have been incapable of buying them. My offer has been rejected [because the price was considered too low]. If they refuse to sell to me, nobody else should buy them. (Kiemtoré 2013)

Two years later, a similar case stopped the production in Fandjora, near the town of Banfora. The conflict opposed Aristide Boudo, a less-known investor holding an ASGM permit in the area, and a group of women who demanded to sell the residues to external buyers instead of complying with the price fixed by the *comptoir*. In both these conflicts, as in other cases I observed across the region, the growing influence of cyanidation techniques, and the perspectives of greater profit these entailed, provoked a radical rethinking not only of value (of the residues), but also of governance. After having relied for a long time on self-organized miners and processors, many private *comptoirs* started using their formal permits as a proof of their exclusive rights over the entirety of production in the mining sites under their control. Some of these situations ended up in court and had some press coverage. But while in most instances the *comptoirs* won the case, their dominant position could not always be restored or enforced, and the controversies continued. This conflictual phase left a visible trace both in the multiple strategies enacted by miners and traders to resist the appropriation of their work and profit by the *comptoirs*, and

in its contribution to the profound changes in the socio-technical system observed at least in most sites of western Burkina Faso at least after 2015.

In many locations I visited since 2015—such as the sites in the municipalities of Koumbia, Diébougou and Dissinh, all located in western Burkina Faso—tense relations between miners and *comptoirs* had negatively affected the *comptoirs*' influence and created space to replace them by other informal actors.² When miners, owners of crushing and washing stations and other traders chose to regain autonomy by abandoning the existing sites and relocating in new areas, they reorganized their activities under the supervision of newly created committees, usually involving experienced miners and traders together with some local representatives or traditional institutions controlling the land. In any case, the generalization of cyanide-based processing made it impossible to simply return to previously dominating modes of production centered around the crushing-washing-mercury process. The fixation of prices for the sale of final residues—which were now regularly processed with cyanide—remained a central issue for the new governing committees: Their decisions usually ended up restricting the autonomy and the profit margin previously enjoyed by the women owning the washing stalls and the other processors. In several cases, I observed a trend toward the integration of the different phases of the production chain, with some leaders of the mining teams—called *bokasoba* in Mooré or “pit chiefs”—expanding their investments beyond activities related to excavation, and building their own washing and cyanidation facilities. This way, they could keep and process all the raw material extracted from one pit together, without having to renounce parts of the product to compensate service providers and commercial partners as before. Collaborators and workers in the different phases of production (excavation, washing, cyanidation) would thus be compensated at the end of the process, most often in cash, with their status approaching that of waged workers (for the analysis of similar processes in the Philippines, see Verbrugge 2014). Somehow, the attempts of *comptoir* owners to extend their control over the entire production process and consolidate their ownership of all its (by)products, which had been encouraged by the diffusion of cyanide-based processing, were replicated by pit chiefs and other wealthier miners at a smaller scale.

13.4 A TECHNOLOGICAL FRONTIER? SOCIO-TECHNICAL INNOVATIONS AT THE PERIPHERY

As Verbrugge observes in Chapter 5 of this volume, ASGM miners employ a very diverse range of artifacts, chemical substances and techniques in their extraction and processing activities. The variety of socio-technical systems observable in the artisanal gold mining arena, and the innovations that continuously generate or reshape precarious gold mining crystallizations, should make us wary of reductionist definitions of the “ASGM sector.” Manual techniques and “traditional” modes of production cohabit, as we have seen in the two examples presented above, with the emergence of new technologies. These may be more costly and call for greater investments, thus shifting the balance between the necessary input of capital and labor, and requiring more specialized knowledge. The intensification of production and the partial mechanization of both extractive and processing activities, that these technological innovations generate or facilitate, blur the boundaries between the “artisanal” and the “industrial” and question the established definitions of ASGM both among scholars and policy-makers (see introduction to this volume).

