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Occupational Health and Safety Concerns in the Artisanal and Small-Scale Mining Sector: A Review

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1. Introduction

The rapid expansion of artisanal and small-scale mining (ASM) – low-tech, labour-intensive minerals extraction and processing – has polarized the donor community. On the one hand, it is a vital lifeline for hundreds of millions of people worldwide, many of whom have few alternative sources of income. On the other hand, activities are associated with a range of problems, foremost a burgeoning list of health and safety concerns. The purpose of this report is to review these problems but in doing so, offers explanations as to why they have emerged, intensified over time and more importantly, not been tackled effectively. It is argued that the health and safety concerns on display at most ASM sites worldwide are – much like most of the other problems the sector has been associated with, such as widespread environmental degradation, criminality, and violence – attributable to its confinement to the informal economy. Whilst the connection is rarely made, the failure of governments across Latin America, Asia, and sub-Saharan Africa to prioritize the legalization and support of ASM has spawned a dynamic sector comprised of an eclectic collection of activities but which, are unregulated and unchecked.

The initial sections of this report provide essential background that explains why informality is so persistent in ASM worldwide, with the goal of "locating" the discussion that follows on the health and safety concerns reported in the sector. After reviewing scholarly work undertaken that singles out and examines the pervasiveness of individual health and safety concerns in ASM, and attempts made to address them, the report pivots to the four country cases themselves: Brazil, Colombia, Uganda, and Zimbabwe. Work conducted on the socioeconomic impacts of, and health and safety records in, the ASM sector found in each of these countries is reviewed. The message preached across the four countries is – and consistent with the theme of the review – that the poor health and safety record of the ASM sector in each is a hallmark of persistent informality, which regulations and policies are responsible for "creating."

2. Context

Over the past two decades, ASM has cemented its position as one of the most important rural nonfarm activities in the developing world (see Appendix I for estimates of direct employment in ASM in selected countries). The embeddedness of the sector's activities and their ability to deliver wealth to some of the world's poorest areas, however, have not been consistently recognized by host governments, donors, and NGOs. "Small-Scale Mining" was officially used in an international development context in the United Nations' landmark publication, Small-Scale Mining in the Developing Countries.[1] Whilst the report highlighted the economic importance of ASM, it mostly sought to identify a suitable working definition of "small-scale mining", highlighted the types of minerals those engaged what was considered "small-scale mining" target, and listed examples of the types of equipment used to extract them. The latter point is particularly important because it would become the main focus of policy debates on ASM towards the late-1970s, and throughout the 1980s and early-1990s. These dialogues took place at a time when officials at the World Bank and IMF were working with governments across Latin America, sub-Saharan Africa and Asia to liberalize their legislation, with the goal of attracting the foreign investment needed to "grow" capital-intensive, mechanized (large-scale) mining and mineral exploration activity.[2] A rapid appraisal of the events that would follow is instructive, as it helps to contextualize, within these three regions, the catalogue of Occupational Health and Safety concerns now on display at ASM sites across the world.

Whether borne out of governments' push to prioritize and promote large-scale mining or not, technical assessments of the sector (i.e., ASM) during this period were not particularly complimentary nor encouraging. For example, there was growing consensus that "[the sector's] labour force is usually unorganized and operates outside of any social legislation which may be on the books",[3] that "A characteristic commonly associated with small-scale mining in developing countries is the predominance of antiquated, inefficient mining methods and the limited application of modern extraction technology",[4] and that "Typically, the small mine owner pays little attention to laws".[5] What a review of the literature suggests, however, is that these problems were the result of host governments not having the legal and institutional architecture in place to regulate ASM effectively and steer it down a sustainable path.

Davidson was among the first to report on what this would have entailed, arguing that "Governments must be prepared to move beyond the establishment of legal frameworks, to identify deposits and areas amenable to small-scale development, including the preliminary evaluation of their technical and economic viability at different levels of operation".[6] An often-overlooked aspect of policymakers' failure – and ultimately, oversight on the part of the officials at the IMF and World Bank advising them – to anticipate the importance of having in place the institutional and regulatory bedrock required to steer ASM down a sustainable path was not incentivizing legalization for those engaged in the sector. Noetstaller was among the first to observe this, reporting that "Licensing and registration procedures required to obtain exploration or mining rights have to be simple, rapid and inexpensive".[7] Over a decade later, officials at the International Labour Organization (ILO), reflecting on the state of the ASM sector at the turn of the century in the organization's landmark publication, Social and Labour Issues in Small-Scale Mining, were far more scathing in their criticisms of host governments. They went on record arguing that:

> *Sometimes the regulations are so complex that small-scale miners are dissuaded from attempting to adhere to them. Moreover, the widespread lack of institutional capacity to implement small-scale mining regulations means that the chances of being caught and sanctioned are slim. Sometimes the regulations serve to stifle small-scale mining, trapping it in suboptimal operations rather than promoting it as a sustainable, profitable entrepreneurial activity that can provide significant employment in rural areas. So, the only way forward is down an illegal path.*[8]

Reference made here to "an illegal path" is important because at the time of the report's publication in 1999, a number of developing countries with lengthy histories of artisanal and small-scale activity were experiencing (large-scale) mining "booms". The list included Peru, Ghana, Chile, Indonesia, Tanzania, and the Philippines.[9] This has impacted efforts to formalize ASM in these, and other, developing countries that have opened their economies to multinational (mining companies). Specifically, prioritization of the latter, which has netted host governments hundreds of millions of dollars in revenue through ground rents, permit fees, income tax and royalties, has resulted in prolonged neglect of the needs of the former.[10] This has also led to ASM's confinement to the informal economy, where it has expanded rapidly but is unmonitored and unregulated.

Understanding how, exactly, this has come about goes a long way toward explaining why ASM has such a poor Occupational Health and Safety record.

3. How has the confinement of ASM to the informal economy come about?

The Occupational Health and Safety record of ASM has attracted significant media attention. Not a day goes by without a newspaper or news program drawing attention to an accident or incident at a site. Recent examples include "Kenya's mining pit collapses, traps 12",[11] "At least 23 dead after open-pit gold mine collapses in Venezuela";[12] and "Toxic, deadly, cheap: Life for women gold miners in the Philippines".[13] What continues to be overlooked, however, is the connection between these, and interrelated, Occupational Health and Safety challenges in the ASM sector on the one hand, and its persistent informality on the other hand. Failure to do so risks failing to identify the root causes of the mounting Occupational Health and Safety crisis in the ASM sector – i.e., the absence of regulation and monitoring due to its confinement of operations to the informal economy – and putting forward band-aid solutions. It also risks putting into motion inappropriate strategies such as bans on ASM and ushering in inappropriate programs aimed at putting those engaged in the sector into "alternative livelihoods" (which end up not being anything of the sort).

A deepened understanding of this connection would confirm that a questionable Occupational Health and Safety record is one of many manifestations or "expressions" of ASM's informality. Davidson (inadvertently) weighed in on many of these "expressions," noting that:

> *As a migratory and transient activity for many, it has historically been highly disorganized, difficult to monitor, characterized by inefficient mining and processing practices, and a part of the informal economy. Its ad hoc nature has resulted in a myriad of secondary problems including loss of mineral resource; local environmental degradation; unsafe and harsh working conditions; temporary, often wretched living conditions; economic exploitation of mineworkers by unscrupulous financiers, mine operators and law enforcement officers; and eve de facto dispossession of existing communities and aboriginal groups.*[14]

When ASM's Occupational Health and Safety concerns are examined alongside the "myriad of secondary problems" identified in the above passage, the case for more effective formalization of the sector – which would, at least theoretically, lead to more effective monitoring and regulation of activities – can be made more convincingly. What evidence is there in support of the claim that "For the most part, small-scale mining has been benignly neglected or simply ignored"[15] by host governments and donors?

The first sign was the passing of legislation and launching of projects that "treated small-scale mining as a subset of large, formal mining."[16] This would spawn regulatory environments and institutional setups that have proved inappropriate for ASM which prospective licensees struggle to work under or simply ignore. In Colombia, for example, records reveal that in a single month (July 2013), 39 percent of the 8125 requests for formalization were rejected for not following the correct (formalization) procedures developed based on Law 1320 of 2010 and Decree 933 of 2013.[17] Another example is Tanzania, where, following passage of the Mining Act of 1998, both a Primary Prospecting Licences and Primary Mining Licences were established for Tanzanians looking to conduct small-scale mining. It was soon realized, however, that the former was superfluous, given that ASM has a far shorter lifecycle than that of large-scale mining. It was therefore abolished following implementation of the revised 2010 Mining Act.[18] In Brazil, it has simply been a case of artisanal operators ignoring environmental permits, a procedure typically associated with large-scale mining. For instance, it was reported that in 2010 that 99.3 percent of licensed artisanal miners operating in the Amazonian region of the country were ignoring Law 97.507/89 and were not in possession of the proper environmental permits.[19]

A second – and interrelated – sign was the design and implementation of licensing schemes for ASM that were simply inappropriate and, in many instances, more suitable for multinational companies. For example, in Peru, it has long been a case of the application procedure being problematic – specifically, it being highly-bureaucratic. In 2010, for example, it was reported that ASM in the country was regulated by 21 different pieces of legislation and that in order to formalize an operation, individuals had to complete 22 steps.[20] In several African countries, in addition to the bureaucracy of the application procedure, the costs of securing a license has been identified as a major deterrent to formalizing ASM activities. Examples of where this has happened include Ghana, where the costs of securing a Small-Scale Mining License can run into the thousands of dollars;[21] Zimbabwe, where, as Spiegel reports, during a period of "crackdown" on riverbed gold panning, activities were "subjected to ever-more-costly, bureaucratic and inaccessible national licensing requirements";[22] and the Central African Republic, where artisanal miners struggle to purchase an annual license (patente) at a fee of US$100, as well as with paying a host of additional taxes, royalties and rents.[23]

