University of Nottingham
Rights Lab

Blood Batteries

The human rights and environmental impacts of cobalt mining in the Democratic Republic of the Congo

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Contents

List of abbreviations

CDM	Congo Dongfang Mining
CHEMAF	Chemicals of Africa
CMBRD	Batoto ya Ruwe Mining Coopérative for Development
CMDS	Coopérative Minière pour le Développement et le Social
CMKK	Coopérative Minière du Katanga Kwa Kilimo
CMMK	Madini na Kilimo Mining Coopérative
CMOC	China Molybdenum Company
COMAKAT	Coopérative Minière Artisanale du Katanga
COMAKOL	Coopérative Minière Artisanale de Kolwezi
COMIAU	Coopérative Minière Artisanale Umoja
COMMUS	Compagnie Minière de Musonoïe Global SAS
EMAK	Exploitation Minière Artisanale au Katanga
FARDC	Forces Armées de la République Démocratique du Congo
GÉCAMINES	Générale des Carrières et des Mines
KCC	Kamoto Copper Company
MUMI	Mutanda Mining SARL
SAEMAPE	Service d'Assistance et d'Encadrement des Mines Artisanales et de Petit Echelle
SCMK	Société Coopérative Minière du Katanga
SICOMINES	Sino-Congolèse des Mines
TFM	Tenke-Fungurume Mining
UMHK	Union Minière du Haut-Katanga
ZEA	Zone d'Exploitation Artisanale

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All photos included in this report are by Siddharth Kara & AudioDean

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About the author

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British Academy Global Professorships

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A mining pit at the Shabara mine in Lualaba province, filled with more than 10,000 artisanal miners scrounging for cobalt

1. Executive summary

**"You want to know about cobalt? Cobalt is a curse.
It is killing Congolese people."**

- A mother of three who washes cobalt ore near Kolwezi, age 30

Cobalt is an essential component in the manufacture of most lithium-ion (L-ion) rechargeable batteries found in smartphones, tablets, laptops, and electric vehicles (EVs). The metal has therefore become indispensable to our gadget-driven lifestyle, as well as the "green transition" from fossil fuels toward (supposedly) cleaner energy sources. In 2024, 76% of the world's supply of cobalt[1] was mined in the southeastern provinces of the DRC: Haut-Katanga and Lualaba. The capital of Lualaba province, Kolwezi, has become ground zero for the devastating impacts the cobalt scramble is having on the people and environment of the DRC.

The violent conditions in which cobalt is mined in the DRC have received considerable attention in recent years, yet consumer-facing technology companies and EV manufacturers continue to promote their cobalt supply chains from the DRC as fully audited and compliant with international human rights norms and environmental sustainability practices. Foreign mining companies extracting cobalt from the Congo's mines typically promulgate similar talking points. The Congolese voices from the ground, however, tell a very different story.

This report aims to add to the growing body of research on cobalt mining in the DRC with new data on the human rights and environmental impacts of both industrial and artisanal mining operations. I hope that this new data will lead to more effective efforts to address the disheartening conditions uncovered during this project. Durable change, however, can only be achieved when the technology and EV giants perched atop the cobalt supply chain accept genuine responsibility for the people in the Congo who eke out a base existence digging for their cobalt in highly hazardous conditions.

The project includes three modes of enquiry: 1) a labour survey of artisanal miners, 2) water sampling and analysis in mining areas in and around Kolwezi, and 3) geospatial analysis of the environmental impact of industrial and artisanal mining operations around Kolwezi.

The labour survey was the most extensive aspect of the project. Research teams completed 1,431 surveys with artisanal and small-scale miners (ASM), of which 895 (62.5%) were in Lualaba province, and 536 (37.5%) were in Haut-Katanga province.

The summary findings of the labour surveys are included below (see section 8 for detail):

- 36.8% of respondents met the project's conservative criteria for forced labour
- 9.2% of respondents met the project's conservative criteria for child labour
- 6.5% of respondents met the criteria for debt bondage, and 4.4% met the criteria for human trafficking
- 87.8% of respondents began working as artisanal miners due to the lack of any alternative means of survival
- $3.28 was the average daily income, with heavy gender-based bias (males: $3.52; females: $1.84)
- Workdays were long, at roughly 9½ hours
- Implied hourly wages were $0.34 ($0.40 for males and $0.20 for females)
- 27.7% of respondents began working in artisanal mining as a minor
- Only 7.3% of respondents reported having a secondary source of income
- The average age of the respondents was about 25 years
- Self-reported literacy rates were 76.1%; however, functional literacy is much lower
- The average respondent only completed about 4 years of school
- Almost two-thirds of respondents reported a chronic illness or ailment, such as respiratory illnesses, skin diseases, gastrointestinal diseases, gynaecological issues, hernia, haemorrhoids, vision problems, back and neck pain/injuries, and broken bones
- More than half of respondents reported suffering threats and abuse in the workplace
- Roughly 70% of respondents would rather quit working as artisanal miners but were unable to do so, primarily due to the lack of any alternate means of survival
- Not a single respondent was a member of a trade union, as none exist
- Not a single respondent had a written agreement for their work

Overall, the data reveals that artisanal mining for cobalt is a very hazardous vocation undertaken for basic survival, involving long hours, subsistence wages, and severe health impacts. The data further reveals that within the surveyed respondents, there is a high rate of forced labour and an almost 10% rate of child labour.

It should be stressed that behind this data lies an enormity of human suffering that is impossible to quantify. Artisanal miners endure a pandemic of injury, toxic contamination, and death as they scramble to meet the world's feverish demand for cobalt. Countless artisanal miners, including children, are buried alive each year in *éboulements* (tunnel collapses) and *glissements de terrain* (landslides, or pit wall collapses).

Based on the data gathered, I estimate the total number of artisanal miners digging for cobalt in the DRC is roughly between 273,000 to 314,000 (see section 9 for detail). The data also reveals that a significant portion of artisanal miners surveyed work in conditions akin to modern-day slavery.

In addition to labour surveys, the researchers assessed the environmental impact of cobalt mining around the city of Kolwezi from 2009 to 2021 using Earth Observation (EO) and geospatial analysis. These techniques are highly effective at being able to identify both large-scale as well as artisanal mining sites in remote areas. They were also effective at quantifying the enormous loss of agricultural land and water bodies around Kolwezi due to mining expansion over time (see section 10 for detail).

Finally, the project included a case study of water sampling in and around the cobalt mining centre of Kolwezi, to assess concentrations of heavy metals caused by toxic dumping by mining companies. The results showed levels of heavy metals between 10 to 930 times the World Health Organization's recommended maximum. The communities that drink, wash, and fish in these waters are suffering a rash of negative health consequences as a result of the highly toxic water sources they are compelled to use (see section 11 for detail).

One final note – there is a powerful negative feedback loop relating to poverty, environmental degradation, and child labour in the Congo's mining sector. Penny wages for parents working as artisanal miners, exacerbated by the loss of alternate livelihoods from the destruction of arable land and contamination of water bodies, cause many families to remove children from school when they can no longer afford the fees of around $5 per month. These same children end up joining their parents in the scramble for cobalt to help the family survive.

The southeastern provinces of the DRC have become a zone of human sacrifice at the altar of our gadget-driven lifestyle. The Congo's environment has been desecrated to facilitate a greener future for the global north. This toxic dynamic is a direct result of the disregard by consumer-facing technology companies, EV companies, as well as downstream mining companies for the humanity of the Congolese people, facilitated by corruption and greed in the Congolese government.

As the truth of the Congo's cobalt mines continues to permeate a world that cannot function without the suffering of the Congolese people, I join my Congolese colleagues in expressing my earnest hopes that sustainable change will soon follow.

Children stack sacks of cobalt at an artisanal mine in Haut-Katanga province.

2. Overview of research

A. Ethics approval

Ethics approval for this project was granted by the School of Geography at the University of Nottingham, prior to any field research being conducted. The Principal Investigator was Siddharth Kara, Associate Professor at the Rights Lab, University of Nottingham.

B. Research objectives

Field research in the DRC took place between November 2021 and November 2023. The objectives for the project were to:

1. Gather data on the working conditions of the Congo's artisanal miners across Haut-Katanga and Lualaba provinces;
2. Determine the scale of forced labour, child labour, debt bondage, and human trafficking among these workers;
3. Provide estimates of the total number of artisanal cobalt miners in the DRC, as well as the scale of forced labour, child labour, debt bondage, and human trafficking among survey respondents;
4. Trace the supply chain from artisanal mining areas into the formal supply chain through a representative sample of "supply runs" from various mining areas;
5. Assess the environmental impacts of cobalt mining in the DRC through EO and water sample analysis.

C. Informed consent and distress protocols

A total of 20 field researchers conducted interviews with artisanal miners and members of mining communities. The field researchers were interviewed by Professors Kara and Mutombo to ensure suitability for the tasks they would undertake.

The field research involved interacting with potentially vulnerable groups, including children, individuals with cognitive impairment, mental health conditions, physical or sensory impairments, and previous life experiences (e.g., victims of abuse).

The local research teams followed distress protocols established by the Rights Lab for all human subject encounters. In all cases, researchers ensured that: participants fully understood the purpose of the study, were taken through the participant information and consent in detail, and were informed that their responses were anonymised. The researchers monitored all participants for any signs of discomfort or distress, and signposted them to further support from local NGO partner organisations. All participants received contact information for the local project team and were given the chance to withdraw from the research at any point, during the interview and afterwards, until the end of the fieldwork period. Consent and participant information forms were made available to all respondents in Swahili.

Following protocols approved by the ethics committee at the School of Geography, parental and/or legal guardian consent was obtained via a parental consent form for children under the age of 18. As many children active in cobalt mining do not have or are not in contact with parents or appropriate guardians, the researchers only interviewed children with parental consent and in their presence, or with the consent and in the presence of the staff at shelters for former child labourers. All children who were interviewed provided verbal assent to participate. All individuals who were photographed provided verbal assent to do so.

Local research teams consisted of male and female researchers with previous experience working in artisanal mining communities, and were thus familiar with the array of hazards faced by artisanal miners. The researchers included people who had conducted previous academic research with artisanal miners, or NGO workers who provided services in the communities. These past experiences helped attenuate the potential for harm during the interview process.

The PI conducted a two-day in-person training workshop in Lubumbashi with the research teams prior to the commencement of field research. The workshop detailed all ethics procedures required by the project and submitted to the University of Nottingham ethics process, as well as the importance of respecting and prioritising their own mental and physical wellbeing.

The PI and all field researchers established a network of safe and secure guest houses in which they stayed during the field research period spanning the areas of Haut-Katanga and Lualaba provinces. Many of these were trusted guest houses that had been used by the PI during previous research. The guest houses were located in the cities of Lubumbashi, Likasi, Fungurume, and Kolwezi.

All researchers were provided with local mobile phones and a local contact (Professor Auguste Mutombo) who managed their efforts during the fieldwork and ensured the security of the research data.

D. Sources of data

Data was collected through survey instruments[2] administered at mining sites, mining camps, and local mining communities in the cobalt provinces. Site selection was guided by local researchers and NGO partners, as well as experience from previous fieldwork by the PI in the region. At each site, researchers approached potential respondents to secure participation in the survey, yielding a total of N = 1,431 respondents.

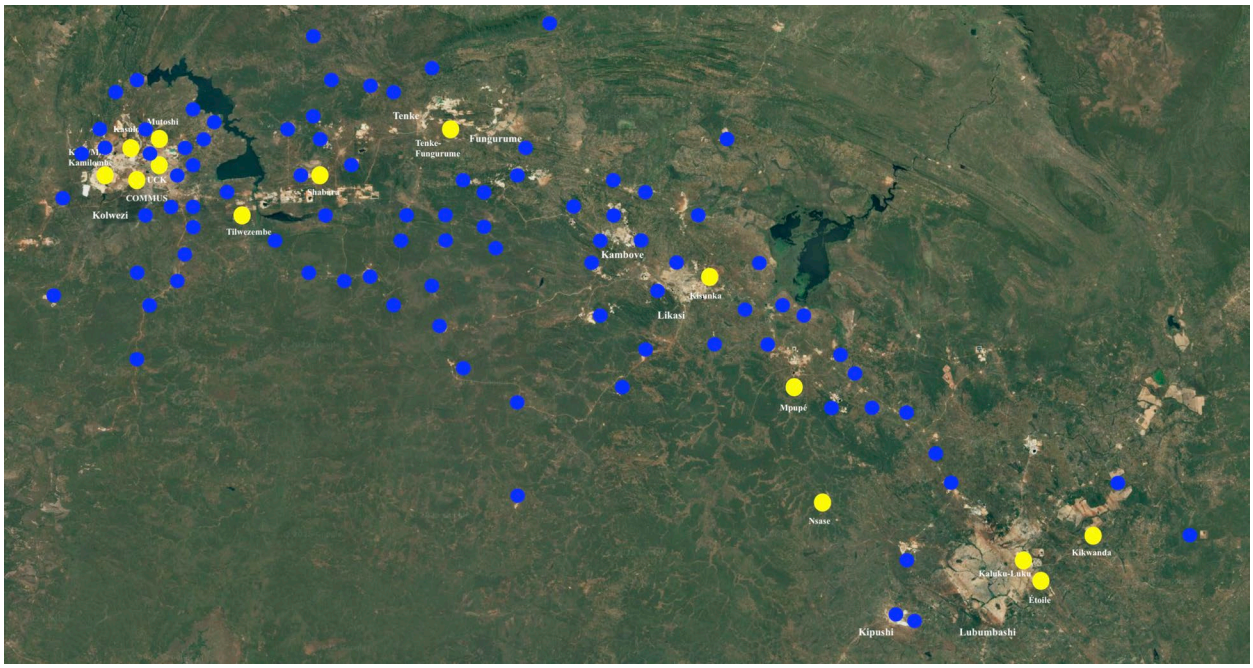
The major mining sites investigated included:

Lualaba province:	Haut-Katanga province:
Kasulo	Kisunka
Mutoshi	Nsase
KCC	Mpupé
Mashmba East	Kaluka-Luku
Kamilombe	Kikwanda
COMMUS	Étoile
UCK	
Shabara	
Tilwezembe	
Tenke-Fungurume	

In addition to these primary sites, 55 smaller artisanal mining areas were investigated in Lualaba province, and an additional 34 smaller sites in Haut-Katanga province. The research zone covered an area of roughly 160 miles by 50 miles across the provinces, which contained all major copper-cobalt mining concessions in the DRC, therefore providing strong representation of the relevant geography.

The location of the sites documented can be seen in Map 1, covering the southeastern corner of the DRC near the border with Zambia. Yellow circles mark the major sites, and blue circles mark the smaller mining areas where interviews were conducted.

Map 1: Labour survey site location



Water samples were gathered from rivers, lakes, streams, and wells in and around Kolwezi, overlapping with most of the major mining sites documented by the labour surveys.

Supply chain tracing involved the physical tracing of minerals from the point of excavation to a mineral processing facility or to the DRC-Zambia border. For instance, on one “supply run,” sacks of cobalt ore were tracked from an artisanal mining site to a wholesale marketplace (depot). The same sacks were then followed to mineral processing facilities in cities such as Kolwezi, Likasi, and Lubumbashi. Processed ore was in some cases followed from the processing facilities to the border crossing at Kipushi or Kasumbalesa. Tracing the flow of minerals in this manner helped tighten the links between the informal, artisanal mining sector and the formal supply chain. In all cases, the transport of minerals was documented using hand-written notes. Photographs were not taken to avoid suspicion and to reduce risk to the researchers.

E. Data management and GDPR

The handling of personal data always conformed to the requirements of the UK Data Protection Act 2018/GDPR. Data collection processes performed outside of the UK followed GDPR compliance. Interview data was recorded in French and Swahili (written paper copy) by the local research teams and transcribed into English.

Data was encrypted during interviews, transit, and storage. Data collected during fieldwork was transferred to the University of Nottingham at the first opportunity via the secure online data sharing service OneDrive. All files were stored on the University Research Data Filestore, which has failover support across two separate data centres, nightly incremental backups and weekly full backups to tape. Access to the service requires authorised credentials, is restricted by the institutional firewall, and is encrypted for sensitive data.

All environmental samples were transported and held in locked cold storage at the School of Public Health at the University of Lubumbashi. One professor only at the University had access to the samples for analysis. Upon completion of analysis, the samples were destroyed in a safe manner.