In the case of Tonso, gold mining has both intensified—with the targeting of primary deposits and the increase of income (INSUCO 2014; Lanzano and Arnaldi di Balme 2017)—and partly mechanized, as Burkinabe migrant miners introduced new techniques and modes of work organization and specialization. While the *bè* was not a closed system and has always been characterized by a certain degree of mobility (Bolay 2014; Luning et al. 2014), the temporarily increased migration flows associated with the boom in gold prices paved the way for a “South-South” circulation of knowledge and for (partly) endogenous technological innovations (Lanzano and Arnaldi di Balme 2017). In western Burkina Faso, the use of machines—engine mills and sometimes *laveries* or mechanized sluice boxes—and of chemicals like mercury was pervasive well before the most recent innovations. In this case, cyanide-based processing techniques responded to the growing demand for intensification and for more effective processing, in response to a widespread perception of declining gold content of the extracted ore and the correspondingly declining profits (see Chapter 3). While cyanidation was not an entirely new technique, its increased accessibility and its generalization produced dramatic transformations whose effects far exceeded those on the mere technological landscape. Similarly to what has been described in other contexts (Libassi,

in this volume), this innovation affected the mechanisms of value creation, turning by-products that were previously considered residual into the most profitable outcomes of the production chain. It also reshaped the patterns of organization and division of work, causing a “verticalization” and a hierarchization of mining teams and incentivizing pit chiefs to integrate the different processing phases in order to minimize losses and transaction costs.

Innovations can appear at unpredictable times and often follow uneven patterns of diffusion and distribution across space. This is probably more true in ASGM, where technologies are not adopted at a large scale and where mechanisms of learning and of knowledge circulation are not institutionalized, but rather linked to the volatile flows of humans and artifacts in a highly informalized economy. The metaphor of an expanding frontier, which has been used by scholars to describe both the spatial expansion of ASGM activities (Verbrugge and Geenen 2019; see also various authors in Werthmann and Grätz 2012) and the exceptionality of the sociopolitical formations—the mining crystallizations—constantly (re)created by this expansion at its peripheries (Grätz 2004; Arnaldi di Balme and Lanzano 2013; Bryceson and Geenen 2016; Côte and Korf 2018), could be also employed in reference to technological innovation. For example, Dumett (2012) includes the “technological frontier” in his account of the several parallel frontiers along which both artisanal and industrial gold mining expanded in the Gold Coast (present-day Ghana) between the late nineteenth and the early twentieth centuries. In that historical phase, colonial innovations—such as mechanized grinding or the use of cyanide—spread among artisanal mining communities often as a result of a trickle-down process from the technological advances of the industrial sector, in which the colonial government or the foreign private companies were investing. These innovations contributed to the expansion of a frontier that proceeded not only horizontally across regions, but also vertically toward greater depths in the underground.³

Luning (2018) has rightly underlined some risks implied in using the notion of the frontier, for example, that of obscuring the “density” of preexisting social relations and cultural worlds in those margins or peripheries—the “institutional vacuums” in Kopytoff’s formulation (Kopytoff 1987)—where the core population (or activity, or technology) is supposed to advance and reproduce itself. Indeed, in the two case studies I presented here, “new” technologies reach areas where they find preexisting established gold mining crystallizations. These can consist in modes

of gold production that present a high degree of social embeddedness (the *bè* in eastern Guinea), or in emerging and constantly renegotiated arrangements between economic and political actors (private *comptoirs*, customary/local chiefs and itinerant miners and traders in western Burkina Faso). What can be useful in the notion of a “technological frontier”—as in other versions of the concept such as the capitalist frontier or the “commodity frontier” (Moore 2000)—is not so much the idea of automatism and irreversibility that we sometimes associate to it and that should be deconstructed. In fact, the end of the relatively short-lived experience of the “Burkinabe pits” in Tonso, with forced evictions of non-Guinean artisanal miners from the Bouré–Siéké region between 2015 and 2016, or the multiple reactions and resistances met by the expansion of cyanide-based processing in Burkina Faso, show how the circulation of knowledge and technology is far from seamless or uncontroversial. Rather, the focus should be put on the interstitial and marginal spaces of the imagined technological frontier, where innovations find obstacles or conditions for their reproduction and trigger creative processes of (often selective) appropriation. The articulation—or the “friction,” to use Tsing’s concept (Tsing 2005)—between the global forces of mining capitalism and the local dynamics of the sociopolitical governance of extractive activities is what interests us, because it reveals how gold mining crystallizations are (re)created and how they adapt and respond to demands and incentives for change.

The transformations observed in the ASGM sites of eastern Guinea and western Burkina Faso occurred not simply on a technological, but rather on a “socio-technical” level (in the sense suggested by, among others, Akrich 1989; Pfaffenberger 1992). Technological items and knowledge are embedded in patterns of social relations of production. When they travel or appear in new locations, they generate both a “disembedding”—they function in a situation that is disconnected from the original context, and they also produce a disconnection in preexisting relations of production in the new context—and a “re-embedding”—they are variously appropriated in the new context and reshape social relations around them—of gold production. The “Burkinabe pits” targeting primary deposits put local institutions of Tonso like the elders, the *damantigi* or the *tomboloma* under considerable pressure, and while their centrality remained unquestioned, their functions shifted from those of centralized planning and regulation to those of gatekeeping and imposing taxation on the newcomers. The expansion of cyanidation in artisanal

gold mining sites of Burkina Faso produced a crisis in the established patterns of relations and transactions between miners, traders and private investors; but it also stimulated the recreation of new arrangements to solve the conflicts concerning the access to, and the ownership of, the various products of the value chain.