A final sign is the failure to put aside the mineralized terrain needed to support licensed ASM activities. Prioritization of large-scale mine development has led to vast areas coming under the control of companies; the story is the same in all corners of the developing world. For example, in the Philippines, a leading producer of gold, nickel and copper, an estimated one fifth of land is covered by mining and mineral exploration permits.[24] The figure supplied a decade and a half ago for Peru, a major gold, copper and lithium producer, is slightly less at 11 percent (33,963 active mining claims that cover 13,997 km^2).[25] The situation was far more serious in Colombia at around this time, however, where by late-2009, an estimated 60 percent of land was under concession to mining and mineral exploration companies or had applications pending, a direct consequence of an increase in titled hectares earmarked for this purpose rising from 1.1 million hectares in 2001 to 8.4 million hectares in 2008.[26] The data available for mineral-rich sections of sub-Saharan Africa are of equal concern, a list that includes Zambia (45.8 percent), Liberia (17.71 percent), Malawi (22 percent) and Côte d'Ivoire (16.28 percent).[27]

Why is this such a concern for ASM? It is not necessarily artisanal and small-scale operators competing for the same mineralized terrain but rather more of a case of them being deprived legal access to the areas containing the orebodies they covet because they have been inclluded as concessions given to companies. It has long been known that certain mineralized areas – particularly those containing an abundance of alluvial and shallow hardrock deposits – cannot by worked profitably by companies, with their capital-intensive extraction methods but can be by artisanal and small-scale means. Simply put, as Noetstaller pointed out four decades ago, "small mines permit the extraction of numerous, otherwise unexploitable small mineral deposits."[28] Why, then, do host governments continue to parcel them out as part of large-scale mining and mineral exploration concessions? Moreover, why, in the few instances where a path to legalization exists for ASM, are the same governments making it so challenging to secure licenses and permits by imposing exorbitant fees and making applications processes so bureaucratic?

With their eyes fixed on developing large-scale mining, they have failed to expend the energy and resources needed to lay the bedrock for a formalized artisanal and small-scale (mining) sector). The impact of this neglect has been catastrophic: confinement of ASM to the informal economy, where it has expanded unabated. Unregulated and unmonitored, and populated by people who, without security of tenure and constantly evading the authorities, few – unsurprisingly – invest the time and finance required to make sites safer and more hygienic.

The key takeaway from this section of the report is that context matters. Specifically, when advancing understanding of the Occupational Health and Safety record of ASM and identifying solutions to pressing problems in this area, it is imperative to take into how policy has confined its operators to the informal economy and in the process, shaped their unique development trajectory. What the analysis that follows reinforces, therefore, is the imperativeness of promoting ASM formalization strategies capable of having more of an impact in these political environments. This is a key to tackling the sector's pressing Occupational Health and Safety concerns more effectively.

4. Occupational Health and Safety Concerns in ASM: First Sightings

4.1 Origins?

There was little mentioning of any Occupational Health and Safety concerns in Small-Scale Mining in the Developing Countries.[29] They were, however, raised for perhaps the first time in an international policymaking setting at The Future of Small Scale Mining First International Conference, Jurica (Mexico), 26 November – 5 December 1978. Carman was quite critical at the conference, reporting that "there is almost always total disregard of laws concerning health and safety [in ASM]."[30]The author continued by reflecting on personal experiences to capture how unsafe sites were at the time:

> *I can very vividly remember my first descent into a mine in Chile shortly after joining the United Nations. The shaft was vertical and over 200 metres deep. The "cage" consisted of a piece of hard rubber about the size and shape of a bicycle tire which was connected to a small hoist of about 1890 vintage by a quarter inch steel wire rope red with rust. In places where safety procedures are enforced, a quarter inch cable can be used only for hoisting materials and replacement is so frequent that there is no chance for us to form. En passant, it should be mentioned that the rope described above broke about two weeks later, dropping two men to their death...In effect, Too often life is cheaper than equipment. To properly equip even a small shaft will cost thousands. To dispose of a body, less than $100 will be required. And if the bad air leads to silicosis and in the end it always does, when the miner's usefulness becomes impaired, he will simply be let go and there will be no consideration given to compensation.*[31]

The author paints a very morbid picture of ASM but cannot be accused of failing to associated the conditions described with the sector's informality because his piece was published at a time prior to World Bank and IMF intervention in mineral-rich economies en masse. Needless to say, it was also before any meaningful discussion had emerged on formalization of ASM. With the benefit of hindsight, the details shared by Carman were certainly grounds for a least debating the idea of implementing regulations for ASM and supporting the sector more innovatively. It was, after all, a time when the ILO was becoming more visible, pressuring member states to adopt more effective regulations in Occupational Health and Safety at the workplace.

Todradze[32] was one of the first scholars to survey developments on this front in the mining sector. The author spoke of the "three phases of development" in this area up to this point, namely: 1) a period lasting through the 1950s, when governments sought to facilitate basic changes in certain working conditions that were deemed threats to employees; 2) a subsequent period during which there was an the intensification of efforts to mitigate serious occupational hazards of a predominantly mechanical nature; and 3) a period beginning in the 1980s in more industrialized nations emphasising preventative measures. On mining specifically, the author highlighted hazards facing workers such as dust exposure and silicosis, arguing that "Factors that have up to the present time been regarded as inherent in the mining environment are beginning to be regarded as occupational hazards."[33]

Officials at the ILO deserve credit for focusing the discussion on ASM. They correctly pointed out that "Living and working conditions in a small mine are totally different from those of a large-scale operation." The latter "will be highly capitalized, making use of the most modern technology and machinery, under the control of sophisticated organisation and administration, and supported by a well-developed infrastructure which includes, apart from the technical resource is, unorganized settlement and community development with modern communications and facilities." Conversely, at a small mine, they further explain, "the picture is generally the reverse, and the operator of such a mind as well as the miners can seldom benefit from these advantages".[34] They focus heavily on underground mining in their assessment, singling out deaths and injuries brought about by machinery (falls of ground, from haulage and tramming, slips and falls); explosions, floods and fires; poisonous air and dust inhalation; and disease linked to intensive work in unsanitary conditions such as ankylostomiasis (hookworm), bursitis and cellulitis.

Whilst ILO officials called on governments to amend regulations accordingly, most of the recommendations tabled were prescriptive. The discussion on Occupational Health and Safety in ASM specifically did not resume until the late-1980s, following publication of Noetstaller's landmark report.[35] Echoing the views of ILO officials a decade prior, the author acknowledged that "There is a significant difference in safety performance between large and small mines with the former having the better record". It was further explained, in the case of the latter, there was evidence at the time from developing countries "that often even the most basic industrial hygiene principles and safety practices are ignored, causing extremely unfavorable and hazardous working conditions for the persons engaged in mining." The author also weighed in on the issue of accidents, reporting that they are mostly due to inadequate support and transport facilities, as well as health, which, it was argued, are attributed to a lack of sanitation, ventilation, light and dust control.[36] The rationale for highlighting these concerns was made very clear: that "Both from a humanitarian and an economic point of view, the consequences of poor health and safety practices are unacceptable" and that simply put, "a minimum standard of health and safety measures has to be provided in all mines, regardless of size".[37] There were several other papers published at around this time that highlighted Occupational Health and Safety concerns in ASM but most offered little more than descriptive reference to the litany of problems identified countless times previously: the rock falls, pit cave-ins, poor hygiene leading to disease, and machine-induced injuries.[38]

The ILO has maintained a consistent position on mining throughout. Since first raising awareness of Occupational Health and Safety concerns in the sector in the late-1970s, the organization has been at the forefront of efforts aimed at transforming the work environment in the mining sector. Its landmark C176 Safety and Health in Mines Convention, 1995 (No. 176) is a culmination of a fusing of ideas enshrined in preexisting conventions (Box 1), along with additional text that emerged from engagements and negotiations with governments across the world on mining-related matters. Since implementation of C176, the position of ILO officials mining has remained fairly fixed: that it is mostly associated with "hazardous work".[39] Ironically, and quite unexpectedly, an area where there has been some pushback from the organization is ASM, which the ILO Fourth World Day Against Child Labour, A Load too Heavy: Child labour in mining and quarrying (12 June 2005)[40] and the dialogue it has spawned, has, at times, obfuscated.