F. Difficulties encountered

There were a few difficulties encountered during the research. Shutdowns in road transport due to COVID outbreaks in 2022 hampered progress. Flare ups in political violence in 2023 leading up to the national elections that December also necessitated a pause in field work. Some mining areas also proved too dangerous to investigate.

3. The Democratic Republic of the Congo

A. National context

The DRC is the largest Sub-Saharan country in Africa, roughly equivalent to the size of Western Europe. By land area, it is the second-largest country in Africa (following Algeria), and the 11th largest globally. Its neighbouring countries are Angola, Zambia, Tanzania (across Lake Tanganyika), Burundi, Rwanda, Uganda, South Sudan, Central African Republic, and the Republic of the Congo. The national capital is Kinshasa, one of the world's mega-cities with a population of exceeding 20 million. The country is divided into 26 provinces, including the cobalt mining provinces of Haut-Katanga and Lualaba. Lubumbashi is the country's second largest city and capital of Haut-Katanga province. Kolwezi is the capital of Lualaba province.

Map 2: Map of the Democratic Republic of the Congo

The population of the DRC is approximately 115 million, rendering it the fourth most populous country in Africa and fifteenth in the world. The country has one of the fastest-growing populations worldwide, which places considerable pressure on infrastructure and the provision of social services.

There are more than two hundred ethnic groups living in the DRC, with more than two hundred languages spoken. Communication between groups is facilitated by four "national" languages: Swahili, Tshiluba (Kiluba), Lingala, and Kongo. French is the official language for business, instruction, administration, and international communications. Around 90% of the country is Christian. The remaining population follow Islam or traditional African religions.

The DRC possesses abundant natural resources, including approximately $24 trillion in untapped mineral deposits, vast oil and gas reserves, and the world's second-largest rainforest. Despite these natural resources, the World Bank estimates that the DRC is among the five poorest nations in the world.[3] In 2025, an estimated 74% of Congolese people lived on less than $2.15 per day. About 1-in-6 people living in extreme poverty in Sub-Saharan Africa lives in the DRC.[4] The Inequality-adjusted Human Development Index ranks the DRC 180 out of 193 countries.[5] The Global Peace Index categorises the DRC as one of the least peaceful countries in the world after Afghanistan, Yemen, Syria and South Sudan.[6] The DRC is also one of the world's hungriest countries, standing at 37.8 in the Global Hunger Index, described as "alarming."[7] Life expectancy is around 62 years. Sanitation rates are around 50% in urban areas and under 20% in rural areas.

The 2020 Human Capital Index by the World Bank Group ranked the DRC 164 out of 174 countries, reflecting decades of conflict and fragility that have constrained development.[8] Specifically, the DRC's Human Capital Index of 0.37 (below the Sub-Saharan average of 0.4) indicates that a Congolese child can expect to achieve only 37% of their potential, limited by, inter alia, poor education, gender-based violence, and insufficient health care systems.

According to the World Bank, the number of children enrolled in primary education increased from 11.9 million in 2010-2011 to 16.1 million in 2018-2019, reaching 21.3 million by 2023-2024. During the same period, secondary education enrolment doubled from 2.3 million (2010-2011) to 6 million (2018-2019) and then increased to 7.5 million (2023-2024).[9]

According to the UNESCO Institute of Statistics (UIS data), in 2021, completion rates for primary school were at 79% for girls and 86% for boys. Secondary education completion rates were lower, with only 51.4% of girls and 63.5% of boys.[10] The quality of education remains poor, with 97% of 10-year-olds being functionally illiterate.[11]

Women in the DRC face significant barriers to economic opportunities and empowerment, including discrimination and high rates of gender-based violence. More than half of women (52%) report having experienced physical violence, and almost a third have experienced sexual violence (27%), most commonly committed by their current partner.[12]

Health care systems have been greatly impacted by the country's prolonged conflicts and civil strife, along with the COVID-19 pandemic and recurrent disease outbreaks such as cholera, measles, and Ebola.[13] The country has one of the world's highest maternal mortality ratios at 547 deaths per 100,000 live births.[14]

B. A brief history of the DRC

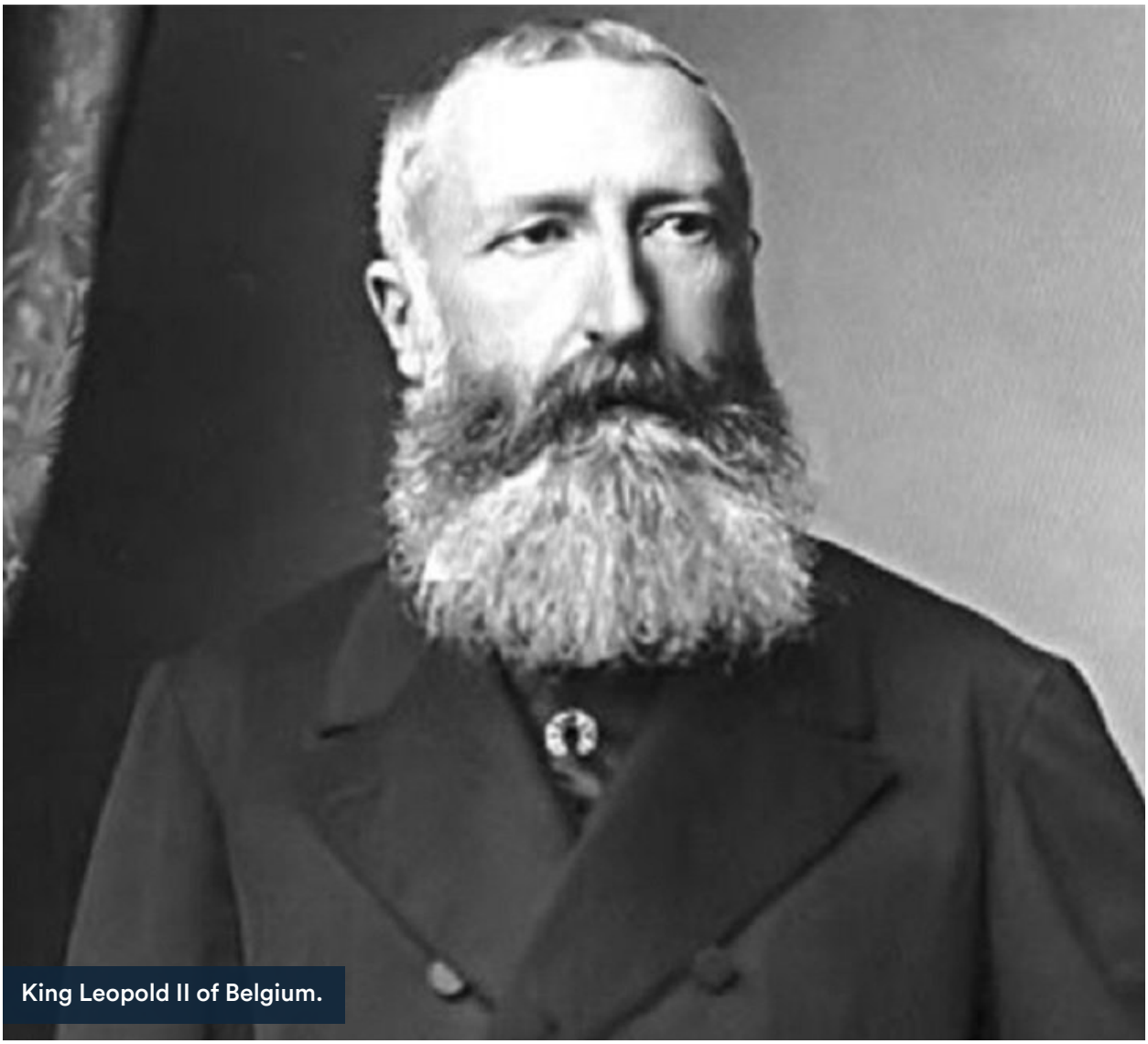
The history of the DRC is characterized by exploitation, colonisation, and conflict.[15]

Pre-colonial period

Before the arrival of European colonial powers, the territory that is now the DRC was home to a variety of indigenous groups and powerful kingdoms dating back several thousand years. Among the most prominent were the Kingdom of Kongo in the west, the Luba Kingdom in the south-central region, and the Lunda Kingdom to the southeast. These kingdoms had sophisticated systems of governance, trade networks, and cultural traditions. The Congo River played a central role in trade and communication between these kingdoms and neighbouring regions.

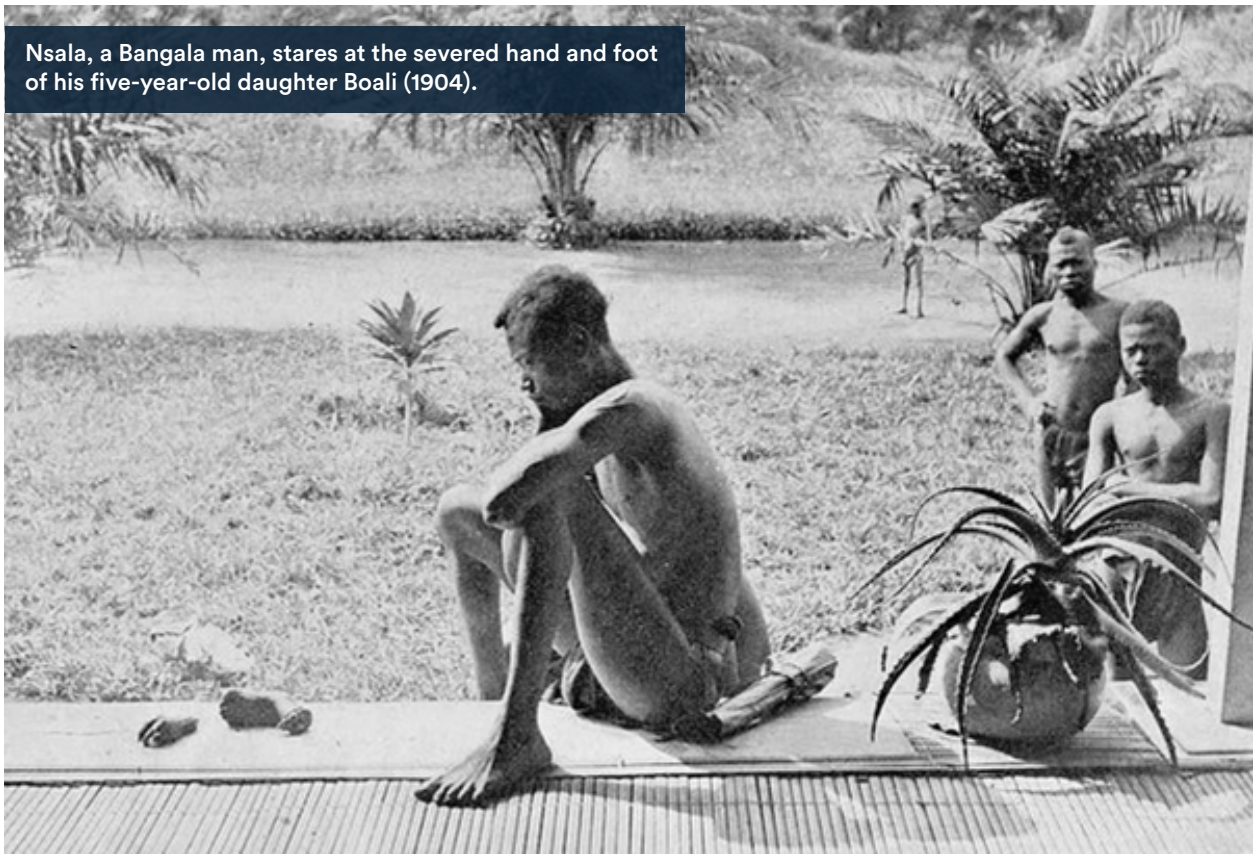
European exploration and the Congo Free State[16]

The Portuguese explorer, Diego Cão, was the first European to encounter the people of the Kongo Kingdom near the mouth of the Congo River in 1482. Slave-trading soon followed. During the Atlantic slave trade from the early 1500s to 1866, roughly one-fourth of all Africans trafficked across the Atlantic by Europeans departed from Loango Bay, near the mouth of the Congo River.



King Leopold II of Belgium.

Following the Berlin Conference in 1884-1885, under the ruse of humanitarian intentions, King Leopold II of Belgium formally acquired rights to the Congo basin as personal property and named it *Congo-Vrijstaat*, the Congo Free State. Leopold's rule in the Congo Free State is infamous for its brutality. Widespread atrocities were committed by Leopold's Force Publique, who used terror, torture, and slavery to compel the native population to extract rubber sap from the Congolese rainforest, which was exported to Europe to be used in rubber tyres for cars and bicycles. One particularly notorious form of punishment was to sever the hands and feet of the wives and children of men who failed to meet their rubber sap quota.



Nsala, a Bangala man, stares at the severed hand and foot of his five-year-old daughter Boali (1904).

The atrocities sparked international outrage. Roger Casement, E.D. Morel, George Washington Williams, and other human rights activists rallied the world to the cause, and Leopold was forced to sell his colony to the Belgian state in 1908. It was around this time that the minerals in an area called Katanga were first prospected by the Belgians.

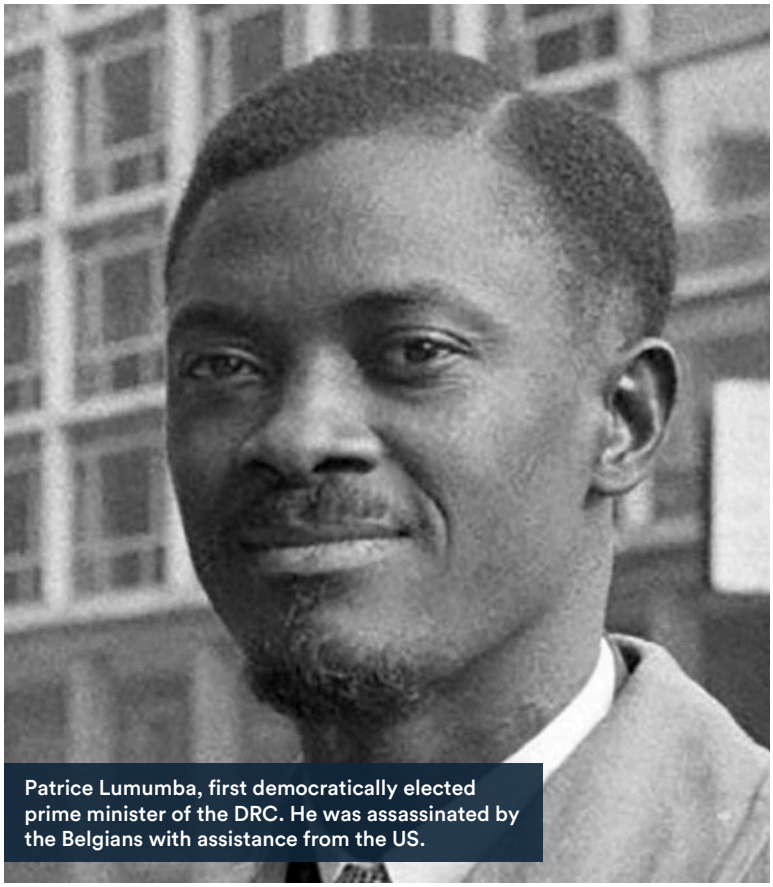
Belgian colonial rule (1908-1960)

Under Belgian rule, the Congo was officially known as the Belgian Congo. The Belgian Congo focused primarily on the exploitation of copper and other metals in the Katanga region, following the creation of the Upper Katanga Mining Union (Union Minière du Haut Katanga or UMHK). For 99 years, UMHK had a monopoly over thousands of square kilometres of mining territory in the southern province of Katanga. The Belgians used a harsh forced labour regime for mining in Katanga, which helped make the Belgian Congo the most profitable colony in Africa.

Thousands of Africans toiled in forced labour conditions for UMHK to mine copper for the Belgians.

The Belgians did little to improve the welfare of the local population, maintaining a policy of segregation in which Europeans enjoyed privileges, and the Congolese were relegated to menial labour. The bloodbath of World War II dispelled the notion that Europeans were more civilised and enlightened than Africans, leading to independence movements across Africa. The Congolese people, inspired by the broader movement for decolonisation, began to demand their freedom during the 1950s. In 1955, a mass political movement, the Congolese National Movement (MNC), was founded by Patrice Lumumba, a charismatic leader who advocated for independence.