Innovations were “socio-technical” not only because they produced consequences at the sociopolitical level, but also because they were made possible by socioeconomic dynamics and institutional demands. Contrary to what Pfaffenberger (1992) has termed the “standard view of technology,” technologies do not simply appear when they are abstractly needed, and do not simply succeed when they are more appropriate or effective: The conditions for their emergence, circulation or success are themselves the result of specific political-economic configurations. The competition generated by the growing presence of industrial companies or the scramble for licenses and mining permits, and the perception of scarcity related both to pressure on land and to the declining gold content and profitability in the established mining areas, combined together and produced a demand for the acceleration and intensification of production. This demand took different forms and had different consequences, but it was a central precondition for innovation in both cases presented here. In eastern Guinea, it enabled the inflow of migrant miners who brought their techniques, which were “new” for the area of Tonso, but had been practiced for decades elsewhere. In Burkina Faso, it facilitated the generalization of cyanide-based processing, which was already present in the region but was rarer, less accessible and considered more marginal.

Responding to increased competition and to the growing perception of scarcity, themselves both localized manifestations of the global mining boom of the 2000s, ASGM is subject to constant transformation. Far from being a conservative or residual space characterized by the persistence of “traditional” social relations or modes of production, it reacts dynamically to the structural transformations of both the agrarian and rural contexts in which it is—geographically and historically—embedded and of the global gold production system. As noted by Geenen and Verbrugge in Chapter 2 of this volume, these processes of socio-technical innovation ultimately embody the way in which mining capitalism reaches—and becomes reshaped in—the periphery, producing constantly evolving crystallizations like the ones I described in this chapter.

NOTES

1. I am particularly indebted to Luigi Arnaldi di Balme and to Alizèta Ouédraogo for the collaboration during fieldwork and the ongoing fruitful exchange of ideas. I also benefitted from the precious assistance of Ibrahima Diawara and Sekou Bereté in Guinea, and of Ibrahima Sanou, Gaston Kaboré and Abdel Aziz Diallo in Burkina Faso.
2. The decline of private *comptoirs* was also accelerated by the fall, in late 2014, of Blaise Compaoré's government, with which many companies who held official permits had privileged links. With the regime change, *comptoirs* had to cope with increasing financial and legal problems (Werthmann 2017).
3. The importance of the "vertical" direction in the expansion of gold mining has been underlined by Verbrugge and Geenen (2019). Similarly, although with different implications, Luning and Pijpers (2017) call for greater attention to the "in-depth geopolitics" of social relations and conflicts in the mining arena.

REFERENCES

- Akrich, M. (1989). La construction d'un système socio-technique. *Anthropologie et Sociétés*, 13(2), 31–54.
- Arnaldi di Balme, L., & Lanzano, C. (2013). "Entrepreneurs de la frontière": le rôle des comptoirs privés dans les sites d'extraction artisanale de l'or au Burkina Faso. *Politique Africaine*, 131, 27–49.
- Arnaldi di Balme, L., & Lanzano, C. (2016, November 10–11). *Mud, gold and women: Leftovers, value creation and changing relations of production in artisanal mining (Burkina Faso)*. Paper presented at the workshop "Artisanal and small-scale mining in Africa: Socio-economic change and new research perspectives", The Nordic Africa Institute, Uppsala (unpublished).
- Arnaldi di Balme, L., & Lanzano C. (2019, November 3–6). *The end of gold? Socio-technical change and perceptions of resource scarcity and depletion in Guinea*. Paper presented at the conference of the ASA (Association of Social Anthropologists of the UK & Commonwealth) 2019, University of East Anglia, Norwich (unpublished).
- Bolay, M. (2014). When miners become "foreigners": Competing categorizations within gold mining spaces in Guinea. *Resources Policy*, 40, 117–127.
- Bryceson, D., & Geenen, S. (2016). Artisanal frontier mining of gold in Africa: Labour transformation in Tanzania and the Democratic Republic of Congo. *African Affairs*, 115(459), 296–317.
- Condé, C. F. (2017). *Histoire de Siguiri. De l'implémentation coloniale à l'indépendance (1888–1958)*. Paris: L'Harmattan.