Box 1: Major ILO Conventions that informed the design of C176 Safety and Health in Mines Convention, 1995 (No. 176)[41]

The Hours of Work (Coal Mines) Convention, 1931

The Abolition of Forced Labour Convention, 1957

The Radiation Protection Convention and Recommendation, 1960

The Guarding of Machinery Convention and Recommendation, 1963

The Employment Injury Benefits Convention and Recommendation, 1964

The Minimum Age (Underground Work) Convention and Recommendation, 1965

The Medical Examination of Young Persons (Underground Work) Convention, 1965

The Working Environment (Air Pollution, Noise and Vibration) Convention and Recommendation, 1977

The Occupational Safety and Health Convention and Recommendation, 1981

The Occupational Health Services Convention and Recommendation, 1985

The Asbestos Convention and Recommendation, 1986

The Safety and Health in Construction Convention and Recommendation, 1988

The Chemicals Convention and Recommendation, 1990

The Prevention of Major Industrial Accidents Convention and Recommendation, 1993

Particularly noteworthy are the – at times, forgotten – important messages conveyed in the organization's seminal report, Social and Labour Issues in Small-Scale Mining;[42] most are still relevant today. It very importantly put spotlight on a number of the key livelihoods issues in ASM – which are today, at the heart of most discussions aimed at building a case for formalizing and supporting the sector – for the first time. These include ASM being an important source of livelihood, its links with agriculture and it is making sizable contributions to national mineral production and exports in many countries. But most importantly, Social and Labour Issues in Small-Scale Mining made the connection between the sector's persistent informality, a lack of regulation and problems at sites such as a poor health and safety record:

> *Assistance to small-scale miners should demonstrate that, without unduly constraining their activities, there might be a better way – better in terms of health and wealth, better for the land, and better for the country. Unless small-scale miners can be convinced there will be immediate tangible benefits from doing things differently, there is little point in continuing down the same old path. The way forward is to bring small-scale mining into the formal sector without stifling entrepreneurial zeal but at the same time improving the lot of the 13 million or so who work in small-scale mining and the much large number – 80-100 million – who depend on it for some or all of their livelihood. If this can be achieved, small-scale mining will be a success.*[43]

The statement above could be read as ASM's confinement to the informal economy has transformed it into what it has become today, specifically a sector characterized by unsafe and unhygienic working conditions.

The important takeaway here is that whilst the ILO has since been a major critic of working conditions at sites, when putting forward assessments of ASM's Occupational Health and Safety record, its officials have rarely lost sight of the sector's economic importance. The first significant study it commissioned explored child labour in ASM, focusing on the cases of Niger, Peru, and the Philippines. Of the three, only in Niger[44]was work carried out in ASM communities that were not producing gold. One of these communities was Tounouga, where 200 families (3000 people, including 1620 child workers below the age of 18) mining salt deposits were interviewed. They were observed to "face all hazards, and in a more serious fashion, not just because of their weaker bodies but also because there are more children than adults involved in the extraction phase, where they breath in the dust and their skin becomes dried and cracked, especially during cold periods".[45] A trona mining site comprised of 120 families with 600 workers, including 360 children under 18, was also visited in Birni Ngaouré, Boboye Region. It was observed here that people work with "their back bent with a hoe in hand, for 8-10 hours a day", they "are also exposed to the vagaries of the weather, with its seasonal variations of great cold from November to February and great heat from April to June, and its daily variations of cold from 8 am to 10 am and heat from 11 am", and that "The dust produced by scraping the ground also irritates the eyes, nose, throat and lung".[46]

The author attributed these underwhelming conditions to a lack of regulatory oversight. The conclusion drawn from findings gathered in Tounouga was that "There are no legal provisions or regulations dealing specifically with safety and health aspects of salt mining or with the prevention of child labour in this sector", and therefore, "As with the majority of activities in the informal sector, salt workers have neither group nor individual protective equipment".[47] Similarly, in Birni Ngaouré, the author explains, "As in the country's other informal sectors, there are no initial or periodic medical examinations; neither is there any social security cover". As a result, here, when an accident or illness occurs, typically, "the patient is not moved to the medical centre, but returns home to his or her family to recover, either by resting or by undergoing traditional treatment practices."[48]

The details shared from Niger are a testament to how committed the ILO has been to providing nuanced assessments of Occupational Health and Safety in ASM. In Social and Labour Issues in Small-Scale Mining,[49] an attempt was made to collect and share data gathered from ILO member countries on ASM-related accidents. Officials did so because they recognized that "Small-scale mining has a poor reputation for safety, but there is little data to support or rebut claims that it is inherently unsafe with high levels of fatal and disabling accidents." But they also recognized that in this sector, "problems relating to occupational health are more serious and pervasive, touching all who work in and around small-scale mining and processing operations, and their families".[50] It was against this background that they identified the following "five major health risks in small-scale mining and processing", informed by answers to a questionnaire supplied to ILO member countries:

1). Exposure to dust (silicosis).

2). Effects of noise and vibration.

3). Effects of poor ventilation (heat, humidity, lack of oxygen).

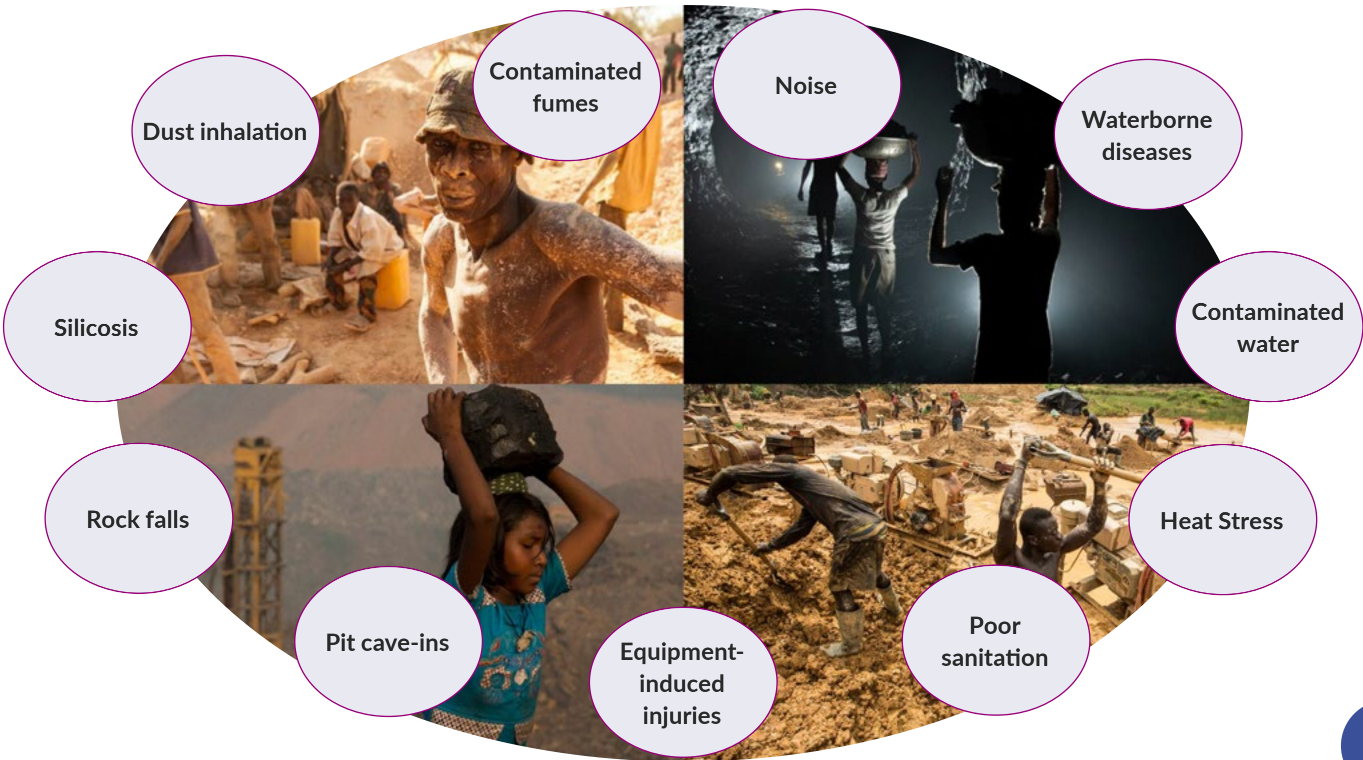
4). Effects of over-exertion, inadequate workspace, and inappropriate equipment; and

5). Exposure to mercury and other chemicals.

It is the latter, however, that has dominated the Occupational Health and Safety agenda of ASM for four decades. Before explaining how, it worth noting that the ILO later produced a report, Safety & health in small-scale surface mines: A handbook,[51] intended as a guide for those working in near-surface ASM operations. It not only frames the discussion on Occupational Health and Safety in ASM using language in C176 and further highlights individual hazards but also prescribes a series of priority guidelines for ASM operations located at the surface. It emphasizes the "Duties of the mine operator" and outlines the following steps that should be followed to make sites safer work environments: 1) eliminating the risk, 2) controlling the risk at the source; 3) minimizing the risk; and 4) using personal protective equipment. Ironically, however, in failing to refer to informality either implicitly or explicitly, ILO officials stray slightly off course the very discussion on informality they themselves have shaped. The point in need of clarification, therefore, is that whilst relevant to all ASM activities, Safety & health in small-scale surface mines: A handbook is likely only to be consumed as a resource by individuals in possession of a license – specifically those who have security of tenure and are therefore in a position to even consider following guidelines such as those outlined above.

Nevertheless, the document provides a timely summary of the main Occupational Health and Safety Concerns in ASM, which are mapped in Figure 1 and are reviewed more extensively in Section 5. The report now turns briefly to the mercury pollution problem in ASM, which, because of its pervasiveness, has long been the focal point of the Occupational Health and Safety agenda in the sector but as a direct consequence, has heavily overshadowed other pressing concerns.