Under increasing pressure both from the Congolese population and the international community, the Belgian government granted independence to the Congo on 30 June, 1960. Patrice Lumumba became the country's first democratically elected prime minister. At a ceremony marking the first day of freedom, Lumumba declared in front of King Baudouin of Belgium, "We are no longer your monkeys."



Patrice Lumumba, first democratically elected prime minister of the DRC. He was assassinated by the Belgians with assistance from the US.

Reconquest of the Congo and the assassination of Patrice Lumumba (1960-1965)

The newly independent nation faced immediate crises, including economic instability, ethnic tensions, and a lack of experienced political leaders. In the country's mining centre of Katanga, UMHK and its security forces still held power. Eleven days after independence, Belgium orchestrated the secession of Katanga province from the DRC, in effect re-colonizing the country's vital mining sector. The central government, led by Lumumba, sought to maintain national unity, but this led to political strife and a growing conflict with the Belgians, the United States, and the United Nations.

In the wake of the Katanga crisis, Lumumba first sought support from the United Nations to expel Belgian military forces from Katanga, which was refused. He turned next to the Soviet Union, aligning himself with communist powers during the Cold War. This move alarmed the United States and Belgium, both of whom feared the spread of communism in Africa, and the flow of the Congo's mineral riches to the Soviets. In January 1961, Patrice Lumumba was captured and, with the complicity of Belgian officials, executed. A bloody dictator, Joseph Mobutu, was propped up by western powers to take Lumumba's place.

The Mobutu Era and the Rwandan Genocide (1965-1997)[17]

Joseph Mobutu renamed the country Zaire and established a dictatorship that lasted for 32 years from 1965 to 1997. Mobutu consolidated power through a system of patronage, political repression, and the cultivation of a personality cult. His regime, while initially popular for bringing stability, became notorious for corruption, human rights abuses, and economic mismanagement. Mobutu nationalised UMHK and renamed it Générale des Carrières et des Mines SA (Gécamines). High copper prices in the 1970s and 1980s helped make Gécamines the largest contributor to the national treasury.

During the 1980s and early 1990s, the country faced increasing pressure due to decades of poor governance and a precipitous fall in copper prices. Once the Cold War ended, Western support for Mobutu began to wane. Economic conditions worsened, and widespread corruption and mismanagement led to poverty and social unrest.

A genocide in neighbouring Rwanda (April – July 1994) precipitated the fall of Mobutu. Approximately 900,000 Tutsis were massacred by Hutu aggressors.[18] The genocide sparked a mass exodus of around 1.5 million refugees, most of whom settled in eastern Zaire. Whereas the genocide ended when the Hutu government in Kigali was overthrown by the Tutsis, it had lasting and devastating effects. In 1996, the Rwandan government alongside Uganda (and then, Burundi, Angola, and Eritrea) launched an offensive into Zaire starting the First Congo War and killing an estimated 200,000 people.[19]

In 1997, Laurent-Désiré Kabila, with military and financial support from neighbouring Rwanda and Uganda, invaded the DRC. Mobutu was overthrown, and Kabila took control, renaming the country the Democratic Republic of the Congo. According to the United Nations, a “mass scale looting” took root, in which military commanders made business deals with foreign mining companies for the mineral reserves in Katanga.[20]

Post-war period and ongoing challenges (2003-Present)

Laurent Kabila was assassinated in 2001 and replaced by his son, Joseph Kabila. Kabila brokered a multi-lateral peace agreement with the Rwandans and Ugandans in 2003. Aiming to revive the mining sector, in 2002 the government published a new Mining Code.

In 2007, a so-called "minerals for infrastructure" agreement with China was signed, in which China's state-owned banks agreed to provide $6 billion for DRC infrastructure in exchange for the rights to several mineral concessions.[21] In 2008, the DRC signed a cooperation agreement with the Group of Chinese Companies (CREC and SINOHYDRO) financed by Exim Bank (Chinese Bank), with a focus on two projects: improving infrastructure for the DRC and developing a joint mining project SICOMINES-Gécamines. Kabila auctioned several more major copper-cobalt concessions to Chinese state-run mining companies, with rumours of bribes and kickbacks.

Following the 2018 general election, in the country's first peaceful transition of power since independence, Joseph Kabila was succeeded by Félix Tshisekedi. Tshisekedi won again in the 2023 elections. Challenges such as poverty, infrastructure deficits, and military conflict persist.

Insecurity in eastern DRC

In January 2025, the Rwandan-backed M23 (March 23 Movement) rebel group invaded the eastern Congo and seized the cities of Goma and Bukavu along Lake Kivu. The invasion has resulted in several thousand deaths and the displacement of hundreds of thousands of people. The origins of the conflict date back to the Rwandan genocide, when dozens of militia groups sought to control the lucrative 3TG (tin, tungsten, tantalum, gold) mineral territories in the eastern Congo. The 3TG minerals are vital components to consumer electronic devices and microprocessors. On 27 June 2025, the DRC and Rwanda signed a peace treaty, the Washington Accord, to end the conflict in the eastern DRC. The US is meant to provide security guarantees in the eastern Congo in exchange for access to vital mineral territories. Despite the signing, violence andinsecurity in the area continues.

4. The DRC's mining sector

A. Overview

The mining sector of the DRC has been the country's primary source of wealth since colonial times. Following the nationalization of UMHK by Joseph Mobutu to form Gécamines in 1967, the country's mining sector was run down through mismanagement and graft, ultimately leading to the financial collapse of Gécamines during the 1990s. This collapse unleashed hardship on hundreds of thousands of Congolese people in the mining provinces, as they were left without jobs, incomes, and social safety nets. Many people resorted to artisanal and small-scale mining (ASM) as the only means of survival.

ASM is typically contrasted to industrial or large-scale mining (LSM), although in practical terms the distinctions lose meaning on the ground in the DRC. Industrial mining involves the extraction of ore bodies in mining concessions through the use of heavy machinery, whereas ASM involves the extraction of ore through rudimentary techniques using shovels, rebar, and pickaxes. In the Congo's cobalt mining sector, ASM operates as an informal underbelly to the industrial mining of cobalt, feeding tens of thousands of tons of cobalt ore each year into the supply chains of industrial mining companies, where it is combined with industrial production and fed up the chain into rechargeable gadgets and cars. The OECD estimates that between 70% and 80% of total cobalt production from the DRC is LSM, with the remaining 20% to 30% coming from ASM.[22] As will be discussed in more detail, it is very challenging to disaggregate LSM from ASM cobalt production in the DRC, as ASM production in many cases takes place *inside* industrial mining concessions and is classified as such.

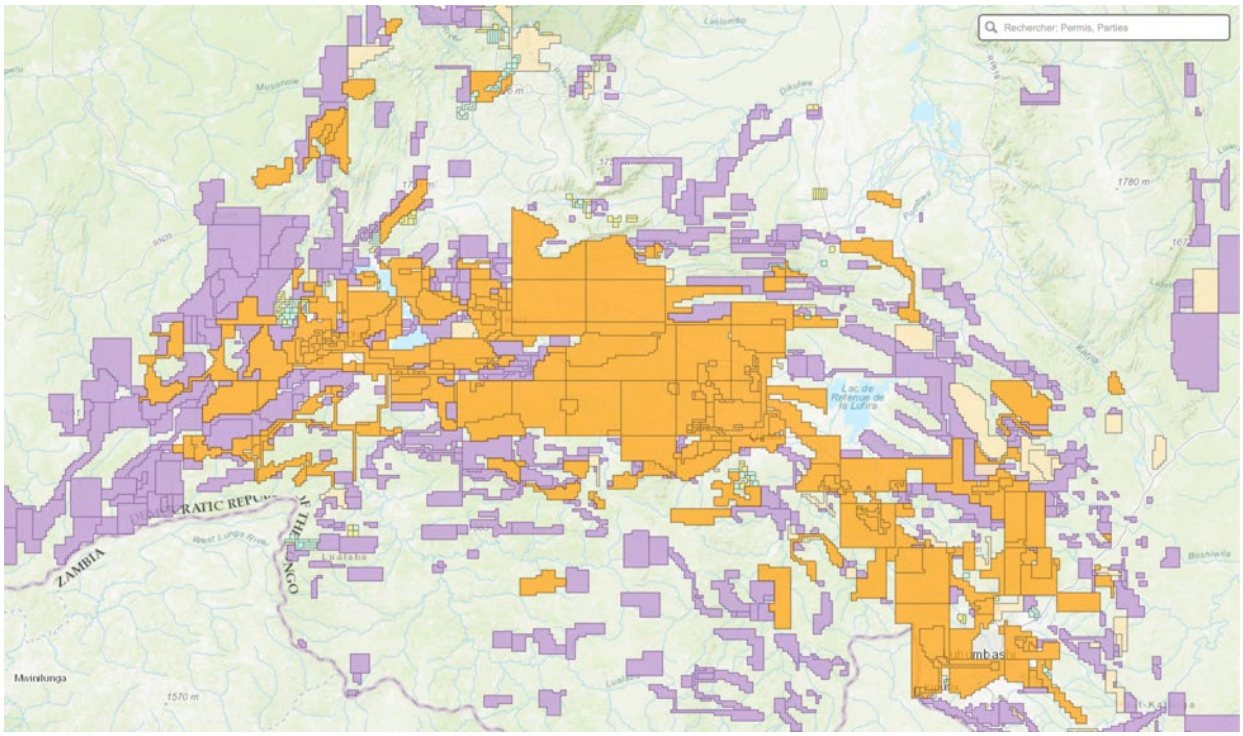
Industrial mining operations in the DRC are typically structured as joint ventures between the state-owned mining company, Gécamines, and a foreign mining company, with the foreign company taking the majority share (typically 70% to 90%). Fifteen of the 19 major copper-cobalt mining concessions in the DRC are majority-owned by Chinese mining companies.[23]

The DRC's mining sector is overseen at the national level by the Ministère des Mines (Ministry of Mines). The key responsibilities of the MoM include: formulating policies and regulations to manage mineral resources in compliance with the country's mining laws; granting exploration and exploitation permits to foreign mining companies; overseeing the sustainable extraction of minerals; monitoring the financial aspects of the mining sector; enforcing environmental regulations; facilitating investments in the mining sector; and mitigating the negative impact of mining on local communities.

At the provincial level, mining activity is administered by an array of actors, including the governors of the provinces, including the Provincial Division of Mines and Technical Services (PDMS), the Technical Unit for Mining Coordination and Planning (CTCPM), the Centre for Evaluation, Expertise and Certification of precious mineral substances (CEEC), the Mining Cadastre (CAMI), the Service of Assistance and Supervision of Artisanal and Small-scale Mining (SAEMAPE), the Geological National Service of Congo (SGNC), and the Mining Fund for Future Generations (FOMIN).[24]

The following map shows the territory under permit as of 2024 in Haut-Katanga and Lualaba provinces for the exploitation of copper and cobalt (orange), and the territory under permit for exploration (purple) by the DRC's Ministry of Mines, stretching from Lubumbashi at one end of the arc to Kolwezi at the other:

Map 3: Territories Under Permit for Exploration and Exploitation[25]



The territories under permit for extraction are almost the size of England in terms of total square miles. Crucially, all people who used to live in this land prior to the permits being issued were displaced. There is no known quantum of how many people were forcibly relocated, but it would likely be hundreds of thousands.

The shaded purple areas are under permit for exploration to foreign mining companies, permitting them to assess whether they would like to begin extracting ore found in the area. Much of the purple, which is particularly heavy around Kolwezi, could become orange in the future, leading to more displacement, deforestation, and loss of water sources.

The severe level of population displacement and environmental degradation caused by copper-cobalt mining in the DRC has placed considerable pressure on the local population, stripping them of their homes, security, and livelihoods. As the data will bear out, countless people have been left with only one option – scrounge each day for cobalt, no matter how hazardous and toxic the work may be – just to survive.

B. The DRC's mining codes

The mining sector in the DRC is governed by the country's Mining Code, adopted in 2002 and amended in 2018.

The 2002 Mining Code[26]

To attract foreign investment and formalize the mining sector, the government of Joseph Kabila implemented the 2002 Mining Code, drafted with support from the World Bank. The legal framework emphasized transparency, tax incentives, and regulatory stability, leading to an influx of multinational mining corporations. Key players such as Glencore and China's state-backed firms secured major concessions in copper, cobalt, and gold under the 2002 Code.

Some of the main provisions of the 2002 Mining Code include:

- The state retains permanent sovereignty over all mineral resources;
- The government grants mining rights and permits to companies, but ownership of the land does not include ownership of the minerals;
- The Ministry of Mines is responsible for overseeing the sector, while the Cadastre Minier manages mining permits.

The code also defines various permits for different mining activities:

Table 1: Permits under the 2002 Mining Code

Type of permit	Purpose	Duration	Renewable?
Exploration permit	Prospecting and feasibility studies	5 years (large mines), 3 years (small-scale)	Yes, once
Exploitation permit	Mining and commercial production	25 years	Yes, in 15-year increments
Small-scale mining permit	Small artisanal operations	10 years	Yes, in 5-year increments
Quarry permit	Extraction of construction materials	5 years	Yes

Artisanal mining cooperatives were also established under the 2002 Mining Code as a means of managing artisanal miners in authorized Zones d'Exploitation Artisanales (ZEAs). The cooperatives were charged with registering workers, paying their wages, ensuring safe working conditions, and preventing child labour. Cooperatives are typically set up by political elite or wealthy businessmen, who in turn take 10% or 20% of the production value as the management fee. In many cases, cooperatives do little more than provide a veneer of formality under which forced labour, child labour, and debt bondage persist, while generating substantial profits for their founders.

Although the 2002 Mining Code successfully revitalized the Congo's mining sector, it also had significant shortcomings. The liberalisation of the sector often came at the expense of local communities, as contracts were signed under opaque conditions, environmental regulations were weakly enforced, and revenue-sharing mechanisms were insufficient. Additionally, ASM proliferated with minimal formality and transparency, contributing to human rights violations, child labour, and unsafe working conditions.

The 2018 Mining Code

The DRC's 2018 Mining Code is officially known as Law No. 18/001.[27] According to the Ministry of Mines, the Mining Code was revised in 2018 to "ensure that the human rights of communities who live on the frontline of mining sites are scrupulously and entirely respected during the establishment of any new mining project."[28] In addition, several key economic aspects of the mining sector were revised, such as the following:

- The state holds a mandatory 10% stake in all mining projects;
- An additional 5% stake must be given to the state for every permit renewal.

Royalties and taxes were also revised:

Table 2: Royalty Rates Under the DRC's Mining Codes

Tax/Royalty	2002 Code	2018 Code
Royalties on base metals (copper, zinc, etc.)	2%	3.5%
Royalties on precious metals (gold, silver, platinum, etc.)	2.5%	3.5%
Royalties on strategic minerals (cobalt, lithium, coltan, etc.)	N/A	10%
Corporate tax	30%	30%
Super-profits tax (if prices rise by 25% over feasibility study forecasts)	N/A	50%
Surface tax (per hectare, per year)	Increased	Increased

The 2018 revision also introduced a 10% royalty on "strategic minerals", mainly affecting cobalt, lithium and coltan. Furthermore, the government reserved the right to declare any mineral "strategic", allowing it to impose higher taxes and royalties

Crucially, mining companies were tasked with compliance with environmental and social regulations:

- Environmental Impact Assessments became mandatory before obtaining a mining permit;
- Companies were obliged to create an Environmental Management Plan to prevent pollution and land degradation;
- A portion of revenues must be set aside for community development;
- Companies were required to contribute to a Mine Closure and Rehabilitation Fund to restore the land after operations ended.

As some of our findings will demonstrate, very little of these environmental regulations are being enforced in the copper-cobalt provinces.

Management of the artisanal mining sector was assigned to an agency called Service d'Assistance et d'Encadrement des Mines Artisanales et de Petit Echelle (SAEMAPE), which was created by the Prime Minister's Decree No. 17/009 of April 4, 2017. SAEMAPE's key responsibilities include:[29]

- Providing training and technical assistance to artisanal miners;
- Helping artisanal miners adopt safer, more efficient, and environmentally friendly mining techniques;
- Enforcing environmental regulations by promoting responsible mining practices;
- Working to improve the livelihoods of artisanal miners by advocating for fair trade practices, better working conditions, and financial inclusion.