- Côte, M., & Korf, B. (2018). Making concessions: Extractive enclaves, entangled capitalism and regulative pluralism at the gold mining frontier in Burkina Faso. *World Development*, 101, 466–476.
- Dessertine, A. (2016). From pickaxes to metal detectors: Gold mining mobility and space in Upper Guinea, Guinea Conakry. *The Extractive Industries and Society*, 3, 435–441.
- Dumett, R. (2012). Parallel mining frontiers in the Gold Coast and Asante in the late 19th and early 20th centuries. In K. Werthmann & T. Grätz (Eds.), *Mining frontiers in Africa: Anthropological and historical perspectives* (pp. 33–54). Köln: Rüdiger Köpper Verlag.
- Grätz, T. (2004). Les frontières de l’orpaillage en Afrique occidentale. *Autrepart*, 2(30), 135–150.
- INSUCO (International Sustainable Consulting). (2014). *Étude de base sur l’orpaillage artisanal dans la Préfecture de Siguiri*. Conakry: rapport d’étude.
- Kiemtoré, S. O. (2013, July 20). Orpaillage dans la Bougouriba: Bataille judiciaire entre le pagne et le pantalon. *Sidwaya*.
- Kopytoff, I. (1987). The internal African frontier: The making of African political culture. In I. Kopytoff (Ed.), *The African frontier: The reproduction of traditional African societies* (pp. 3–84). Bloomington and Indianapolis: Indiana University Press.
- Lanzano, C. (2018). Gold digging and the politics of time: Changing timescapes of artisanal mining in West Africa. *The Extractive Industries and Society*, 5, 253–259.
- Lanzano, C., & Arnaldi di Balme, L. (2017). Des “puits burkinabè” en Haute Guinée: processus et enjeux de la circulation de savoirs techniques dans le secteur minier artisanal. *Autrepart*, 82, 87–108.
- Luning, S. (2012). Processing promises of gold: A minefield of company-community relations in Burkina Faso. *Africa Today*, 58(3), 22–39.
- Luning, S. (2018). Mining temporalities: Future perspectives. *The Extractive Industries and Society*, 5(2), 281–286.
- Luning, S., Jansen, J., & Panella, C. (2014). The “Mise en valeur” of the gold mines in the Haut-Niger, 1918–1939. *French Colonial History*, 15, 67–86.
- Luning, S., & Pijpers, R. (2017). Governing access to gold in Ghana: In-depth geopolitics on mining concessions. *Africa*, 87(4), 758–779.
- Moore, J. (2000). Sugar and the expansion of the early modern world-economy: Commodity frontiers, ecological transformation, and industrialization. *Review (Fernand Braudel Center)*, 23(3), 409–433.
- Ouédraogo, A. (2014). *“Tanpogse”: les femmes de la colline. Anthropologie de l’orpaillage au féminin (Burkina Faso)* (Mémoire de Master 2 Recherche). Université Lumière-Lyon 2, Lyon.
- Pfaffenberger, B. (1992). Social anthropology of technology. *Annual Review of Anthropology*, 21, 491–516.

- Tsing, A. L. (2005). *Friction: An ethnography of global connection*. Princeton: Princeton University Press.
- Verbrugge, B. (2014). Capital interests: A historical analysis of the transformation of small-scale gold mining in Compostela Valley province, Southern Philippines. *The Extractive Industries and Society*, 1, 86–95.
- Verbrugge, B., & Geenen, S. (2019). The gold commodity frontier: A fresh perspective on change and diversity in the global gold mining economy. *The Extractive Industries and Society*, 6(2), 413–423.
- Werthmann, K. (2006). Gold diggers, earth priests and district heads: Land rights and gold mining in Southwestern Burkina Faso. In R. Kuba & C. Lentz (Eds.), *Land and the politics of belonging in West Africa* (pp. 119–136). Leiden: Brill.
- Werthmann, K. (2007). Gold mining and Jula influence in precolonial Southern Burkina Faso. *The Journal of African History*, 48(3), 395–414.
- Werthmann, K. (2017). The drawbacks of privatization: Artisanal gold mining in Burkina Faso, 1986–2016. *Resources Policy*, 52, 418–426.
- Werthmann, K., & Grätz, T. (Eds.). (2012). *Mining frontiers in Africa: Anthropological and historical perspectives*. Köln: Rüdiger Köpper Verlag.