Figure 1: Depiction of Occupational Health and Safety Concerns in ASM



4.2 Brazil on the Mind

No assessment of Occupational Health and Safety in ASM would be complete without some reference to mercury pollution. Mercury has featured in gold mining for over 3000 years, coveted for its simplicity and effectiveness. It is used to extract gold from ore as a stable amalgam, which is then heated to isolate it by evaporating the mercury.[52] In addition to airborne releases, the inorganic mercury used in mining is typically dispensed, once used, into the natural environment. Here, this inorganic mercury bioaccumulates and methylates, which poses serious threats to human health and wildlife. These impacts have been extensively reviewed over the years: in methylated form (MeHg), mercury disperses throughout the blood stream, targeting the central nervous system, its contamination manifesting as coordination problems, hearing and vision impairment, numbness in toes and fingers, convulsions and even death.[53] The concern with ASM is that it accounts for an estimated 37 percent of global anthropogenic emissions of mercury, by far the largest share (of global emissions).[54]

Despite there being effective measures available to reduce and minimize emissions of mercury from ASM, there has been an incessant preoccupation with banning its use, despite there being no viable substitutes. This continues through to the present, as evidenced by the behaviours of signatories to the Minamata Convention on Mercury, "a global treaty to protect human health and the environment from the adverse effects of mercury" that came into effect in 2013.[55] Whilst governments that have ratified the convention that have a sizable artisanal and small-scale gold mining and processing sector within their territory are mandated to "take steps to reduce, and where feasible eliminate, the use of mercury and mercury compounds in, and the emissions and releases to the environment of mercury from, such mining and processing",[56] most (governments) have interpreted this to mean commitment to an outright ban (on mercury use) in ASM. This includes countries in which there are no alternatives to mercury.

Why does the mercury pollution problem continue to dominate so many dialogues on ASM and is always the focal point of discussions on its sector's Occupational Health and Safety dimension? The view here is that the context in which it first came to the attention of the international public and media outlets is responsible for this: specifically, the garimpeiro gold rushes in the Brazilian Amazon in the 1980s and 1990s. As this mining was taking place at a time when destruction of the Amazon rainforest was the most talked about environmental issue in the international press, the damage it has caused has left a permanent scar on the world's conscience. In addition to defacing sizable patches of rainforest, the millions of gold miners converging on to pristine sections of the Amazon rainforest were responsible for the release of at least 2000 tonnes of mercury into the environment.[57] Because of the time and the place (bearing in mind that preservation of the Amazonian rainforest was such a topical issue at the time that it influenced the choice of the Earth Summitt being cited in Rio), the story of the garimpeiros and the impacts they have had on the environment would capture the imagination of policymakers, NGOs and scholars for decades. Sightings of marauding garimpeiro spawned a number of environmental studies in the 1980s and 1990s,[58] a body of work that offers a glimpse of the severity of the mercury pollution problem attributable to the ASM activities embedded here at the time. Studies confirmed that MeHg concentrations in the soils,[59] waterbodies[60] and air[61] surrounding sites, as well as miners and residents of local communities (confirmed using blood, urine, and hair samples),[62] are persistently high.

The garimpeiro gold rushes in 1980s and 1990s Brazil influenced the international policymaking and research communities in two quite diverse ways. First, much like Brazil, the bulk of the earliest ASM research conducted elsewhere also focused on mercury contamination and little else. Work mirroring the Brazilian studies would be carried out in countries such as the Philippines,[63] Zimbabwe,[64] Tanzania[65] and Suriname,[66] each drawing similar conclusions. The body of work provided to be enough of an impetus for the United Nations to launch the US$13 million Global Mercury Project (GMP), which, focusing on the five gold-rich countries of Brazil, Sudan, Zimbabwe, Indonesia, and Lao, aimed to:

a). Reduce mercury pollution of international waters by emissions emanating from small-scale gold mining.

b). Introduce cleaner technologies for gold extraction and to train people in their application.

c). To develop capacity and regulatory mechanisms that will enable the sector to minimize mercury pollution.

d). To introduce environmental and health monitoring programmes.

e). To build capacity of local laboratories to assess the extent and impact of mercury pollution.[67]

There was also a significant amount of work that would showcase the "livelihoods" dimension of ASM at this time,[68] including numerous studies carried out under the auspices of the GMP.[69] The problem, however, is that the valuable work that showcases the socioeconomic importance of ASM – even in a persistently informal state – that has emerged in abundance over the past three decades is routinely overshadowed by coverage of the mercury pollution problem in the sector (See Box 2 on the following page for more information on mercury use in ASM).

How attributable this is to the documentation and images of the garimpeiro gold rushes of the late-1980s and early-1990s has rarely been stated explicitly but they have, to some degree, been responsible for the tepid response of policymakers, worldwide, toward formalizing and supporting ASM. Specifically, an impression left by the garimpeiros is that all ASM is rush-type activity, populated by individuals who are looking to "get-rich quick," which is clearly not the case. In fact, it is now widely accepted that most people who choose to engage in ASM worldwide do so to escape poverty or more broadly, because there are few, if any, alternative sources of employment. The failure of host governments to recognize this sooner rather than later has led to the outcomes shared in Section 3 of this report and more pointedly, has heavily compromised their ability to formalize ASM.

This has clearly contributed to discussions on the mercury pollution problem lingering in ASM policymaking circles and on the extractive industries agendas of donors. When it seemed like the garimpeiro gold rushes would finally take a back seat to the "livelihoods" dimension of ASM in the early-2000s, the mercury pollution problem was once again thrusted into the spotlight because of the GMP; shortly after the GMP began winding down in 2007 and 2008, interest in mercury pollution in ASM once again galvanized, this time on the back of the build-up to the launch of the Minamata Convention on Mercury (i.e., in 2013); and interest has continued to intensify since the launch of planetGOLD, a US$350 million multi-country program that "works in partnership with governments, the private sector, and ASGM communities to significantly improve the production practices and work environment of artisanal and small-scale miners",[76] Phase I of which commenced in 2018.

Moving forward, in reviewing more closely the body of work that covers Occupational Health and Safety concerns in ASM that have consistently been overshadowed by coverage of the mercury pollution problem in the sector, persistent informality – and the absence of regulation and monitoring of operations it is associated with – cannot be ignored. Even the architects of the Minamata Convention on Mercury recognize the importance of formalization, as evidenced by the requirement that ratifying countries outline "Steps to facilitate the formalization or regulation of the artisanal and small-scale gold mining sector" in their National Action Plans.[77] Formalization of the ASM sector, officials at the United Nations further maintain, "is seen by many as a pre-condition for the effective reduction and control of mercury use, since it can facilitate organization, education, access to assistance, and the regulation of gold and mercury trade".[78]

In framing the work on ASM's other Occupational Health and Safety concerns in Section 5, therefore, it is instructive that the informality of the sector be considered and to recognize how, with more effective regulation and monitoring, many of these problems could be addressed comprehensively.

Box 2: A spotlight on mercury uses in ASM.

It has been conservatively estimated that at least 20 million people in more than 70 countries engage directly in artisanal and small-scale gold mining. The sector's operations, most of which are unregulated and unmonitored, account for the release of at least 2000 tonnes of mercury annually, with notable contributions from activities in China at 200-250 tonnes/ annum, Indonesia at 100-150 tonnes/annum, and Brazil, Bolivia, Colombia, Peru, Philippines, Venezuela and Zimbabwe, each at 10-30 tonnes/annum. Mercury has featured in gold mining for more than 3000 years and continues to have appeal because of its effectiveness, wide availability, and relative inexpensiveness.[70]

Mercury is the only metal that is in liquid form at room temperature and is therefore commonly referred to as "quicksilver." When applied to gold-aggregated particles, an amalgam is produced, which is subsequently burned, typically in the open air without using protective equipment such as gloves and masks (Plate 1). This heating, along with the application of nitric acid, yields pure gold. The resulting emissions, along with the mercury that vaporizes from tailings, settles, methylates and bioaccumulates to toxic levels.

Overexposure to methylmercury is linked to a number of health-related ailments, including vision impairment, neurological damage, kidney disorder and physical deformity.[71] There is certainly a legacy of mercury pollution from ASM, dating back to the colonial period, that many countries are still dealing with and which has been used by host governments and donors to rationalize a search for alternatives. Nriagu captured the scale of this impact, reporting, inter alia, that annual loss of mercury in the silver mines of Spanish America was in the range of 612 tonnes/year; how importation of mercury into the United States between 1850 and 1900 averaged 1360 tonnes annually, 90 percent of which was employed in gold and silver mining; and how cumulative losses of mercury up to the colonial period in the Americas were in the range of 257,000 tonnes.[72]

Throughout the 1990s and 2000s, to combat the mercury pollution problem, donors worked with host governments to implement a series of clean technologies such as shaking tables, magnetic sluice boxes and centrifuges, and retorts, which are devices that allow amalgam to be burned safely (within an enclosed system) without emitting mercury vapour in the air.[73] Their poor uptake, however, has not been due to a lack of effectiveness but rather the failure of governments and donors to create supply chains and marketing channels required for their effective distribution.[74]

Under the GMP, emphasis was placed on educating miners about the health-related impacts of mercury and showcasing these technologies as potential means for reducing emission levels. A combination of unrealistic expectations on the part of donors and host governments (i.e. donors expecting miners to adopt new technologies following a single demonstration and/or workshop) and the absence of a coordinated approach across countries outside of those on the GMP's list led to an abandonment of this approach. Donors and governments would pivot to a more preventative approach, culminating in the launch of the Minamata Convention on Mercury in 2013. The convention entered into force in 2017 and at the time of writing, there were 128 signatories.

Countries that have ratified the convention are required to produce a National Action Plan, in which they must detail their plans for reducing emissions of mercury and, where possible, how its use can be eradicated entirely. Many ratifying countries, however, have (mis)interpreted ratification as meaning a push to ban mercury use altogether, which has spawned draconian measures (military-led sweeps of communities, penalties and imprisonment) to facilitate eradication.[75] Its effectiveness as a policy tool for not only eradicating mercury use in ASM and ushering in substitutes but also mainstreaming the sector remains very unclear.