SAEMAPE also took charge of issuing ZEAs. To date, SAEMAPE has designated fewer than 100 ZEAs in Haut-Katanga and Lualaba provinces, which is insufficient to accommodate the hundreds of thousands of people who try to earn a living by digging for cobalt. As a result, artisanal miners dig in hundreds of unauthorized mining areas scattered across the region. Many of these sites are located right next to industrial mining operations since the diggers know there is likely to be valuable ore under the ground.

Crucially, SAEMAPE lacks resources to pay its agents and officials adequately. As a result, many of them extort "taxes" and "fees" from artisanal miners, which was a common complaint the research teams received countless times during their fieldwork.

5. The cobalt market

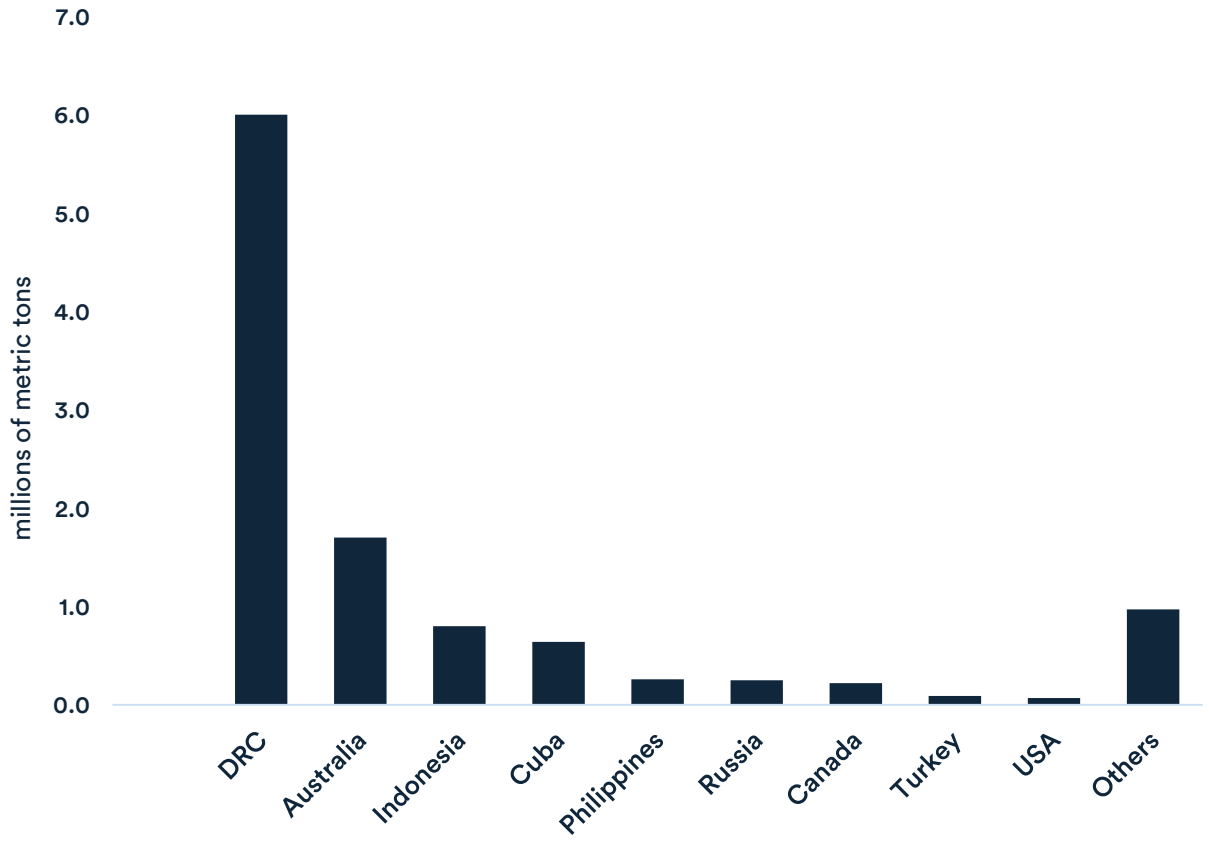
A. The Central African Copperbelt[30]

The majority of the world's terrestrial reserves of cobalt are located in the Central African Copperbelt (CACB). The CACB is one of the world's most significant metallogenic regions, hosting vast reserves of copper, nickel, silver, zinc, uranium, and cobalt. It spans the southeastern portion of the DRC from Kolwezi to Kipushi, onwards into northern Zambia. The CACB is part of the larger Lufilian Arc and is primarily associated with the Katanga Supergroup, a thick succession of sedimentary rocks deposited in the Katangan Basin between ~880 and 500 million years ago. The CACB has undergone multiple phases of deformation, primarily associated with the Lufilian Orogeny (~550-500 million years ago). This event led to the thrusting and folding of the crust that pushed ore bodies closer to the surface, making them accessible to modern-day artisanal miners. Copper is found primarily in chalcopyrite, bornite, and chalcocite. Cobalt is found primarily in carrollite and heterogenite.

A chunk of heterogenite at an artisanal cobalt mine in Haut-Katanga province

In 2024, the total global reserves of cobalt amounted to an estimated 11 million metric tons. More than half of the world's cobalt reserves are in the DRC with 6 million metric tons, followed by Australia with 1.7 million metric tons and Indonesia with 640,000 metric tons. The countries with the top cobalt reserves can be seen in the chart below:

Table 3: Cobalt reserves 2024[31]

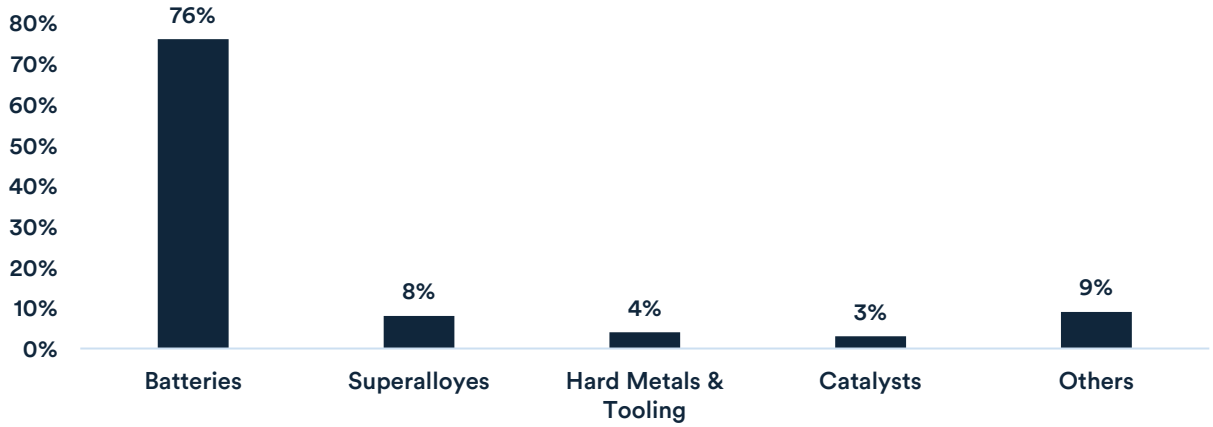


B. Uses of cobalt

Cobalt is used in many alloys (superalloys for parts in aircraft engines, corrosion resistant alloys, high-speed steels, cemented carbides), in magnets and magnetic recording media, as a catalyst for petroleum refining, and as drying agents for paints and inks. Because cobalt has high energy density and thermal stability, it has become an essential component for rechargeable batteries. The more energy a battery can hold without catching on fire, the less often consumers have to plug in to recharge.

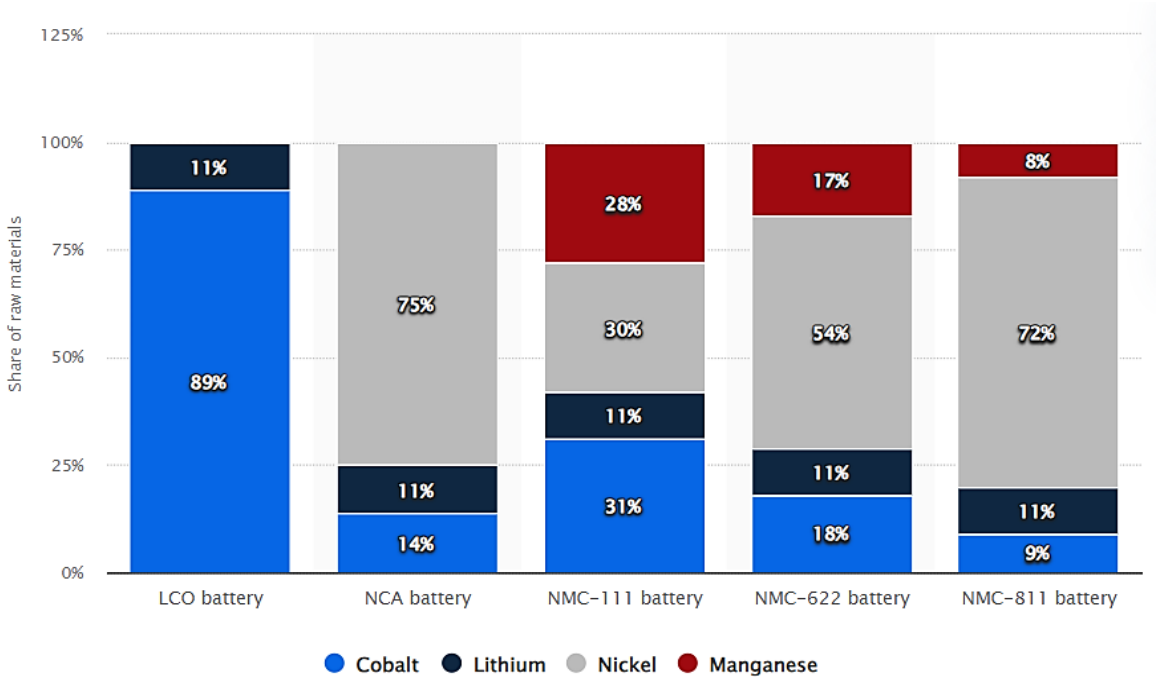
Cobalt use in 2024 is shown in the following chart:

Table 4: Uses of cobalt[32]



Different types of rechargeable batteries vary in their composition. The following table shows the share of raw materials used for the primary L-ion battery chemistries manufactured today: LCO (lithium-cobalt-oxide), NCA (lithium-nickel-cobalt-aluminium oxides) and, NMC (nickel-manganese-cobalt oxide):

Table 5: L-ion battery chemistries [33]



There are roughly 10 grammes of refined cobalt in every mobile phone, 20 grammes in every laptop computer, and up to 10 kg in the typical EV battery pack.

C. Drivers of cobalt demand

Rechargeable batteries are driving most of the future demand for cobalt, growing from a 74% share in 2024 to an estimated 84% share in 2030.[34] EVs are responsible for the bulk of this demand. In 2024, one in five cars sold globally was an EV, totalling about 17.1 million EVs, as compared to about 320,000 sold a decade earlier in 2014. EV sales are expected to grow from 17.1 million in 2024 to 27 million in 2026.[35] Three markets across the global north dominate EV sales. In 2024, China accounted for 76% of global passenger EV sales; Europe accounted for 17%, and North America accounted for 10%.[36]

Policy mandates are boosting EV industry investment:

1. The US Inflation Reduction Act[37] (16 August 2022), seeks to reduce carbon emissions by 40% by 2030. The IRA is a combination of grants, loans, tax provisions and other incentives to accelerate the deployment of clean energy and EVs. In total, around 370 billion USD will be disbursed for measures dedicated to improving energy security and accelerating clean energy transitions.
2. The American Battery Materials Initiative (October 2022)[38] is an effort to mobilise the government in securing a reliable and sustainable supply of critical minerals used for power and EVs.
3. The EU's Critical Raw Materials Act[39] (11 April 2024) aims to strengthen the European critical raw materials value chain and promote strategic partnerships with mineral-rich countries. EU demand for rare earth metals is expected to increase seven-fold by 2050, hence the Act aims to strengthen all stages of the European critical raw materials value chain, diversify the EU's imports to reduce strategic dependencies, and improve circularity and sustainability.

4. The EU's Net Zero Industry Act[40] (29 June 2024) aims to increase the EU's manufacturing capacity of technologies that support the clean energy transition, including batteries and EVs.
5. China's 14th Five-Year Plan (FYP)[41] (11 March 2021), highlights high-quality, green development intended to reduce the carbon intensity of the economy and to peak carbon dioxide emissions before 2030. It envisages less reliance on heavy industries by proposing a new target to increase the share of the strategic emerging industries (including EVs) from 11.5% of GDP in 2019 to over 17% by 2025. Chinese officials are drafting the 15th FYP for the period 2026-2030.

As a result of these and other policies, EV sales are expected to continue growing briskly for years to come, which will continue to put pressure on mining companies and artisanal miners to increase cobalt production in the DRC.

The Trump administration has expressed its intention to dismantle the US Inflation Reduction Act (IRA) and scrap the so-called 'EV mandate'; however, Congressional approval has not yet been secured for any of these policy changes. The US administration remains committed to implementing the Lobito corridor upgrade in the African Copperbelt, aiming to improve US access to minerals and counter China's control over cobalt and copper in the region.[42]

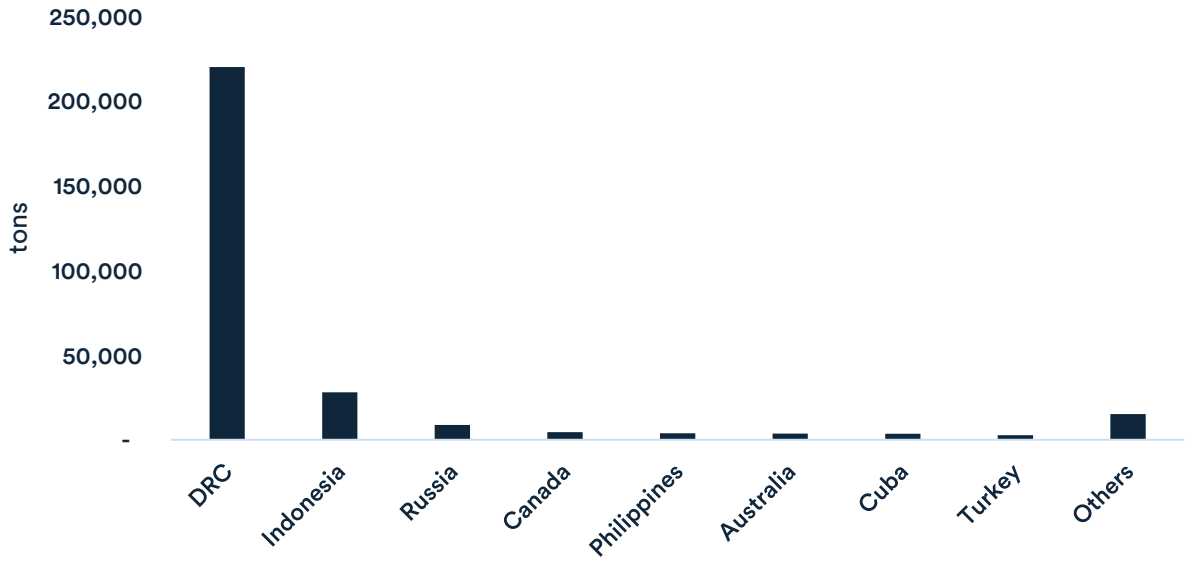
In response to the war in Ukraine and President Trump's foreign policies, the EU unveiled the ReArm Europe Plan/Readiness 2030, aiming to strengthen its defence industrial capabilities, which is expected to exacerbate the demand for defence-related end-use sectors, such as superalloys, magnets and drones.[43]

D. Cobalt mining production

In 2024, the total mine production of cobalt worldwide was 290,000 metric tons, of which 220,000 metric tons came from the DRC, or 76% of the total.[44]

Total mining production by country can be seen in the chart below:

Table 6: Cobalt mining production 2024



The ten largest cobalt mines by production in 2023 were as follows:

Table 7: The ten largest cobalt mines by production[45]

Mine	Country	Owner	Production (000s tonnes, 2023)
Kisanfu	DRC	CMOC	25.5
Metalkol RTR	DRC	Eurasian Resources Group	22.6
Tenke-Fungurume	DRC	CMOC	22.5
KOV	DRC	Glencore	17.7
Mashamba East	DRC	Glencore	13.9
Deziwa	DRC	China Nonferrous Metal Mining	7.2
Étoile	DRC	Shalina Resources	6.4
Mutanda	DRC	Clencore	5.8
PT Halmahera Persada Lygend	Indonesia	Ningbo Lygend Maluku	4.8
Pumpi Cobalt and Copper	DRC	Wanbao Mining	4.0

Based on this data, nine of the ten largest cobalt producing mines in the world are located in the DRC.

E. Refined cobalt production

Raw cobalt ore must be processed to commercial grade quality to be used in rechargeable batteries. Global refined cobalt production hit 222kt in 2024, representing a 17% increase over 2023.[46]

China is by far the largest refiner of cobalt in the world, with a 79% share in 2024. Finland and Canada, the second and third largest cobalt refiners, accounted for 7.2% and 2.7% respectively.[47]

An overview of the main countries that refine cobalt is included below:

1. China: refines 79% of the world's cobalt. The major companies are Zhejiang Huayou Cobalt, Jinchuan Group, and GEM Co., Ltd.
2. Indonesia: has rapidly expanded its cobalt refining industry. The major companies are Tsingshan Holding Group, Huayou Cobalt, and CNGR Advanced Material
3. Finland: the refining hub for Europe. The primary refiner is Umicore.
4. Belgium: a legacy player in the cobalt refining business, primarily through Umicore's refinery in Hoboken.
5. Canada: refines cobalt at facilities like Vale's Long Harbour refinery and Glencore's Sudbury operations.
6. Norway: hosts Glencore's Nikkelverk refinery in Kristiansand, a leading supplier of refined cobalt.
7. Japan: refines cobalt for batteries used in Toyota, Panasonic, and Sony products. The primary companies are Sumitomo Metal Mining and JX Nippon Mining & Metals

F. EV battery manufacturers

EVs are driving the bulk of demand for cobalt and other battery cell component metals. In 2024, demand for EV batteries reached 894.4 GWh, a growth of more than 27% over 2023 in the US and EU, and 35% in China. China's EV demand represented more than half of the global demand in 2024.[48]

The top 10 EV battery manufacturers and their market shares in 2024 were:

Table 8: The top 10 ev battery manufacturers[49]

Company	Country	Market share (%)
CATL	China	37.9
BYD	China	17.2
LG Energy Solution	South Korea	10.8
China Aviation Lithium Battery	China	4.4
SK On	South Korea	4.4
Panasonic	Japan	3.9
Samsung SDI	South Korea	3.3
Gotion High-Tech	China	3.2
EVE Energy	China	2.3
Sunwoda	China	2.1

G. Market value of cobalt

Between 2023 and 2030, the market value of cobalt is anticipated to more than double, from an estimated $10.8 billion in 2023 to a forecast $24.9 billion in 2030.[50] However, inflation, COVID-19 lockdowns in China, and China's EV industry cost-cutting battery strategy seem to have undermined demand for cobalt in 2023 and 2024. According to Reuters, "Chinese battery producers are switching away from nickel cobalt manganese (NCM) chemistry to cheaper lithium iron phosphate (LFP) batteries, meaning cobalt demand will not grow as dramatically as some had previously expected."[51]

The excess cobalt supply across the last two years has led to a drop in price for refined cobalt on the London Metal Exchange. Average prices in 2024 were about $16 per pound, down from $28 per pound in 2023. Price drops have continued dropping into 2025, reaching as low as $9.5 per pound. As the market equilibrates, overall demand for cobalt is expected to remain robust for many years to come.

To help recalibrate the market, the DRC announced in February 2025 a four-month suspension of cobalt exports. Additionally, the DRC is considering implementing export quotas to further manage supply and support price recovery.

Despite current challenges, the global cobalt market is projected to grow at a compound annual growth rate (CAGR) of 8.90% between 2025 and 2034, reaching a volume of approximately 469.38 ktn by 2034. This growth will be driven by the ongoing demand for cobalt in various sectors, including EVs, consumer electronics, aerospace, and defence industries.

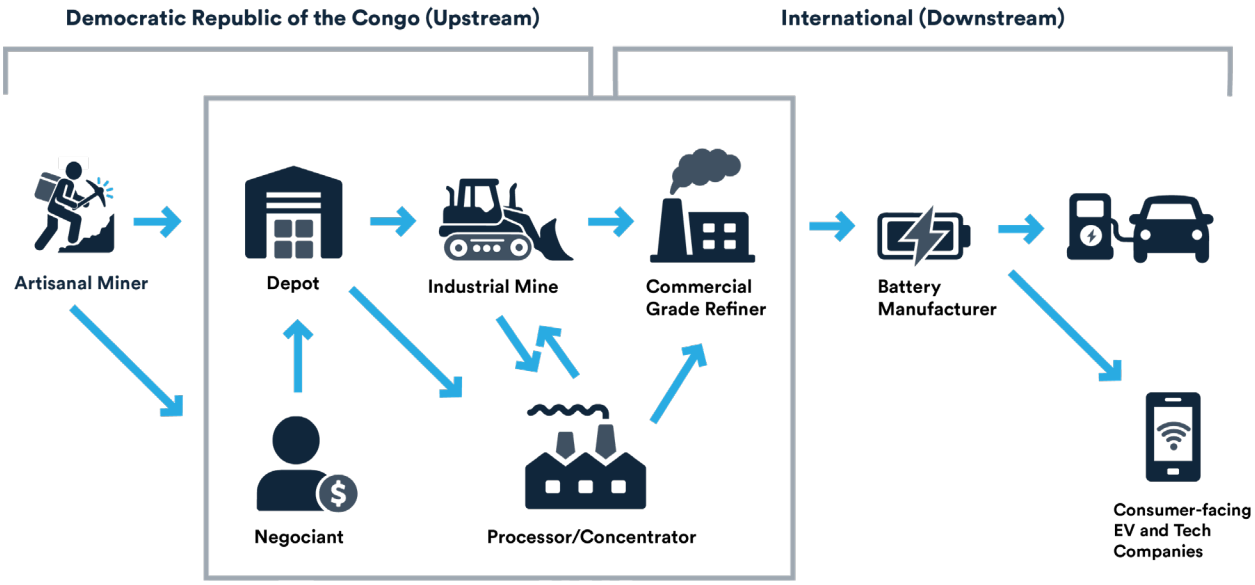
6. The cobalt supply chain

The supply chain of cobalt from the Democratic Republic of the Congo is characterized by false dichotomies between LSM (formal) and ASM (informal) production. Ground surveys and supply chain tracing confirm that: (1) virtually *all* ASM cobalt is sold to major mining companies and mixed with their production, and (2) many, if not most, industrial mining operations have artisanal miners working *inside* their concessions, which cross-contaminates LSM and ASM production.

Artisanal miners can be seen climbing into an industrial mine in Kolwezi to dig for cobalt.

The cobalt supply chain in the DRC can be visualized in simple terms as follows:

Figure 1: The cobalt supply chain[52]



1. ASM underbelly

The bottom of the supply chain consists of the informal underbelly to the global cobalt industry, ASM.

An artisanal mining area near Kipushi.

ASM consists of the following activities:

- *Creuseurs* (diggers): operate as individuals or in groups to excavate cobalt-bearing ore from the surface, pits, trenches, or tunnels. Leaders in tunnel digging teams are called, "attackers". Across the mining provinces, diggers may or may not work under cooperatives, and most do not work at official ZEAs.
- Washing and sorting: women and children who wash ore gathered by diggers in putrid bodies of water, streams, lakes, or rivers to separate the dirt from cobalt ore and worthless stones. Sorters then sort through and separate the worthless stones from cobalt-bearing ore.
- Salakate: these are orphaned children or groups of young women who perform general tasks or odd jobs at an artisanal mining site, helping out others wherever it is needed.

A toxic washing pool used by women and children to separate cobalt ore from dirt and stones.

In almost every artisanal mining site visited by the researchers, there were often beverages, snacks, alcohol, cigarettes, and narcotics being sold. In particular, diggers in tunnels consume alcohol and narcotics to help them overcome the fear of climbing into tunnels and digging underground for twelve or more hours at a time. Virtually all artisanal miners are paid in cash (Congolese Francs), as most are unbanked.

2. Link to the formal supply chain

The boxed stages in Figure 1 show all the areas in which ASM and LSM cobalt can be mixed.

- *Négociants* and Transport: The cobalt-bearing ore is loaded into sacks for sale to *négociants* (traders) or directly to depots/*maisons d'achats* (buying houses). Whether sold to *négociants* or taken directly to depots, the sacks of ore are transported on the backs of motorbikes and pickup trucks to depots for sale.
- *Maisons d'achats*/Depots: Mostly run by Chinese buyers, along with Congolese, Indians, Russians, and Lebanese. They purchase ASM cobalt and pay for the ore based on weight and grade of cobalt (1%, 2%, etc), with hand-painted price lists at the front of the deport. Depot buyers pay no attention to the condition in which the ore may have been extracted (whether it involved child labour or hazardous tunnel digging, etc). Cobalt sacks are sold into the formal supply chain, usually at the end of each day. LSM buyers, often in official mining cargo trucks, purchase the ore and transport it to their processing facilities, to be mixed with LSM production. From this point forward, it is impossible to disaggregate LSM from ASM cobalt.

A copper-cobalt depot in the Kasulo neighbourhood of Kolwezi, with price sheets at the top right.

Crucially, artisanal miners who sell to *négociants*, either through coercion or due to the remoteness of the site at which they are working, are disconnected from the market and earn the lowest incomes of a dollar or two a day. Furthermore, ASM that takes place inside LSM concessions is already mixed with LSM production before the ore is processed, making it again impossible to disaggregate LSM from ASM production. Both scenarios are documented in our surveys (see section 8 below).

To improve transparency and incomes for artisanal miners, in 2019, the DRC established a state company – Entreprise Générale du Cobalt (ECG) – as a new subsidiary of the state-owned Gécamines. The purpose of ECG was "to purchase all ASM cobalt in the country for the market, in an attempt to boost revenue for the country and to address human rights abuses."[53] ECG was given the exclusive right to buy ASM cobalt produced in the DRC at a depot centre at Musompo, about 15km east of Kolwezi. However, as of the Spring of 2025, the ECG buying centre at Musompo remained non-functional. Furthermore, most artisanal miners must still sell their ore for pennies on the dollar to *négociants* to transport their sacks of ore to the Musompo depot centre (or any other depot area), which could be 50km or 100km away.

3. Processing and export

Prior to export from the DRC, cobalt-containing ores must undergo a preliminary processing stage in which the cobalt is separated from other metals in the ore, such as copper and nickel. Some of this processing takes place inside LSM concessions, and some of it takes place at dedicated processors in Kolwezi, Likasi, and Lubumbashi. The preliminary processing typically involves industrial acids, such as sulfuric acid, which produces a toxic, mustard-colored gas that is often allowed to float over surrounding villages and water bodies. The output of the processing is either crude cobalt hydroxide or cobalt concentrate.

The semi-processed cobalt is transported by truck from the DRC to seaports in Africa, primarily Dar es Salaam and Durban, after which most of it is transported to mainland China for commercial grade processing.

Beginning in 2022, an ambitious effort was undertaken to establish a new route for the export of minerals from the DRC, the Lobito Project. The Lobito Project is a major infrastructure initiative aimed at improving transportation in Central and Southern Africa, focused on the Lobito Corridor, a railway system connecting the port city of Lobito in Angola to the mineral-rich regions of the DRC and Zambia. Historically, the railway was underutilized due to conflicts, lack of maintenance, and limited investment. However, with new funding and international partnerships, the corridor is being modernized to provide an alternative to road transport and bring minerals to ports on the west coast of Africa, from which they can be more easily transported to western markets, thereby bypassing China. The project is supported by the US, the EU, Angola, the DRC, and Zambia. The railway is expected to be fully operational by 2027.

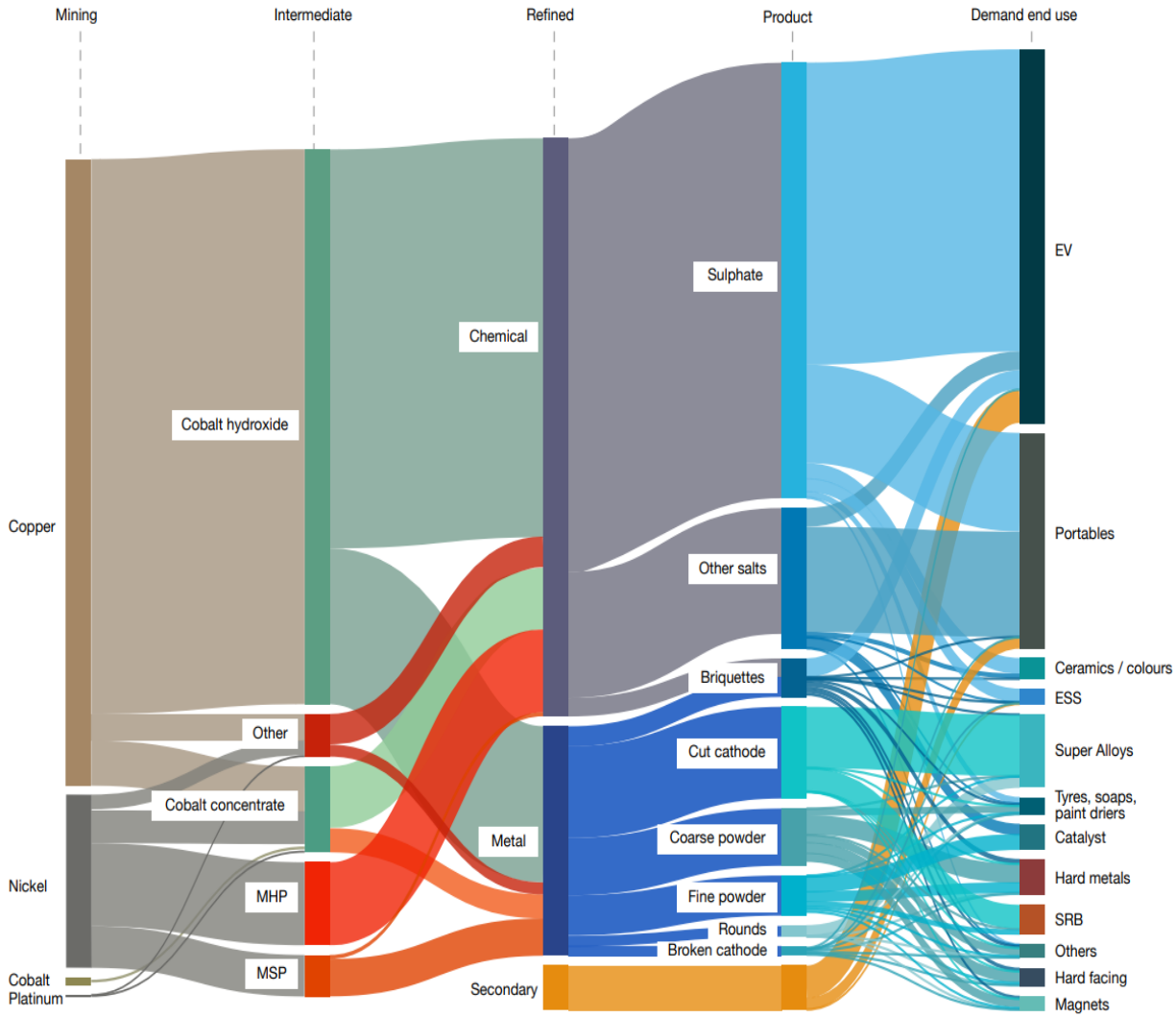
4. Batteries and end use

Commercial grade cobalt is sold to battery manufacturers, who manufacture various chemistries of rechargeable batteries that are used in consumer electronic devices and EVs. Commercial grade cobalt can also be used in other industrial applications, such as super alloys, magnets, and as a catalyst for petroleum refining.

5. Industrial visualisation of the cobalt supply chain

A more industrial visualisation from Benchmark Mineral Intelligence of the stages of the cobalt supply chain as it transforms from ore to end product is included for reference below:

Figure 2: Industrial visualisation of the cobalt supply chain



Data: Benchmark Mineral Intelligence.

7. Legal context

This section outlines the international and domestic legal contexts relating to the labour surveys conducted for this project.