Plate 1: *Miners burning mercury amalgam without protective equipment is a common sight.*

5. Occupational Health and Safety Concerns in ASM: A Review

It is worth noting that and building on claims made by ILO officials over two decades ago on the (un) availability of information, an acute shortage of site-level data on Occupational Health and Safety concerns has made design and implementation of effective educational strategies in this area challenging. Whilst there has since been a flood of studies published that explore various Occupational Health and Safety concerns in the sector, few make the crucial link between work conditions at sites and the policy treatment of operations. Whereas the growing documentation of underwhelming health and safety records at sites, and the dangers they pose to those working there, should provide renewed impetus to devise more creative strategies to formalize operations, this information is doing precisely the opposite. Moving forward, the responsibility lies with scholars to make the crucial connection between the poor working conditions of sites on the one hand, and persistent informality and a lack of regulation on the other hand. Once this link is articulated more clearly, host governments can be engaged to make the policy and institutional changes needed to facilitate more effective formalization of ASM.

There have been a number of broad assessments of Occupational Health and Safety in ASM but do little more than describe conditions at sites.[79] A comprehensive review of the literature conducted by Cossa et al., however, goes a long way toward pinpointing works that use quantitative data to underscore the severity of various Occupational Health and Safety concerns in ASM. The authors identified 2764 "hits" which, after further screening, were narrowed to 176 health studies for final analysis.[80] The authors, however, did not separate those focusing on mercury from others; most (i.e. 155), therefore, unsurprisingly focus on the health-related impacts of extracting gold on a small scale. This section of the report reviews the major works produced to date that zoom in on the key Occupational Health and Safety concerns in ASM that do not focus on mercury. It reinforces, throughout, the idea that informality has exacerbated (and incubated) these problems.

5.1 Dust Exposure

A sizable body of work on dust exposure in ASM has emerged over the years. The messages conveyed in this body of literature have been consistent from the beginning, and most recently echoed in Mumba et al.'s[81] work in Mererani, Northern Tanzania, the location of the only tanzanite deposit in the world. Here, dust samples were collected using an Analytical Air Monitoring System (AMS) and analyzed using Inductively Coupled Plasma Optical Emission Spectroscope, which revealed that miners were inhaling up to 1859 mg of dust over an 8-hour period in drilling zones, 797 mg in loading zones and 382 mg in resting zones. The important conclusion drawn from these obvious concerns was that "Skin conditions like dermatitis and eye irritation further underscore health hazards miners face, and "the critical need for effective dust control and regular health monitoring in the industry." This is happening, the authors further explain, "Due to a lack of effective regulation and management, especially in artisanal and small-scale mining," because of which, "environmental pollution has increased dramatically and has become a major ecological problem." Echoing points raised earlier, formalization, which always ushers in more effective regulation, monitoring, and auditing of activities, and should force operators to update their operations, would position host governments – at least theoretically – to tackle the dust pollution problem at sites more effectively.

The key takeaway with dust pollution and respiratory diseases, however, is that not much has changed over the past three decades, despite experts raising similar concerns and making near-identical recommendations over this period. This includes the same areas visited repeatedly. For example, over two decades ago, researchers drew the same conclusions following visits to Mererani. They confirmed that the median crystalline silica and combustible contents of the respirable dust samples were 14.2 and 5.5 percent, respectively, and that when drilling, blasting and shovelling were undertaken, exposure measurements showed high median levels of respirable dust at 15.5 mg/m^3, respirable crystalline silica at 2.4 mg/m^3, respirable combustible dust at 1.5 mg/m^3 and "total" dust at 28.4 mg/m^3. The conclusion reached was that workers have left themselves exposed to these hazards, and risk developing chronic silicosis, in large part because of an absence of personal protective equipment.[82]

Most of the work published on the respiratory-related ailments linked to ASM focus on tuberculosis and silicosis. All reveal that those working at sites are susceptible to long-term illness due to exposure to dust. Most of these studies were conducted in sub-Saharan Africa, which again, speaks to concerns raised by ILO officials about there being a need for more data on Occupational Health and Safety in ASM. This is important in the case of dust exposure because there is reason to believe that overall, ASM sites in sub-Saharan Africa are less mechanized than those in Latin America and Asia. If this is the case, the chances of miners using personal protective equipment or at least consider using it are likely to be higher.

The studies that are available have been conducted across a number of countries in sub-Saharan Africa, including Tanzania, Ghana and Zimbabwe. Some report findings from screenings of miners for disease,[83] whilst others weigh in on the scale of the problem by surveying hospital admissions data.[84]Howlett et al. have modelled the data available on tuberculosis and silica exposure at ASM sites.[85] Although the data are still in short supply, there are enough available to paint a fairly worrying picture about dust exposure and its health-related consequences at ASM sites worldwide.

5.2 Other Occupational Health and Safety Risks

The data available on other Occupational Health and Safety risks in ASM are even more scarce. Based on a review of the literature, outside of the work carried out on mercury contamination linked to gold extraction, most of the studies conducted in this area fall into the following three broad categories: 1) Risk Management; 2) More Comprehensive Assessments of Health and Safety; and 3) Water Contamination and Disease. The pieces that fall into the first category range from the purely prescriptive to work that utilizes data gathered with the goal of providing a glimpse of the level of awareness of health and safety at sites. In the case of the former, there are works such as Rupprecht,[86] who identifies some of the basic risks observed in surface artisanal mining operations in South Africa, and provides recommendations to prevent major accidents and fatalities; a survey of 110 miners working in the Asutifi North District of the Ahafo Region of Ghana that revealed that Occupational Health and Safety Systems were non-existent;[87] work by Stemn et al. that examined publicly-available information on ASM accidents/fatalities in Ghana;[88] and studies that demonstrate that where there is appreciable level of health and safety concerns among mining populations, there is a greater chance of personal protective equipment being used.[89]

There are a handful of studies that fall into the second category; most have also been carried out in sub-Saharan Africa. Some of these studies, it would seem, were commissioned with the intention of pinpointing additional Occupational Health and Safety concerns. The work of Rose and Allen-Spies,[90] for example, revealed that artisanal diamond miners working across seven sites in Kimberley, South Africa, were exposed to a range of occupational hazards, including physical (ultraviolet radiation exposure, injuries due to trauma), respiratory (silica dust exposure), biomechanical (heavy lifting, repetitive movement) and psychological (work-related stress, anxiety) hazards. They also confirmed that there was a shortage of personal protective equipment at sites. An equally-comprehensive assessment was carried out in the Ruashi small-scale copper/cobalt mine in DR Congo by Elenge and De Brouwer.[91] The authors identify a series of risks resulting from poor hygiene and site conditions across the "workplaces" they identify at sites, namely the locations of diggers, crushers, furnace workers and loaders. In addition to dust inhalation, these risks include injury from rock collapse, suffocation underground, dehydration and problems linked to trauma. One of the more engaging studies that falls into the category of "More Comprehensive Assessments of Health and Safety" was undertaken by Trima et al. reflected on the impact of remediation efforts at ASM sites (27,000 m^3 total area) in Zamfara State, Northern Nigeria. Although mining for gold, the authors investigated efforts made to remediate an area where villagers had died and others were being treated due to lead poisoning linked to tailings contamination.[92] Alongside these health-based assessments, there are equally-rich analyses of safety at ASM sites, each of which explores major dangers and injury rates at sites.[93]

On the final category there is a sizable collection of studies – conducted across the globe – which examine water contamination and sanitation concerns at ASM sites. They all draw similar conclusions: that sanitation in ASM communities is poor, and that the quality of potable water is under threat, which has implications for human health.[94] There are also several studies that investigate incidences of malaria in ASM communities, the spread of which is fuelled by the proliferation of stagnant waterbodies that provide breeding grounds for infected mosquitoes. These studies have also been conducted in all corners of the developing world, a significant percentage in artisanal and small-scale gold mining communities.[95]

Each of these studies is informative, sharing details about various Occupational Health and Safety concerns at ASM sites. Few, however, make the connection with informality, although occasionally there is a reference made to a lack of regulation. In summary, this body of work struggles to "locate" these problems, nor offer tangible solutions to addressing them through regulation and policy. Moving forward, the connection between informality in the ASM sector and the poor health and safety records of the workplaces where activities take place must be highlighted in research for there to be any chance of legal frameworks and policies to be overhauled. In most countries with sizable ASM economies, regulations governing the Occupational aspects of the sector are ignored in broader formalization strategies, are not particularly comprehensive, fall under broader legal frameworks or are absent altogether (Table 1).

Table 1: Occupational Health and Safety regulations relevant to ASM in selected countries

Country	Law/Regulation and Year	Explanation
Ghana	Minerals and Mining Act, 2006 (Act 703) + Minerals Commission Regulations	Provides a licensing regime for ASM and requires environmental protection, safety measures, and training of miners.
Tanzania	Mining Act, 2010 (Amended 2017)	Sets provisions for small-scale mining licenses and mandates environmental and safety compliance, including use of protective gear and safer technologies.
DR Congo	Mining Code, 2002 (Revised 2018)	Legalizes small-scale mining zones (ZEAs), mandates occupational health and safety standards, and prohibits child labour.
Zimbabwe	Mines and Minerals Act [Chapter 21:05] (1961, with updates)	Regulates safety measures, including mine inspections, worker protections, and penalties for unsafe practices in small-scale operations.
Peru	Law 27651 - Formalization and Promotion of Small-Scale Mining (2002)	Sets conditions for formalizing ASM activities and includes environmental and occupational health and safety obligations.
Indonesia	Law No. 4/2009 on Mineral and Coal Mining + GR No. 96/2021	Requires miners to comply with occupational safety, use personal protective equipment, and carry out reclamation, with health and safety plans submitted during licensing.
Mongolia	Minerals Law, 2006 (Amended 2014); ASM Regulations (2010)	Formalizes ASM and mandates adherence to occupational health and safety guidelines, including use of mercury-reduction technologies.
Colombia	Decree 933 of 2013 + Law 685 of 2001 (Mining Code)	Supports the formalization of ASM and includes mandatory occupational safety, health assessments, and environmental impact management.
Uganda	Mining and Minerals Act, 2022	Provides a legal framework for the formalization of ASM activities, emphasizing health and safety standards, environmental protection, and community development.
Brazil	Normas Reguladoras de Mineração (NRM) – Regulatory Standards for Mining	Establishes mandatory health and safety guidelines for all mining operations, including ASM, focusing on risk management, worker safety training, and environmental conservation.