A. International conventions

1. Forced labour: The ILO Forced Labour Convention No.29 defines forced labour as: "all work or service which is exacted from any person under the threat of a penalty and for which the person has not offered himself or herself voluntarily."[54] The definition consists of three elements:

1. "Work or service" refers to all types of economic activity in any industry or sector including in the informal economy;
2. "Menace of any penalty" refers to a wide range of coercive tactics and/or penalties used to compel someone to work;
3. "Offered voluntarily" refers to the free and informed consent of an individual to take a job with freedom to leave at any time. Where there in an absence of these factors, the work is deemed "involuntary".

To constitute forced labour under ILO Convention No. 29, the work must be both involuntary and coerced. Indicators used to determine these conditions in the surveys used for this project are based on those outlined by the ILO:[55]

1. **Restriction of movement**
2. **Physical or sexual violence**
3. **Intimidation and threats**
4. **Abuse of vulnerability**
5. **Isolation**
6. **Deception**
7. **Retention of identity documents**
8. **Withholding of wages**
9. **Debt bondage**
10. **Abusive working and living conditions**
11. **Excessive worktime**

There is no hard and fast rule on how many criteria are required to determine a case of forced labour. For instance, ILO guidance indicates that just one indicator can be sufficient. For the purposes of this project, a respondent was defined as being in forced labour if: (1) criteria 1-3 were met, and (2) at least 3 of the remaining criteria were met. This approach was used to provide a conservative assessment of levels of forced labour in the DRC's artisanal cobalt mining sector.

For instance, isolation, abusive working conditions, and excessive overtime could reasonably be construed as amounting to forced labour; however, the PI required that restrictions on movement, violence, and coercion should be required as well. The practical result is an understatement of the levels of forced labour, as opposed to an overstatement.

2. Child labour: The term child labour is often defined as work that deprives children of their childhood, their potential and their dignity, and that is harmful to their physical and mental development. According to the ILO, child labour refers to work that:

- Is mentally, physically, socially or morally dangerous and harmful to children; and/or
- Interferes with their schooling by depriving them of the opportunity to attend school; obliging them to leave school prematurely; or requiring them to attempt to combine school attendance with excessively long and heavy work.[56]

Whether or not particular forms of work can be called child labour depends on the child's age, the type and hours of work performed, the conditions under which it is performed, and the objectives pursued by individual countries. For the purposes of this project, a respondent was defined as being in child labour if the individual was:

1. Under the age of 18
2. Working at least four hours a day, and
3. **Was not** attending school

The third criterion was a particularly restrictive one, as many children working in artisanal mining areas do so for a few hours after attending school each day or during holidays. These children were not included as child labourers for the purposes of this study, in order to produce as conservative an estimate on child labour as possible. It is also the case that self-reporting on school attendance can be unreliable, as children and their parents have become increasingly sensitive to the need of keeping children in school. As it was not possible for the researchers to probe the accuracy of reports of school attendance, these surveys were excluded from the quantum for child labour. Including them would have almost doubled the figures for child labour.

A subset of child labour is the "Worst Forms of Child Labour," which is defined by ILO Convention No.182[57] as hazardous work (such as mining), being enslaved, separated from their families, exposed to serious hazards and illnesses and/or left to fend for themselves on the streets of large cities – often at a very early age.

The Convention makes it clear that all such work should never be undertaken by children under the age of 18. Almost every case of child labour documented for this project would be considered one of the worst forms of child labour under ILO Convention No. 182.

3. Debt bondage: The United Nations Supplementary Convention on the Abolition of Slavery defines debt bondage as, "the status or condition arising from a pledge by a debtor of his personal services or of those of a person under his control as security for a debt, if the value of those services as reasonably assessed is not applied towards the liquidation of the debt or the length and nature of those services are not respectively limited and defined."[58] In practical terms, debt bondage occurs when a party with more power and access to resources makes an economic advance to a person or persons with much less power and resources, then uses forced labour to extract a labour value out of the debtor that far exceeds the value of the loan.

Respondents were categorized as being in debt bondage if the individual had taken a loan or economic advance and was working off the value of the credit through pledged labour, but was subjected to wage deductions, excessive interest rates, coercion and/or violence, and was not able to stop working until the loan was repaid.

4. Human trafficking: The "Palermo Protocol" is the central international treaty aimed at combating human trafficking. Officially known as the Protocol to Prevent, Suppress and Punish Trafficking in Persons, Especially Women and Children, it was adopted in 2000 as part of the United Nations Convention against Transnational Organized Crime.[59]

The Palermo Protocol defines human trafficking as: "The recruitment, transportation, transfer, harbouring, or receipt of persons by means of force, fraud, coercion, deception, abuse of power, or taking advantage of a person's vulnerability for the purpose of exploitation."

Forms of exploitation include:

- Forced labour and debt bondage
- Sexual exploitation (including prostitution)
- Slavery or practices similar to slavery
- Servitude
- Organ trafficking

The definition explicitly states that child trafficking (under 18 years old) is a crime, even if coercion is not involved.Respondents were categorised as having experienced human trafficking if they were recruited by a third party to travel to the worksite, made promises relating to wages and working conditions, then was subsequently forced to work in conditions of forced labour or debt bondage.

The DRC has ratified ILO Conventions No. 29, and 182, as well as the United Nations Supplementary Convention on the Abolition of Slavery, and the Palermo Protocol.

B. Domestic law in the DRC

The DRC has a range of laws relating to exploitative labour conditions, including:[60]

1. Slavery and the slave trade: Provisions related to slavery are found in the DRC's Constitution at article 16 which declares that no one may be held in slavery and the Decrees of the King-Sovereign of 1 July 1891 concerning the Slave Trade which prohibits slave trading but not slavery itself.

Article 68 of the Penal Code criminalises abducting, arresting or detaining persons to sell them as slaves, causing them to be abducted, arrested or detained, and disposing of persons under their authority for the same purpose while sexual slavery and forced prostitution are prohibited under articles 174e and 174c.

Article 3 of the Labour Code also prohibits child slavery under the worst forms of child labour.

2. Practices similar to slavery (including debt bondage): Provisions related to institutions and practices similar to slavery are found in the DRC's Constitution at article 16 which declares that no one may be held in conditions analogous to slavery.

Article 174f of the Penal Code also prohibits forced marriage.

Article 3 of the Labour Code also abolishes practices similar to slavery, bonded labour (debt bondage), and serfdom against children under the worst forms of child labour.

3. Forced or compulsory labour: Provisions related to forced labour are found in the DRC's Constitution at Article 16 which declares that no one may be subjected to forced or compulsory labour and Article 2 of the Labour Code which prohibits forced or compulsory labour.

4. Human trafficking: Provisions related to trafficking in persons are found in the Child Protection Code (Law No 9/001), which prohibits trafficking in children under Article 162.

In addition to the general legal framework on exploitative labour and child labour in the DRC, the country has an array of legislation specific to the mining sector, the most important of which is the DRC's Mining Code.

8. Labour survey results

"The mine keeps growing…Our children keep dying."

- A mother who lives in the Kanina neighbourhood of Kolwezi, age 26

This section presents the findings of the labour surveys conducted for this project. A total of 1,431 respondents completed the survey. Many hundreds more surveys were partially completed and were therefore not included in these results. Surveys may have been partially completed due to a respondent's needing to return to work or attend to household needs, or electing to cease the interview process.

Out of the 1,431 respondents documented, 895 (62.5%) were in Lualaba province, and 536 (37.5%) were in Haut-Katanga province. Within each province, surveys were conducted in and around 10 major mining sites in Lualaba and 6 major mining sites in Haut-Katanga. In addition, surveys were conducted at 55 smaller ASM sites in Lualaba, and 34 smaller sites in Haut-Katanga.

Some of the summary findings of interest are included below:

- 36.8% of respondents met the project's conservative criteria for forced labour
- 9.2% of respondents met the project's conservative criteria for child labour
- Debt bondage and human trafficking were less prevalent, although there are hotspots of note: Kasulo and Mutoshi for debt bondage and Nsase for human trafficking
- Only 15.2% of respondents reported enjoying the work
- 87.8% of respondents began working as artisanal miners due to the lack of any reasonable alternative means of survival
- $3.28 was the average daily income, with heavy gender-based bias (males: $3.52; females: $1.84)
- Workdays were long, at roughly 9½ hours
- Implied hourly wages were $0.34; $0.40 for males and $0.20 for females

- 85.3% of respondents interviewed were male; 14.7% were female
    - NB: the skew towards male respondents is partly explained by the fact that arduous mining activity tends to be male dominated, and partly by the fact that female respondents were less likely to speak with our researchers. The gender-based skew has the effect of placing an upward bias on some of the data, for instance average wages.
- 27.7% of respondents began working in artisanal mining as a minor
- Only 7.3% of respondents reported having a secondary source of income
- The average age of the respondents was about 25 years
- Self-reported literacy rates were 76.1%; however, functional literacy is much lower
- The average respondent only completed 4 years of school
- Almost two-thirds of respondents reported a chronic illness or ailment, such as respiratory illnesses, skin diseases, gastrointestinal diseases, nausea and vomiting, gynaecological issues, hernia, haemorrhoids, vision problems, back and neck pain/injuries, or broken bones
- More than 90% of respondents reported having access to medical care, primarily through community health centres and clinics; however, the quality of medical care is poor. Many clinics lack supplies as basic as paracetamol to treat fever and pain.
- More than half of respondents reported suffering threats and abuse in the workplace
- Approximately 70% of respondents would rather quit working as artisanal miners but were unable to do so, primarily due to the lack of any alternate means of survival
- Not a single respondent was a member of a trade union, as none exist
- Not a single respondent had a written agreement for their work

Overall, the data reveals that artisanal mining for cobalt is a very hazardous vocation undertaken for basic survival, involving long hours, subsistence wages, and severe health impacts. The data further reveals that within the surveyed respondents, there is a high rate of forced labour and an almost 10% rate of child labour.

The summary data from the surveys at the provincial level is included in the following table:

Table 9: Labour survey summary data

	All respondents	Lualaba province	Haut-Katanga province
Number of respondents	1,431	895	536
Forced labour	36.8%	38.4%	34.0%
Child labour	9.2%	9.5%	8.8%
Debt bondage	6.5%	7.8%	4.3%
Human trafficking	4.4%	0.7%	10.6%
Like the work	15.2%	16.9%	12.5%
Written agreement for job	0.0%	0.0%	0.0%
Began due to survival or lack of alt	87.8%	86.5%	89.9%
Average daily income	$3.28	$3.58	$2.77
Male	$3.52	$3.79	$3.04
Female	$1.84	$2.01	$1.66
Other source of income	7.3%	7.4%	7.3%
Average age	24.9	24.6	25.4
Male	85.3%	87.9%	81.0%
Female	14.7%	12.1%	19.0%
Avg years worked in artisanal mining	3.1	3.2	3.0
Began as a minor	27.7%	27.9%	27.2%
Family members in artisanal mining	2.4	2.6	2.1
Avg hours worked per day	9.4	9.5	9.1
Literate	76.1%	73.6%	80.2%
Avg years of school completed	4.2	4.0	4.4
Free to do other work	22.1%	21.9%	22.4%
Chronic physical ailment or injury	63.9%	64.5%	63.1%
Access to medical care	92.7%	95.1%	88.6%
Suffer threats or abuse	54.6%	63.4%	40.1%
Penalized for not working hard enough	41.9%	43.5%	39.4%
Would rather quit but cannot	69.4%	68.2%	71.5%
Belong to a trade union	0.0%	0.0%	0.0%

1. Lualaba province

Lualaba Province is located in the southeastern part of the DRC. It was created in 2015 when the former Katanga province was subdivided into four smaller provinces: Lualaba, Haut-Katanga, Haut-Lomami, and Tanganyika. Lualaba is known for its vast mineral wealth, particularly copper and cobalt, making it one of the most economically significant regions in the country.

Lualaba province covers an area of approximately 121,000 square kilometres, almost the size of England. The province shares borders with Haut-Katanga to the east, Haut-Lomami and Tanganyika to the north, and Kasai and Kasai-Central to the west. To the south, it borders Zambia, providing an important trade route for the export of minerals and other goods.

The province is characterized by a mix of plateaus, rolling hills, and river valleys. The Lualaba River, which is a major tributary of the Congo River, runs through the province, giving it its name. The river is not only an important waterway but also a key ecological and economic resource for fishing, transport, and hydroelectric power production. Massive contamination of the river and its tributaries by LSM and ASM activity has had tremendous economic and health impacts on the people of the region.

Crucially, Lualaba province contains more than one-fourth of the world's cobalt reserves, as well as substantial reserves of copper and nickel. As a result, the province is home to some of the world's largest mining operations, including those managed by international companies such as Glencore, China Molybdenum, Zijin Mining, Huayou Cobalt, China Nonferrous Metal Mining, Eurasian Resources Group, and Ivanhoe Mines. In addition to mining, agriculture plays an important role in the local economy for growing subsistence crops, such as maize, cassava, and peanuts.

Lualaba province has an estimated population of over 3 million people, composed of various ethnic groups, including the Luba, Bemba, and Lunda peoples. Kolwezi is the provincial capital and the heart of Lualaba's mining industry. The city is divided into two communes: Dilala and Manika. The population of the greater Kolwezi area exceeds 1 million people. Kolwezi's history is closely tied to the discovery and exploitation of mineral resources in the southeastern part of what was once the Belgian Congo in the early 1900s. Since independence, Kolwezi and the surrounding region have suffered invasions, strife, and bloodshed over control of its vast mineral resources, quite apart from considerable environmental damage caused by foreign mining operations.

The local population has been pushed to the fringes by mining operations, and hundreds of thousands of people eke out a base existence in the province as artisanal miners.

The summary data from the major mining sites documented in Lualaba province are included in the following table, each of which will be discussed in more detail below:

Table 10: Labour survey, Lualaba province by site

	Kasulo	Mutoshi	KCC	Mashamba East	Kamilombe	COMMUS
Number of respondents	32	90	88	67	63	45
Forced labour	37.5%	45.6%	29.5%	28.4%	12.7%	22.2%
Child labour	9.4%	7.8%	11.5%	9.0%	7.9%	8.9%
Debt bondage	31.3%	24.4%	0.9%	1.5%	0.0%	0.0%
Human trafficking	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Like the work	40.6%	21.1%	14.2%	16.4%	12.7%	11.1%
Written agreement for job	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Began due to survival or lack of alt	50.0%	87.8%	89.8%	91.0%	92.1%	97.8%
Average daily income	$4.77	$3.40	$3.26	$3.38	$3.35	$3.35
Male	$4.77	$3.69	$3.96	$3.38	$3.43	$3.58
Female	-	$2.03	$2.15	-	$2.08	$2.13
Other source of income	15.6%	3.3%	3.2%	1.8%	2.8%	6.7%
Average age	21.9	26.9	24.4	24.4	24.6	23.3
Male	100.0%	81.1%	60.2%	100.0%	92.1%	84.4%
Female	0.0%	18.9%	39.8%	0.0%	7.9%	15.6%
Avg years worked in artisanal mining	2.8	3.4	3.2	3.5	3.8	2.5
Began as a minor	28.1%	17.8%	35.2%	37.3%	33.3%	33.3%
Family members in artisanal mining	2.4	2.3	2.6	2.3	2.0	2.4
Avg hours worked per day	11.6	8.9	8.7	8.6	8.8	8.7
Literate	78.1%	83.3%	47.7%	47.8%	81.0%	77.8%
Avg years of school completed	4.8	4.4	2.6	3.2	4.6	3.7
Free to do other work	46.9%	50.0%	11.4%	22.4%	27.0%	24.4%
Chronic physical ailment or injury	84.4%	56.7%	67.0%	70.1%	68.3%	57.8%
Access to medical care	93.8%	100.0%	100.0%	100.0%	100.0%	100.0%
Suffer threats or abuse	46.9%	57.8%	73.9%	55.2%	77.8%	68.9%
Penalized for not working hard enough	53.1%	53.3%	19.3%	32.8%	23.8%	26.7%
Would rather quit but cannot	34.4%	74.4%	71.6%	70.1%	63.5%	75.6%
Belong to a trade union	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

(Continued)

	UCK	Shabara	Tilwezembe	Tenke-Fungurume	Other ASM sites
Number of respondents	139	178	23	88	82
Forced labour	50.4%	52.2%	60.9%	34.1%	25.6%
Child labour	8.6%	8.4%	8.7%	9.1%	11.0%
Debt bondage	4.3%	16.9%	0.0%	0.0%	0.0%
Human trafficking	0.0%	1.7%	0.0%	0.0%	3.7%
Like the work	23.0%	18.0%	4.3%	9.1%	12.2%
Written agreement for job	0.0%	0.0%	0.0%	0.0%	0.0%
Began due to survival or lack of alt	86.3%	88.8%	87.0%	78.4%	86.6%
Average daily income	$4.14	$3.99	$3.24	$3.46	$2.45
Male	$4.28	$3.99	$3.24	$3.57	$2.87
Female	$2.18	-	-	$2.05	$1.67
Other source of income	4.3%	7.3%	8.7%	11.4%	8.5%
Average age	23.8	26.1	21.2	24.2	23.8
Male	94.2%	100.0%	100.0%	93.2%	64.6%
Female	5.8%	0.0%	0.0%	6.8%	35.4%
Avg years worked in artisanal mining	2.8	3.4	2.6	3.3	3.1
Began as a minor	25.2%	16.3%	30.4%	35.2%	37.8%
Family members in artisanal mining	2.8	2.5	3.2	2.8	3.1
Avg hours worked per day	10.5	9.9	10.1	10.3	8.6
Literate	82.0%	91.0%	78.3%	72.7%	51.2%
Avg years of school completed	4.6	4.7	4.0	3.8	2.6
Free to do other work	18.7%	9.6%	13.0%	29.5%	14.6%
Chronic physical ailment or injury	65.5%	69.7%	65.2%	58.0%	56.1%
Access to medical care	96.4%	95.5%	87.0%	100.0%	68.3%
Suffer threats or abuse	51.8%	68.0%	82.6%	55.7%	69.5%
Penalized for not working hard enough	52.5%	65.2%	69.6%	36.4%	25.6%
Would rather quit but cannot	71.9%	59.6%	78.3%	69.3%	78.0%
Belong to a trade union	0.0%	0.0%	0.0%	0.0%	0.0%

A. Kasulo

"I fear to die in the tunnel."

- A tunnel digger in the Kasulo neighbourhood of Kolwezi, age 17

Kasulo is a neighbourhood in the northeast of Kolwezi, and it is ground zero for tunnel digging. In 2014, residents of Kasulo uncovered substantial cobalt reserves beneath their homes. This discovery led to a surge in tunnel digging by artisanal miners, turning the neighbourhood into a chewed-up zone of makeshift mines. There are between one and two thousand tunnels as deep as sixty meters in Kasulo, all of which have been excavated by hand. Pink tarps typically mark the entrance to a tunnel, to help prevent people from falling into them during the night. The entire area has become a frenetic scene of scrounging, digging, and dying for cobalt.

A tunnel shaft excavated by artisanal miners in Kasulo.

Typically, thirty or more diggers work underground in a single tunnel for twelve or more hours at a time. They excavate a primary shaft straight down, until they find a vein of heterogenite ore, which they follow in whatever direction it might lead. It is the job of the “attacker” to lead the group through the tunnel shafts and determine how far they should follow the heterogenite vein.

The tunnels in Kasulo do not have supports, rock bolts, or ventilation shafts. The diggers use small lights attached to a headband to see while they are underground, as they hack at the walls of a tunnel shaft to extract heterogenite ore. The ore is then loaded into raffia sacks and pulled up to the surface by ropes. While in the tunnels, the diggers cannot sit upright, and are forced to breathe toxic particulates the entire time.

Inevitably, a tunnel collapses, burying alive most everyone underground at the time. Wives lose husbands, and mothers lose sons in the most excruciating manner. “The day my son died, I died”, explained one mother who lost her son to a tunnel collapse in Kasulo. Most bodies are never recovered and cannot receive proper burial rights. There is no known estimate of how many diggers have been buried alive in Kasulo, but the number is likely more than a thousand. “When there is death, we do not talk about it”, explained one digger.

Many tunnel diggers drink heavily and abuse narcotics to numb their fears of being buried alive. Others put their faith in God, and many indicated they did not eat food prepared by a woman having her period while digging in a tunnel, out of a superstition that this would lead to a collapse. The tunnel diggers interviewed explained to our researchers that they took the risk of digging in tunnels because the potential to earn substantial income is greater in Kasulo than anywhere else in the cobalt mining provinces. The high grade of cobalt under Kasulo – upwards of 15% to 20% - means that an artisanal miner can earn five or ten dollars in a day, a far greater sum than artisanal miners elsewhere in the DRC.

In 2017, Congo Dongfang Mining (CDM), a subsidiary of China's Huayou Cobalt, was granted a cobalt mining concession in the heart of Kasulo. More than 550 households in the neighbourhood were displaced, and CDM erected an artisanal mining operation in the area. The author investigated the site and reported in *Cobalt Red* that there were several hundred tunnels inside the complex, no safety equipment, and that debt bondage was a common mode of labour exploitation. CDM officials provided advances to a team of diggers prior to tunnel excavation, which could take a month or more to yield a heterogenite vein, after which the diggers were forced to sell their production to CDM for rates up to 30% lower than rates outside of CDM’s concession.

There are approximately 14,000 to 16,000 artisanal miners working in the Kasulo neighbourhood (excluding those in the CDM concession) on any given day. They are mostly adult males and teenage boys, due to the strength required to excavate a tunnel by hand. Workers sell their production to depots scattered across the neighbourhood, almost all of which are managed by agents working for CDM.

Researchers watched on several occasions as trucks from the CDM concession hauled the artisanal production from these depots into the concession, presumably to be added to the production inside the concession and trucked to Lubumbashi for processing at CDM's processing facility.

Kasulo is heavy guarded by a mix of FARDC and Republican Guard, which made access challenging for our researchers. Accordingly, the number of respondents in Kasulo is lower than other major sites.

The CDM concession in the heart of Kasulo.

The following table presents the data from Kasulo:

Table 11: Labour survey, Kasulo

	Kasulo
Number of respondents	32
Forced labour	37.5%
Child labour	9.4%
Debt bondage	31.3%
Human trafficking	0.0%
Like the work	40.6%
Written agreement for job	0.0%
Began due to survival or lack of alt	50.0%
Average daily income	$4.77
Male	$4.77
Female	-
Other source of income	15.6%
Average age	21.9
Male	100.0%
Female	0.0%
Avg years worked in artisanal mining	2.8
Began as a minor	28.1%
Family members in artisanal mining	2.4
Avg hours worked per day	11.6
Literate	78.1%
Avg years of school completed	4.8
Free to do other work	46.9%
Chronic physical ailment or injury	84.4%
Access to medical care	93.8%
Suffer threats or abuse	46.9%
Penalized for not working hard enough	53.1%
Would rather quit but cannot	34.4%
Belong to a trade union	0.0%

Forced labour (37.5%) and child labour (9.4%) were close to the average for the project; however, Kasulo had the highest rate of debt bondage (31.3%) of any major site documented. Whereas artisanal miners inside the CDM concession took advances from the company, in the broader neighbourhood of Kasulo the diggers were provided advances from "sponsors" who were typically the owners of the homes in which the tunnel was being excavated. The sponsors, or agents working for them, took the diggers' production to sell at the depots in Kasulo and reported the price obtained, out of which the diggers usually received a 40% or 50% share. The remainder was a wage deduction for the advance. Although it is impossible to know for certain, it is probable based on anecdotal evidence that the sponsors or their agents reported a lower income from the sale of heterogenite ore than they received, which is another tactic for extracting more labour value out of the diggers than the value of their advance.

Kasulo had the highest rate of any major site at which the respondents reported that they liked the work (40.6%). The result is likely a function of the fact that Kasulo had the highest average daily incomes ($4.77) of any major site documented. Only half the respondents reported starting to work as artisanal miners due to a need to survive, a lower proportion than other sites. This result is likely explained by the fact that many artisanal miners were drawn to Kasulo by the prospect of "riches", hence they made a voluntary choice to start the work, as opposed to one driven by the duress of extreme poverty. Kasulo had the highest rate of respondents who had an alternate source of income (15.6%), as many of the diggers used their elevated incomes to start side businesses, such as selling alcohol or digging equipment.

Kasulo had the longest workday at 11.6 hours, driven by the fact that some diggers can spend up to 18 or more hours at a time inside a tunnel. Diggers in Kasulo reported higher rates of being able to pursue other work (46.9%). They also reported the highest rate of chronic illness or injury (84.4%) of any major site documented. Injuries consisted of lacerations, broken bones, respiratory ailments, skin diseases, hernias, and vision impairment. The high prevalence of injuries is a direct result of tunnel digging. Some diggers fall down shafts, and many others cut themselves while excavating the tunnel or mining a heterogenite vein. Respiratory ailments were most certainly a function of having to breathe a high level of toxic particulates and dust while working inside the tunnels.

Threats and abuse (46.9%) and penalties for not working hard enough (53.1%) were received at the hands of sponsors or their agents when production did not meet expectations. Just over a third of

surveyed individuals indicated they would rather quit but could not, a relatively low number compared to other sites.

The overall picture of Kasulo is that of a massive gamble. Men and boys risk their lives for the prospect of incomes that are between two or three times more than the incomes of those who dig for cobalt in trenches and pits in other sites in the copper-cobalt provinces.

B. Mutoshi

Mutoshi is a former Gécamines mining concession located northeast of Kasulo. It was originally exploited by the Belgians for gold in the early 1900s. Since 2016, the concession has been operated by CHEMAF in a joint venture with Gécamines. In 2017, CHEMAF began operating a "model mine" for artisanal miners in the community, many of whom lived in the nearby village of Mukoma. The model mine was supposed to improve conditions for artisanal miners by providing security, an electric fence to prevent unauthorized individuals and children from working at the site, the provision of safety equipment, fair wages, and health and sanitation facilities. The author revealed in *Cobalt Red* that many of these aspirations were on paper only. The site was not secured by an electrified fence, children dug on the site or sold their production to CHEMAF, and wages often went unpaid for weeks or months at a time. There were, however, definite improvements in the safety of women and girls from gender-based violence. Improved sanitation also helped reduce illness. The model mine ceased functioning in 2020, and the site reverted to an open space for artisanal production.

At the time of our research, artisanal miners at Mutoshi were organized under one of three artisanal mining cooperatives: the Coopérative Minière Artisanale de Kolwezi (COMAKOL), the Coopérative Minière Batoto ya Ruwe pour le Développement (CMBRD), and the Coopérative Minière Artisanale Umoja (COMIAU). Each cooperative registered individuals to work and provided them with a *carte d'enregistrement* [registration card] that authorized them to enter the site. Although children were not permitted to work for the cooperatives, many teenagers provided voter ID cards that showed their age to be 18 years, when they were in fact younger. In addition, children as young as thirteen and fourteen were seen walking into the site to dig from areas other than the main security entrance.

Cooperative officials at the site informed the researchers that the concession was subdivided into four sectors: (1) Kafiato, which is the local name of a product derived from copper, (2) Mutoshi-Cobalt which is where most of the cobalt-bearing ore is located, (3) "100 bags," because when workers dig for gold in the area it is necessary to fill 100 bags to find 1 gram of gold, and (4) "Ramblée

23," which means storage number 23. Based on the information provided by the cooperatives, between 15,000 and 16,000 individuals work at Mutoshi, although the number of actual diggers at the site is probably greater. None of the artisanal miners at Mutoshi have safety equipment.

Researchers visited all four areas at the Mutoshi mine but focused on the cobalt-producing sections. There was a noticeable lack of sanitation and potable water. There was only one toilet at the site, which the artisanal miners were not allowed to use as it was restricted to cooperative staff. Females involved in washing ore in three putrid pools of water complained of an array of ailments, including gynaecological problems, reproductive issues (birth defects and stillbirths), dysentery, dermatitis, and urinary tract infections. One woman explained: "My baby was born without a mouth." The infant died shortly after birth.

The formal workday at Mutoshi is from 7:30 a.m. to 4:00 p.m., although many diggers indicated that they worked well into the night or during night shifts. Many artisanal miners at Mutoshi reported harassment by state services, including the Mining Police, the National Intelligence Agency, and SAEMAPE officials. The officials extorted bribes from the artisanal miners to supplement their incomes. "Whenever we see them, we become nervous", explained one of the male diggers at Mutoshi. "They will always make us pay CF 200 [$0.08]." Cooperative officials did not intervene in the shakedowns, leaving the workers with even less income for their daily toil.

At the end of each day, extracted and washed ore was loaded onto trucks and taken to an offsite depot where it was measured for grade, crushed, and sent to the CHEMAF processing facility in Lubumbashi. Artisanal miners were paid based on weight and grade, as reported by cooperative officials.

The "Mutoshi-Cobalt" zone inside the Mutoshi concession.

The following table presents the data from Mutoshi:

Table 12: Labour survey, Mutoshi

	Mutoshi
Number of respondents	90
Forced labour	45.6%
Child labour	7.8%
Debt bondage	24.4%
Human trafficking	0.0%
Like the work	21.1%
Written agreement for job	0.0%
Began due to survival or lack of alt	87.8%
Average daily income	$3.40
Male	$3.69
Female	$2.03
Other source of income	3.3%
Average age	26.9
Male	81.1%
Female	18.9%
Avg years worked in artisanal mining	3.4
Began as a minor	17.8%
Family members in artisanal mining	2.3
Avg hours worked per day	8.9
Literate	83.3%
Avg years of school completed	4.4
Free to do other work	50.0%
Chronic physical ailment or injury	56.7%
Access to medical care	100.0%
Suffer threats or abuse	57.8%
Penalized for not working hard enough	53.3%
Would rather quit but cannot	74.4%
Belong to a trade union	0.0%

Researchers surveyed 90 respondents in the Mutoshi concession, out of which 45.6% were forced labour and 7.8% were child labour. Mutoshi also had the second highest level of debt bondage behind Kasulo at 24.4%. In this case, advances were provided by cooperatives when workers first arrived, or loans were provided at some subsequent point, typically so that an individual could meet basic subsistence needs, confirmed by the fact that 87.8% of respondents began working at Mutoshi due to a lack of any reasonable alternative means of survival. Wages were deducted and underpaid, and respondents reported that coercive tactics and threats were used to compel the individual to continue working off the debt far beyond the value of the initial advance.

Average daily incomes were $3.69 for males and $2.03 for females. Women tended to wash and sort ore after it was excavated. Researchers only saw a few relatively shallow (10m) tunnels at the Mutoshi site.

Only 3.3% of respondents reported having an alternate source of income, hence Mutoshi was their sole means of survival. A relatively low 17.8% of artisanal miners at Mutoshi began work as minors. The workday was around nine hours, which was slightly longer than the formal working hours of the mine. Self-reported literacy was 83.3%, with about 4.4 years of schooling completed on average. More than half (56.7%) of respondents reported chronic illnesses or injuries, most of which related to respiratory issues, back and neck injuries, and the aforementioned ailments faced by female workers who washed ore. All workers stated they had access to medical care at the Mutoshi concession, although the small medical clinic on site was only equipped to handle minor injuries. Almost six-in-ten (57.8%) respondents reported suffering threats and abuse, all of which came from cooperative managers, along with the daily harassment from state services. More than half (53.3%) of respondents suffered penalties if a cooperative official felt they were not working hard enough, usually in the form of reduced or denied wages. Finally, three quarters (74.4%) of interviewees indicated they would rather quit working at Mutoshi but felt they could not, due to the lack of an alternative means of survival.

C. Kapata and environs: KCC, Mashamba East, Kamilombe

Kapata is a large village/peri-urban area in the southwestern corner of Kolwezi. The village is surrounded by enormous industrial mining operations in every direction except to the south, where it is bordered by Lake Kabulungu. Working clockwise from west to east, the major industrial mines surrounding Kapata are: Dikuluwe, SICOMINES, Mashamba West, Mashamba East, and Kamoto Copper Company (KCC). The greenfield copper mine, Kamoa-Kakula is farther west from Kapata. Although artisanal miners work in and around all the mines that border the village, the largest numbers can be found at KCC, Mashamba East, and Kamilombe, hence these were the areas investigated by the researchers. Pollution from these industrial mines, including dust and toxic particulates, is a major cause of distress and ill-health for the residents of Kapata. Water from the lake, as well as from wells inside the village of Kapata were sampled as part of our project (see section 11 below).