6. The Case Studies

This section of the report reviews developments in the four case study countries: 1) Brazil, 2) Colombia, 3) Uganda and 4) Zimbabwe. Various aspects of the ASM sector rooted in each have been examined quite extensively in the literature, albeit for varied reasons. Of the four, however, the ASM sectors in Brazil and Zimbabwe have been examined most extensively and showcased much longer in the literature. As explained in Section 5, the ASM sector in the former attracted international headlines in the 1980s during the heyday of the garimpeiro gold rushes. They were responsible for removing sizable sections of the Amazonian rainforest and depositing significant quantities of mercury into the surrounding environment. The latter is one of few countries in sub-Saharan Africa to have proactively engaged with ASM with the goal of facilitating formalization of, and providing technical assistance to, the sector's operations. This cycle began in the early-1990s.[96]

Colombia also has a lengthy history of ASM formalization, illuminated by efforts initiated in the 2000s to launch "Fairtrade Gold" (now "Fairmined Gold" after a brief period as "Fairtrade and Fairmined Gold"). Those spearheading the effort have done so in an environment where there has been a "conflation of ASM with informality and criminality", specifically and the strong association of artisanal and small-scale gold mining in the country with the financing of rebel groups.[97] Coverage of ASM in Uganda is comparatively sparse and of what does exist, most of the focus is on gold.

This section of the report reviews key works produced on ASM in Brazil, Colombia, Uganda, and Zimbabwe. The aim is to provide, for each country, a flavour of where the focus of research has been to date whilst simultaneously presenting key details about ASM, including information about laws and regulations, commodities being extracted and formalization. These cases are framed in ways that set the stage for the fieldwork being planned in each country.

6.1 Brazil

Estimated ASM Population Size:	1,000,000
Key Locations of ASM Activities:	Pará, Minas Gerais and Goiás states
Minerals traditionally mined on an artisanal and small scale:	Gold, diamonds, emeralds, granite
Main ASM sector:	Gold and coloured gemstones
Emerging ASM sector(s):	Lithium and niobium

In the twentieth century, the gold frontier moved to the Amazon. It was ignited by the discovery of gold in Serra Pelada, Southern Para State, in 1979. An individual rancher had discovered gold on his property and soon constructed a landing strip and began parcelling out claims to garimpeiros. The area would host as many as 100,000 garimpeiros and traders at its peak in 1983, a mass in-migration fuelled by television programs and newspapers which depicted the area as a location where people could get rich overnight.[98]

Why is recounting historical events so important in the case of Brazil? The short answer is that it continues to suffer from the aftershocks of this gold rush, specifically, a legacy of mercury pollution. As most gold in the Amazon occurs in alluvial settings, "quicksilver" has been used with great effectiveness here, capturing fine particles.[99] Whilst today, garimpeiro activities are nowhere close to being as concentrated as they once were, local communities continue to suffer immensely from the contamination left behind by the rushes of 30-40 years ago. Moreover, although Brazil only accounts for 2-3 percent of global gold production,[100] mercury is still used indiscriminately throughout the Amazon. The subject continues to capture the attention of environmental health experts throughout the Brazilian states of Amazonas, Roraima, Mato Grosso and Pará.

A considerable amount of work has been carried out in the Tapajós Basin (as the Tapajós River runs through the Amazon Rainforest), where studies have confirmed that there are still elevated concentrations of mercury in a variety of environmental media (soils, water plants, etc.) and in humans (deduced from samples of urine, blood and hair).[101] Some of the more concerning reports come from the Yanomami Indigenous Territory, where it is claimed that garimpeiro activity has defaced the lands and contaminated the waters that the indigenous groups found here depend on for their survival. There are also studies that reveal that there are elevated concentrations of mercury in the water being consumed here, as a result of contaminated mining waste, and high concentrations of malaria brought by the mosquitos heavily concentrated around idle ponds and dammed sections of rivers linked to gaimpeiro activity.[102] Research has revealed that the mercury used at ASM sites throughout the Amazon Basin is being smuggled in through Bolivia.[103] Scholars have confirmed that conditions at garimpeiro sites are substandard, a result of low levels of education, unstable payments and poor hygiene in surrounding communities.[104]

Importantly, and consistent with the messages preached in this review, researchers have done an excellent job in recent years of "locating" these dynamics within debates on informality in country's ASM sector. The ASM activities now entrenched in the Brazilian Amazon exhibit what is perhaps best described as "organized informality".[105] In the Tapajós Region, for example, the organizational dynamics of ASM on display are attributable to ""the absence of the state, the illegality and informality of mining operations, the remote and rural area, and the organizational structure".[106] The root causes of this can be traced back to the ambiguities in Brazilian law, which, despite claims that may suggest otherwise, allows for the purchase and usage of mercury under certain conditions. The use of mercury in ASM remains widespread throughout the country. Monitoring of its distribution has become more difficult since 2015 when the government rescinded a strict regulation implemented in 1989 that required small-scale miners to register mercury recovery facilities.[107] This helps to explain why, between 2019 and 2020, of the estimated 174 tons of gold produced in Brazil, the origins of two-thirds was of unknown, illegal or potentially-illegal origin. Moreover, as most originated from garimpeiro-controlled sites, it is safe to assume that production accounted for the release of 150 to 195 tons of mercury.[108]

These ambiguities extend to where small-scale gold mining activity can take place. As Swartz et al.[109] explain, garimpo activity is prohibited in various sections of the rainforest, such as the territory that comprises Reservas Indígenas and Parque National. Outside of these areas, however, gold mining is allowed with a permit, the securing of which entails registering at the national mining office (Agência Nacional de Mineração) and filing an environmental impact assessment (licenciamento ambiental) issued by the federal states. The problem is that the process is costly and beyond the financial means of most garimpeiros. De Theije confirms that this has been the case in Mato Grosso State where, in 2017, the added requirement for archaeological reports led to delay 80 licenses being renewed because it increased the costs for doing so to US$18,000.[110] With costs and bureaucracy being such formidable barriers to securing a Licença de Garimpo (PLG) from the National Mining Agency (ANM), gaimpeiros have elected to secure a prospecting license (pesquisa mineral com lavra experimental) for a limited time, which is then used (illegally) to mine gold.[111] This is disconcerting because the area of Brazil covered by garimpo mining has increased fivefold between 1985 and 2022, from 218 km^2 to 2627 km^2, more than 91 percent and 77 percent of which, respectively, was concentrated in the Amazon and showed explicit signs of illegality.[112]

The crucial link made by scholars between informality and the conditions of garimpo sites bodes well for future diagnoses of Occupational Health and Safety in the Brazilian ASM sector. This applies to locations rich in gold as well as other minerals. It is important to note, too, that Brazil has had a clear ASM formalization strategy from the outset, however ineffective it may have been. It was established following implementation of the Federal Constitution (1988), in which it is stressed that the state prioritizes the organization of garimpeiros into cooperatives; moreover, in 1989, the government established the PLG.[113] On a positive note, whilst the costs and bureaucracy have proved discouraging for garimpeiros, the data show that they have not dissuaded individuals from organizing themselves into cooperatives with the aim of securing a PLG.Whereas in 1990s, there were only three PLG requests, by 2020, there were 636 (PLG) requests by 54 cooperatives, and by the end of 2021, there were 254 cooperatives with a combined 3375 mining titles.[114] These cooperatives have significant influence over ASM, and are seen as potential vehicles to facilitate changes in the practices of diggers.[115]

Outside of gold, there have been a handful of studies that examine Occupational Health and Safety concerns in other segments of country's ASM sector,[116] which is exceptionally diverse.[117] Moving forward, these, along with future work that seeks to uncover details about garimpo sites, must do a better job of "locating" findings in debates on the informality of ASM in Brazil. The country does not have explicit Occupational Health and Safety standards in place to regulate ASM. Further, the legislation that is in place is not geared toward preventing pollution or minimizing safety risks at sites.[118] More effective routes to formalization, therefore, could lead to improved work conditions throughout the Brazilian ASM sector.

6.2 Colombia

Estimated ASM Population Size:	300,000
Key Locations of ASM Activities:	Departments of Antioquia, Chocó, and Boyacá
Minerals traditionally mined on an artisanal and small scale:	Gold and coloured gemstones (particularly emeralds), coal and construction minerals
Emerging ASM sector(s):	Lithium and platinum

Like Brazil, in Colombia, much of the focus on Occupational Health and Safety in ASM is on mercury. This is unsurprising as Colombia is the world's largest mercury polluter per capita, accounting for the release of between 50 and 100 tonnes each year; most of these emissions originate from ASM.[119] There have been a handful of studies carried out over the years which, similar to those conducted in Brazil, confirm that ASM is responsible for significant releases of mercury and has contaminated soils, water, plant matter and local populations.[120]

A collection of other studies has been carried out that point to there being poor health and safety conditions in other segments of Colombia's ASM sector. The situation in the country's small-scale coal mining sector is likely be spotlighted over the next two decades given the plan hatched by the government to phase it out (i.e., coal) by 2040.[121] At present, approximately 10 percent of Colombian coal originates from small and medium-scale mines.[122] If the study carried out by Rey et al.[123] is any indication, there is a strong association between exposure to carbon dust and pneumoconiosis in Colombia's underground small-scale coal mines that warrants immediate attention. Colombia's platinum, a commodity which is on the "critical minerals" lists of most countries, could also become a focus moving forward, given the chemical used (chlorine and ammonium chloride) to purify the metal.

Most of the work carried out on ASM in Colombia focuses on its economic importance. The sector has played an important economic role in Colombian society for centuries;[124] today is no different. For example, small and medium-scale coal mines provide an estimated 100,000 jobs in the Cundinamarca, Boyacá, Norte de Santander, Santander, and Antioquia departments. This is due in large part because there are few alternative job opportunities in the areas where small and medium-scale coal mining activities are found.[125] There are also several informative studies that have been undertaken that provide a glimpse of the socioeconomic importance of small-scale gold mining and small-scale platinum mining in departments such as Chocó.[126]

Importantly, scholars who have studied the Colombia case closely have brought to light the extent to which the government has confined ASM to the informal economy. The Ministry of Mines and Energy has only formalized seven percent of total registered mining units in the country;[127] only 13 percent of national gold production comes from the formal sector; and although a National Development Plan was conceived in 2019 that included an agenda to formalize 40 percent of ASM by the end of the year, only 2 percent of operating gold mines had received titles.[128] It appears that policymakers simply cannot move on from the past in a country where as Kauffman and Côte (2021) explain, "the conflation of ASM with informality, and informality with criminality still stands".[129] Perhaps it has been the inability of policymakers to disassociate the two[130] that has resulted in them failing to address complaints about the bureaucracy of the licensing application process for small-scale mining and the costs that must be paid for permits. Nevertheless, there is broad consensus that these factors are discouraging individuals from securing licenses.[131]

In the context of Occupational Health and Safety, the persistent informality of ASM in Colombia will impede efforts to address, comprehensively, conditions at sites.

6.3 Uganda

Estimated ASM Population Size:	300,000
Key Locations of ASM Activities:	Kigezi Region, Karamoja Region, Eastern Uganda (Busia District) and Central Uganda (Kitumbi)
Minerals traditionally mined on an artisanal and small scale:	Gold, tin, copper, and development minerals.
Emerging ASM sector(s):	Cobalt, tungsten, and niobium

Of the four country case studies, it is Uganda where ASM has been examined the least by scholars. There is a small body of literature that highlights its economic importance in the country. Of the estimated 300,000 people employed directly in ASM in the country, half are women. This includes approximately 40,000 jobs in (artisanal) gold mining and 93,000 jobs in clay and clay brick production. The sector overall, however, touches the lives of an estimated five million Ugandans, as expenditures of ASM revenues in local economies have been projected to catalyze an additional 750,000 indirect jobs. The sector's poverty-driven nature has been observed (i.e., how unskilled people have been able to gain employment at sites straightforwardly), as has how most revenues it generates are spent within the communities and districts where minerals are produced. These contributions are collectively sizable: clay brick production and gold production in Karamoja alone have been, respectively, estimated to inject US$500 million and over US$15 million into local economies annually. What is also noteworthy is that close to 90 percent of most development minerals, including stone, aggregates, sand, clay, lime, gypsum, and kaolin, are produced by the country's small-scale miners.[132]

By comparison, work on the Occupational Health and Safety dimension of ASM in Uganda is thin. Like Brazil and Colombia, most of the work published in this area focuses on the health-related impacts of mercury use at small-scale gold mines in the likes of Ibanda (Western Region), Mubende (Central Region), Amudat (Karamoja Region) and Busia (Eastern Region). These studies also make use of environmental media and human hair, urine and blood samples, analysis of which reveals that the settings in which ASM takes place are contaminated with mercury.[133] Aside from mercury pollution, some of the major health concerns identified by those working at ASM sites in Uganda were diarrhoea, skin illness, and injuries, all of which are the attributable to poor working conditions. Moreover, health workers have voiced concerns about municipalities that are the locations of significant ASM activities, such as Ibanda District, having health systems that are ill-equipped to deal with ailments.134

As with Brazil and Colombia, most ASM activities in Uganda are found in the informal economy. In the 2000s, fewer than 5 percent of people operating in the sector were working in permitted areas, despite the introduction of location licenses and inclusion of provisions of ASM in the Mineral Policy of Uganda, 2001.[135] Barreto et al. list the main reasons why this is the case:

- The provisions for extension services and support for fair market access referenced in the Mineral Policy of Uganda are not coordinated by the relevant government authority, namely the Directorate of the Geological Survey and Mines, nor linked to local government programs and financed from their budgets.
- Many artisanal and small-scale miners having little knowledge of the legislation governing the sector.
- There being significant costs for, and bureaucratic barriers to obtaining a location licence, namely annual fees, reporting requirements and payment of taxes (including royalty payments).
- The amount of land available for ASM activity decreasing, the result of the area allocated to large-scale exploration companies having increased. In some instances, the location license only covers 16 ha, which would mean that an operator would require many to operate viably.

A more recent assessment of ASM in Uganda suggests that it is simply a case of legislation not having kept pace with developments in the sector. Despite the Mining and Minerals Act of 2022 having addressed some of these concerns, applicants are still discouraged by the costs and bureaucracy associated with applying for a location license; there being a lack the geological knowledge and maps to make informed decisions and ultimately, the data on mineralization that could be used for collateralizing lending; and there being few formal channels to sell extracted ores.[136]

One key takeaway from the literature on ASM in Uganda is that the sector's persistent informality makes women's health and safety a priority concern. Whilst the percentage of women drawn to ASM sites in Uganda for employment (again, roughly 50 percent) mirrors that of many other countries, there has been considerable attention – more so than elsewhere – paid to their work conditions (in Uganda).[137] The details shared may also not be unique to Uganda but are rich and offer a fresh angle for building a case for more effective ASM formalization strategy. The main concern is the type of work women carry out at ASM sites across Uganda – typically menial jobs such as waste picking, washing, and hauling – which Jackline observes has significant implications for human health. In addition to explaining how "Given the fact that most ASM is largely unregulated and illegal, many miners remain largely unsensitized", the author reports that "Women involved in reworking tailings may simultaneously be exposed to multiple pollutants, individuals reliant on fish in mercury impacted areas are equally at risk".[138] This is problematic because, as Buss et al. explain, in Uganda (and surrounding countries such as DR Congo and Rwanda), interventions made to formalize ASM that pay insufficient attention to gender inequality are likely to entrench women's exclusion from mining roles and bodies.[139]

6.4 Zimbabwe

Estimated ASM Population Size:	300,000
Key Locations of ASM Activities:	Mazowe (Mashonaland Central), Kenzamba (Mashonaland West), Shurugwi, Kadoma, and Runde Rural District
Minerals traditionally mined on an artisanal and small scale:	Gold and diamonds.
Emerging ASM sector(s):	Chromite, lithium, and platinum

The dynamics of ASM in Zimbabwe have been examined extensively in the literature, more so than most countries. It was one of the first countries in sub-Saharan Africa to legalize the sector in 1991, following implementation of the Mining (Alluvial Gold) (Public Streams) Regulations,[140] and for nearly 10 years, it worked in tandem with Ghana, sharing ideas on how to formalize and support ASM. This coordinated approach was facilitated by common funders, particularly, GTZ and DFID.

The work of Oliver Maponga, then a researcher at the University of Zimbabwe, and John Hollaway, a Harare-based mining consultant, in the 1990s and early-2000s was instrumental in keeping the world abreast of developments at ASM sites in Zimbabwe.[141] At the time, Zimbabwe was praised for the institutional foundation it had laid for supporting and commitment to formalizing ASM. Highlights included the following:

1. The decentralization of the regulation and (in part) licensing of ASM activities, facilitated by establishing Rural District Councils.[142]

2. The construction of the Shamva Mining Centre (in Shamva District) in 1989 with finance supplied by GTZ and supplementary funds dispensed by the Intermediate Technology Development Group (ITDG), DFID and the EU. A centralized ore processing facility, the centre was constructed with the specific goal of encouraging miners to move their activities away from the local river, where they were using mercury to amalgamate gold and then discarded it.

3. The launch of the Riverbed Mining Project, funded by GTZ, in Insiza District in the town of Filabusi, along the Manyuchi and Insiza rivers.[143] Dubbed "the first of its kind worldwide" or at least "the first in Sub-Saharan Africa, and certainly in Zimbabwe", the project aimed "at transforming the individual, informal illegal activity of gold panning into a formal, legal activity in which rehabilitation of the riverbed and riverbanks is an integral part of the actual mining process rather than an activity following extraction of the metal".[144]

Judging by what is unfolding in Zimbabwe's ASM communities today, however, it would be challenging to convince even the most ardent of champions of the sector's formalization that the country was once considered a location of "best practice." The important groundwork laid for formalizing ASM in Zimbabwe would be rapidly eroded by a series of poor decisions (most of them politically charged), which the literature documents fairly well. A detailed understanding of these changes, and, the informal trajectory that the sector now finds itself on, helps to "locate" work that sheds light on the poor health and safety standards of sites.

Since the landmark GTZ-funded work, Zimbabwe's ASM sector has been increasingly pushed into the informal economy by policies which stifle its legalization. Miners routinely complain about the complexity of the bureaucracy and rigidity of the rules governing licensing and buying of minerals, which forces them to take drastic measures to ensure their survival. Even the rules around registering a claim, which is the first step in securing a license, are now exceedingly complex.[145] The two additional challenges prospective licensed small-scale miners face that typically force them to turn to the informal economy are 1) a costly EIA reporting requirement, which, in 2009, included a US$4000 fee paid to expert consultants in addition to a government (EIA) registration fee of US$1006[146] (these costs are now alleged to exceed US$10,000 in some instances);[147] and 2) the requirement that miners sell their gold to government-controlled Fidelity Printers and Refiners, despite it regularly paying well below the market price (for gold).[148] The government has only shown an interest in ASM when it has impacted its own bottom line, the most illustrative examples being when the-then Mugabe Government allegedly raided the Marange Diamond fields to secure stones to alleviate acute shortages of foreign exchange in the country,[149] and more recently, moves made to ban exports of lithium to curb artisanal (lithium) mining to pave way for Chinese and foreign companies to work mineralized terrain.[150] These developments have painted a negative picture of ASM in Zimbabwe, which has, very importantly, overshadowed its economic importance in the country. Scholars have discussed this at length over the years, including how the sector sustains subsistence agriculture, provides a lifeline for families looking to pay school fees, has stimulated economic diversification (specifically, spawning ancillary income-earning opportunities), and supported construction trades and local markets with a diverse range of products.[151]

Negative perceptions of the sector have also obfuscated how the poor working conditions reported at sites over the years are, like Brazil, Colombia, and Uganda, a result of the sector's persistent informality, fuelled by government policies and interventions. What, specifically, has this body of literature covered? Whilst capturing, illustratively, specific situations, it follows the same pattern elsewhere, focusing exclusively on gold and failing to connect poor practices to the lack of regulation and monitoring which informality is commonly associated with. There is a body of work which reflects on the human health effects of overexposure to mercury at artisanal and small-scale gold mines in the country.[152] There have also been a number of broad-based health and safety assessments of Zimbabwean small-scale mines conducted over the years, again, predominantly in gold-producing regions such as Mutasa District.[153] Finally, a considerable amount of work has been conducted in the country's ASM communities to ascertain the health implications of workers' exposure to dust. These studies draw similar conclusions to those conducted in other ASM communities worldwide: that exposure to silica-containing dust and limited access to healthcare poses a risk to tuberculosis and silicosis.[154]

The key moving forward in Zimbabwe is, much like in Brazil, Colombia, and Uganda, to make the connection between the sector's informality and poor health and safety conditions at sites. This would be a win-win moving forward, reshaping policy with the goal of facilitating formalization of the sector on the one hand, and catalyzing improvements at sites on the other hand.

7. Concluding Remarks

This report has reviewed the main Occupational Health and Safety concerns in ASM. In doing so, however, it has attempted to "locate" these problems in the broader economic and environment debate on the sector, specifically, its informality. The case made here is that these concerns should be viewed as manifestations of the sector's confinement to the informal economy, where operations flourish unmonitored and unregulated. If encouraged to formalize, those operating in the sector could be regulated and would no doubt be willing to comply with Occupational Health and Safety standards if doing so leads to improved access to technical support.

What, then, will encourage governments to pursue more imaginative and dynamic efforts to encourage ASM operators to legalize their operations? In the four case study countries of Brazil, Colombia, Uganda and Zimbabwe, a starting point would be steering Occupational Health and Safety research away from gold and more towards critical minerals, a sizeable percentage of which ASM operators in the four study countries and elsewhere extract. The list includes cobalt, the 3Ts, platinum, chromium, and lithium. With so many policy interventions globally focusing on NetZero and decarbonization, pivoting to ASM activities engaged in the extraction of critical minerals could go a long way toward building momentum toward new formalization strategies with the explicit goal of addressing Occupational Health and Safety concerns.

A second way of building interest in the Occupational Health and Safety dimension of ASM is to package concerns in the language of the Sustainable Development Goals (SDGs). This has the twofold impact of first, leading researchers who have hitherto siloed Occupational Health and Safety issues in the sector to think more holistically about the impact of operations, and second to (re)position the sector to be included in broader debates on issues such as poverty, livelihoods and climate change and, in the process, afford it the spotlight it has long deserved. Reframing issues in ASM in ways that speak to the SDGs have long been discussed, particularly among researchers carrying out work on the livelihoods dimension of the sector (notably, Goal 1: No Poverty, Goal 3: Good Health and Wellbeing; and Goal 5: Gender Equality). There is no reason the same cannot be done with Occupational Health and Safety concerns, which speak directly to Goal 3: Good Health Sanitation and Goal 6: Clean Water and Sanitation.

As indicated at the outset, the important takeaway moving forward in the context of the four case studies is that the poor health and safety record of ASM sector found in each country is a hallmark of its persistent informality, which regulations and policies are responsible for "creating." It is imperative, therefore, that Occupational Health and Safety assessments of ASM conducted in each are done so with this in mind.

Appendix 1: Estimated ASM employment figures in selected countries[155]

Country	*Estimated ASM pop.*	*Major minerals mined on an ASM*
Africa		
DR Congo	2,000,000	gold, diamond, 3T, cobalt, copper
Tanzania	1,500,000	gemstone, gold, diamond, salt
Sudan	1,400,000	gold
Ethiopia	1,260,000	gold, opal, tungsten
Ghana	1,200,000	gold, diamond, salt, sand
Zimbabwe	1,000,000	gold, gemstone, diamond
Burkina Faso	1,000,000	gold
Nigeria	1,000,000	gold, gemstones, tin, baryte
Madagascar	700,000	gold, gemstones
Mozambique	640,000	gold, gemstone, tantalite, clay, construction materials, coal
Niger	600,000	gold
Zambia	500,000	gemstone, 3T, copper, gold
Côte d'Ivoire	500,000	diamonds, gold
Mali	500,000	gold
Central African Republic	450,000	gold, diamond
Eritrea	400,000	gold
Guinea	350,000	gold, diamonds
Sierra Leone	350,000	gold, diamond, 3T, zircon
Uganda	300,000	gold, 3T, salt, clay, sand, stone
Chad	300,000	gold
Angola	250,000	gold, diamond
South Sudan	200,000	gold
Liberia	200,000	gold, diamonds
Kenya	140,000	gold, gemstone, soda ash, diatomite, gypsum, limestone, fluorite, construction materials
Morocco	100,000	lead, zinc, barite, gold, gemstone
Senegal	67,000	gold
Rwanda	65,000	3T, gold
Burundi	60,000	gold, 3T
Malawi	60,000	gold, gemstone

Cameroon	44,000	gold
South Africa	30,000	gold
Namibia	20,000	gemstone, diamond, gold
Togo	17,500	gold
Somalia	15,000	gold
Equatorial Guinea	15,000	gold
Botswana	15,000	gold
Benin	15,000	gold
Mauritania	10,000	gold
Algeria	7,000	gold
Libya	7,000	gold
Guinea Bissau	7,000	gold
Congo	5,000	gold
Gabon	5,000	gold
Somaliland Somalia	100	gold, tin, gemstones, kaolin, sepiolite
Lesotho	100	diamond
Swaziland	100	gold
Americas		
Brazil	850,000	gold, gemstone, diamond
Colombia	600,000	gold, gemstone, coal
Venezuela	300,000	gold
Bolivia	230,000	gold, tin, base metals
Ecuador	150,000	gold
Peru	100,000	gold
Chile	70,000	copper, gold
Mexico	56,000	gold
Suriname	35,000	gold, diamonds
Nicaragua	30,000	gold
Guyana	23,000	gold, diamond
Cuba	6,000	industrial minerals, salt
Argentina	6,000	gold
Dominican Republic	5,000	gold, amber, gemstone
Panama	5,000	gold
Haiti	4,500	gold? unknown
Honduras	3,000	gold
El Salvador	2,000	gold

Jamaica	1,500	gold? unknown
Costa Rica	1,200	gold
Dominica	200	unknown
Guatemala	100	gold
Paraguay	100	clay, gold
Canada	100	gold
Greenland	100	gemstone, ruby
United States	100	gold
Asia		
India	15,000,000	gemstones, diamonds, coal, gold, copper, chromite, manganese, iron ore, bauxite, granite, barite, mica, marble, limestone, sandstones, slate
China	9,000,000	gold, 3T, coal, gemstone, jade
Indonesia	3,600,000	gold, tin, coal, diamond, sandstone, sulphur
Myanmar	525,000	gemstone, gold, industrial minerals, tin, other metals, oil
Pakistan	515,000	coal, gemstone, gold
Philippines	400,000	gold
Sri Lanka	165,000	gemstone, gold
Nepal	120,000	construction materials
Afghanistan	80,000	gemstone, lapis lazuli, emerald, ruby, marble, gold, coal, chromite
Mongolia	70,000	gold, coal, fluorite, limestone
Vietnam	55,000	gemstone, gold
Lao PDR	41,000	gold, gemstone, base metals, tin, construction materials
Thailand	20,000	gemstone
Saudi Arabia	10,000	gold
Kyrgyzstan	6,000	gold, coal
Cambodia	6,000	gemstones, gold
Malaysia	4,600	gold, gemstone, tin
Kazakhstan	100	gold
Tajikistan	100	gold
Iran	100	base metals
Azerbaijan	100	gold
Georgia	100	gold
Türkiye	100	coal

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