Kapata is a heavily crowded area. It suffers from a shortage of housing, basic infrastructure, and sanitation to accommodate the 40,000+ people who live in the village, which includes a large migrant population, as well as hundreds of orphans. Most of the homes in Kapata are made of red bricks or wood, with corrugated metal sheets for roofing. A small, brick home of no more than 150 square feet might have five or six people living in it. There is a central marketplace in the village, as well as a government administrative building. Irrigation is achieved through alley-side ditches that invariably overflow during the rainy season. Stray electric wires snake through the village and provide intermittent electricity. There are a few community health centres in Kapata, the primary one being the Kapata Health Centre; however, the clinics lack adequate staffing of physicians and basic medical supplies.

Kapata was originally established by Gécamines in the 1970s to house the workers at the KCC mine. Workers were provided with a brick home, food rations, schooling for children, as well as training and reasonable wages. Like many other copper mining areas, once Gécamines collapsed in the 1990s, the local population was left to fend for themselves, often resorting to artisanal mining. With the cobalt boom, industrial mines have swallowed the territory around Kapata, which has in turn seen an influx of migrants attracted to the prospect of earning a few dollars a day in income.

There are a few schools in the village, the most well-equipped of which is the Kabulungu School; however, most schools are typically closed for days or even weeks at a time when teachers are not paid. The proximity of the mines to the village means that thousands of school-age children attend a few hours of school during the day, then dig for cobalt in the evenings to help support their families. Men and teenage boys are typically involved with tunnel digging, while women and girls dig at the surface or wash the stones gathered by their male family members. Much of this washing used to take place at the highly toxic Lake Malo that formed during the rainy season each year, but much of that area has been reduced to a muddy slop following years of runoff from the adjacent KCC pit wall.

Although KCC and Mashamba East both have border walls of roughly 3 meters in height, they are regularly scaled by artisanal miners, who excavate inside the mines. Per anecdotal reports from Kapata residents, these artisanal miners either sell their production directly to the mines inside the concession, or to depots operated by agents for the mines just outside the concession walls. Most of these depots are operated by Congolese and Chinese buyers. Research teams watched with ease as artisanal miners scaled down the walls of KCC with their sacks of cobalt and sold them to the depots, where trucks loaded the sacks at the end of the day. Much of the ore from mines around Kapata is processed at the nearby Kamoto Concentrator and Luilu metallurgical plants in Kolwezi.

Children dig for cobalt inside the KCC pit wall. They also climb over the border fence at the top of the wall to dig inside the concession. Ore is then sold to depots (below), just outside the concession.

Glencore owns 75% of KCC and Mashamba East, through its 100% ownership of a subsidiary, Katanga Mining, which in turn manages the mines and the processing facilities. There are between 5,000 and 6,000 artisanal miners each who work in and around KCC and Mashamba East. There are no cooperatives operating at KCC or Mashamba East.

Depots outside the KCC concession.

Kamilombe is a nearby artisanal mining area east of KCC, established in 2001. The name Kamilombe refers to a river that flows at the western boundary of the mine. Kamilombe is owned by Congo Dongfang Mining. In 2011, artisanal mining activities at Kamilombe were organized under the Coopérative Minière pour le Développement et le Social (CMDS), with security enforcement provided by the FARDC. Fencing was erected at the border of the mine around 2019.

Cooperative agents and artisanal miners reported that between 7,000 and 8,000 workers were registered to dig at Kamilombe, although our researchers estimated the number to be closer to 10,000. None of the workers have safety equipment. There are a few toilets at the site, but they are only accessible to cooperative staff. Cooperatives pay the diggers for their production based on weight and grade, although several respondents stated that they were paid sub-market rates. “The soldiers force us to sell the cobalt at this place for lower prices”, complained one artisanal miner. Numerous artisanal miners who worked inside Mashamba East made the same complaint.

Researchers noted that most of the production from Kamilombe was sold by the cooperatives to Chinese buyers inside the concession area. The Chinese buyers in all likelihood represented CDM, the owner of the mine. Although researchers did not follow the transport of minerals from Kamilombe to processing facilities, it is probable that CDM transported the ore to its processing facility in Lubumbashi, along with the production from the Kasulo artisanal mining area. Researchers were told repeatedly by community members of tunnel collapses inside Kamilombe, which would have claimed hundreds of lives.

The following table presents the data from the broader Kapata mining area:

Table 13: Labour survey, Kapata Area

	KCC	Mashamba East	Kamilombe
Number of respondents	88	67	63
Forced labour	29.5%	28.4%	12.7%
Child labour	11.5%	9.0%	7.9%
Debt bondage	0.9%	1.5%	0.0%
Human trafficking	0.0%	0.0%	0.0%
Like the work	14.2%	16.4%	12.7%
Written agreement for job	0.0%	0.0%	0.0%
Began due to survival or lack of alt	89.8%	91.0%	92.1%
Average daily income	$3.26	$3.38	$3.35
Male	$3.96	$3.38	$3.43
Female	$2.15	-	$2.08
Other source of income	3.2%	1.8%	2.8%
Average age	24.4	24.4	24.6
Male	60.2%	100.0%	92.1%
Female	39.8%	0.0%	7.9%
Avg years worked in artisanal mining	3.2	3.5	3.8
Began as a minor	35.2%	37.3%	33.3%
Family members in artisanal mining	2.6	2.3	2.0
Avg hours worked per day	8.7	8.6	8.8
Literate	47.7%	47.8%	81.0%
Avg years of school completed	2.6	3.2	4.6
Free to do other work	11.4%	22.4%	27.0%
Chronic physical ailment or injury	67.0%	70.1%	68.3%
Access to medical care	100.0%	100.0%	100.0%
Suffer threats or abuse	73.9%	55.2%	77.8%
Penalized for not working hard enough	19.3%	32.8%	23.8%
Would rather quit but cannot	71.6%	70.1%	63.5%
Belong to a trade union	0.0%	0.0%	0.0%

Forced labour was much higher at KCC (29.5%) and Mashamba East (28.4%) than Kamilombe (12.7%). The higher rate of forced labour at these two sites might be a function of the more informal working conditions, which made workers more vulnerable to coercion from soldiers in the area. Numerous artisanal miners at Mashamba East in particular complained of violence committed by FARDC soldiers and mining security as a tactic to maintain control and to make them work harder. "We are struck like beasts by the FARDC," complained one artisanal miner. Alternatively, the lower rate of forced labour at Kamilombe may be the result of the reluctance of workers at the site to report coercion or violence committed against them.

Child labour was highest at KCC (11.5%) and lowest at Kamilombe (7.9%). The higher rate of child labour at KCC is likely a function of the proximity of Kapata village to the mine, as well as the relative ease of scaling the border fence. School closures or the inability of families to pay school fees leave children little option but to walk outside the village and start digging. It must be noted that the rate of child labour in the Kapata area would have been considerably higher, had instances of children working a few hours after school been included. Debt bondage and human trafficking were not common in the mines around Kapata.

Few people reported that they enjoyed working as artisanal miners (around 12-16% at the sites), and roughly 9-in-10 respondents at each site began artisanal mining work due to the lack of an alternative means of survival. Average daily incomes hovered around $3.30, with a high of $3.96 for males at KCC and a low of $2.08 for females at Kamilombe. Virtually no one had an alternate source of income in these areas.

KCC had the highest proportion of female respondents (39.8%) of any site that was documented, which was likely a function of the substantial presence of women and girls who washed stones for artisanal miners in the area. Between a third and 37.3% of surveyed individuals in this area began working as artisanal miners as a child, which is among the highest rates of any area documented.

Self-reported literacy rates were poor among respondents at KCC and Mashamba East (less than half), but considerably higher at Kamilombe. The reason for this variance is not clear, unless it is linked somehow to the operation of the cooperative at Kamilombe.

As expected, the number of years of school completed was poor in KCC (2.6 years) and Mashamba East (3.2 years). Chronic ailments and injuries were indicated in 66-70% of respondents, typically related to gynaecological and reproductive health issues for women and girls, along with urinary tract infections and diarrhoeas. Symptoms of heavy metal poisoning, such as nausea, vomiting, and weakness in the limbs were reported. Male diggers reported dermatitis, broken bones, respiratory ailments (asthma, bronchitis, and lung infections), lacerations, and neck and back injuries. There were also reports of children tumbling down the KCC concession wall while trying to carry a heavy sack of cobalt and suffering shattered legs or spines.

All respondents indicated that they had access to medical care in the village. Around 70% of respondents at KCC and Mashamba East indicated they would prefer to quit working as artisanal miners but were not able to do so, a number that dropped to 63.5% at Kamilombe.

The overall picture at the mines around Kapata was one of a cobalt mining explosion that had become the primary means of survival for thousands of women, men, and children in the village. The residents of Kapata dug, washed, and sold their ore under hazardous, coercive, and at times violent conditions. The FARDC seemed to play a central role in this violence. Having so many major mines right next to a village was also a driving force of child labour in the area. The mining operations had also made Kapata a toxic place to live. The air was constantly hazy and acrid, and anecdotal evidence pointed to an increase in birth defects and low birth weights among the women who lived in Kapata. Parents also complained that their children always seemed sick, whether it was coughs, diarrhoeas, or fevers.

The influx of migrants seeking to participate in the cobalt boom had placed immense pressure on Kapata, which was stretched beyond its limits. Many surveyed individuals complained of rapidly escalating housing costs, which compelled many families to add their children to the workforce. Whether the ore was dug inside a mining concession by artisanal miners or sold to agents right outside of the concession, all the evidence pointed to the fact that all the artisanal production entered the formal supply chains of the major mining companies operating in the area. As one resident of Kapata asked, *“Where else do you think it [the cobalt] goes?”*

D. La Compagnie Minière de Musonoie Global SAS (COMMUS)

The COMMUS mine is situated adjacent to the neighbourhood of Kanina, which is about six miles northeast of Kapata. COMMUS is owned by China-based Zijin Mining in a 72%/28% joint-venture with Gécamines. Zijin bought Huayou Cobalt's share in the mine in 2014 for $77.9 million. The two companies are strategic partners and COMMUS ships much of its cobalt supply to Huayou for refining.

The neighbourhood of Kanina is similar to Kapata. Most of the homes are red brick with corrugated metal roofs. The neighbourhood is heavily overcrowded with poor infrastructure. There are a few schools that operate sporadically. Electricity is inconsistent, and there is no sanitation system in the neighbourhood. Like Kapata, residents in Kanina complained of severe pollution from nearby mines. Dust, particulates, and toxic effluents from the COMMUS concession regularly assault the residents of Kanina. "There are explosions at COMMUS," explained one female resident of Kanina, "There is always dirt and gas clouds floating over us. Look at our clothes. We are covered in poison from that mine!"

In addition to pollution, the COMMUS concession has expanded twice since 2014, destroying close to 1,000 households in Kanina. Many displaced residents complained that they were not provided with the promised compensation and new households in which to live.[61]

COMMUS has its own processing facility on-site, which is the likely source of the yellow gas clouds that waft over Kanina, a toxic byproduct of the treatment of ore bodies with sulfuric acid. Mining activities have led to pollution and contamination of water sources. The largest nearby water body, Lake Golf, was used for several years as a washing area for artisanally mined cobalt by women and children in Kanina. The lake is not used as a washing area as much at present, although it remains a common place for women to wash their clothes. Lake Golf is one of the water bodies sampled for this project (see section 11 below).

Kanina is home to the Bon Pasteur Centre, operated by the Catholic NGO, Le Bon Pasteur (The Good Shepherd). The facility has helped remove more than 1,000 children from artisanal mining and supported their education and development. Bon Pasteur also operates a community health centre in Kanina. There are a small number of other community health centres, such as the government-run Kanina Health Centre, that provide basic medical services, such as maternal care, vaccinations, and treatment for common illnesses. These clinics suffer from a chronic shortage of physicians and medical supplies.

According to the residents of Kanina, about 6,000 to 7,000 people dig as artisanal miners inside the COMMUS concession, separate from the Congolese mining employees who use heavy machinery to extract ore. None of the artisanal miners reported having safety equipment. Anecdotal evidence from these artisanal miners indicated that they worked in groups to extract ore in trenches and tunnels, and that all of their production was sold directly to COMMUS. In addition, hundreds of children from Kanina hand-picked cobalt-bearing stones in large piles of tailings that were dumped outside of the concession wall, which were in turn sold to depots along the roadside operated by Chinese agents.

A child from Kanina has gathered heterogenite from a pile of tailings, instead of attending school.

Many respondents spoke about high levels of violence inside the COMMUS mine. “The guards whip us with ropes”, declared one male respondent. Several surveyed individuals also recounted an episode in which children who picked cobalt stones from tailings were shot by COMMUS security guards when they tried to sell their ore to depots other than the nearby ones operated by Chinese agents. Residents described several riots and protests during the last few years, focused on the expansion of the mine and the pollution it caused in Kanina. Residents also reported that on more than one occasion, gunfire was used by COMMUS security and FARDC soldiers to disperse the protesters.

The following table presents the data from artisanal miners who worked inside the COMMUS concession:

Table 14: Labour survey, COMMUS

	COMMUS
Number of respondents	45
Forced labour	22.2%
Child labour	8.9%
Debt bondage	0.0%
Human trafficking	0.0%
Like the work	11.1%
Written agreement for job	0.0%
Began due to survival or lack of alt	97.8%
Average daily income	$3.35
Male	$3.58
Female	$2.13
Other source of income	6.7%
Average age	23.3
Male	84.4%
Female	15.6%
Avg years worked in artisanal mining	2.5
Began as a minor	33.3%
Family members in artisanal mining	2.4
Avg hours worked per day	8.7
Literate	77.8%
Avg years of school completed	3.7
Free to do other work	24.4%
Chronic physical ailment or injury	57.8%
Access to medical care	100.0%
Suffer threats or abuse	68.9%
Penalized for not working hard enough	26.7%
Would rather quit but cannot	75.6%
Belong to a trade union	0.0%

Out of a total of 45 respondents, a little more than 1-in-5 (22.2%) worked in conditions of forced labour. 8.9% of the respondents were child labourers. There were no instances of debt bondage or human trafficking among the surveyed individuals. Only 11.1% of artisanal miners enjoyed their work, and almost every respondent (97.8%) became an artisanal miner out of a lack of any alternate means of survival. Average daily incomes were $3.58 for males and $2.13 for females. 6.7% of respondents had an alternate source of income, which typically involved a small business or service inside the neighbourhood.

Exactly one-third of interviewees began working as children. Self-reported literacy among the respondents was about 78% with 3.7 years of schooling completed on average. About one-fourth (24.4%) of workers indicated they were free to do some other kind of work. 57.8% of respondents reported a chronic illness or injury, akin to those suffered by artisanal miners in Kapata. All surveyed individuals stated they had access to medical care at community health centres. Almost 7-in-10 (68.9%) respondents endured threats and abuse at work, usually at the hands of guards being directed by Chinese bosses inside the COMMUS concession. As previously discussed, many of these episodes were particularly violent, involving whippings with ropes and beatings with batons. 26.7% of artisanal miners were penalized by their bosses for not working hard enough, and three-fourths of respondents indicated they would rather quit working as artisanal miners but were unable to due to a lack of alternative sources of income.

The dynamics in Kanina were similar to Kapata. Pollution seemed unchecked and violence against the artisanal miners, be it from FARDC or mining security, was reported to be a serious problem. Children were drawn into hazardous labour due to the proximity of the mines to their homes, the inability to attend school, and the need to help with family survival.

E. Usine de Cuivre de Kolwezi (UCK)

Usine de Cuivre de Kolwezi (UCK) is an old Gécamines copper mine in the Kasombo district of Kolwezi, a few miles northeast of the city centre. The site includes a processing facility. Artisanal mining for copper began at the site as early as 2003. The system was informal and at the time, ore was sold to a range of traders, including the military. Artisanal mining at UCK became more structured under Lebanese traders, who managed the site from 2014 to 2018. Artisanal miners soon complained that the Lebanese traders were chronically undervaluing the ore they

excavated, and in 2018, an artisanal mining cooperative, Société Coopérative Minière Kasombo, (SCOMIKAS) replaced the Lebanese traders. SCOMIKAS has managed artisanal mining operations at UCK ever since.

In addition to SCOMIKAS, agents of SAEMAPE, the mining police, and the Congolese secret service are a regular presence at UCK. Respondents complained that they all extracted taxes from them, typically in the range of CF 200 or 250 [$0.08 to $0.10], akin to other cooperative-run sites documented.

SCOMIKAS does not permit women to enter the UCK site, hence washing of ore extracted by artisanal miners at UCK takes place in the nearby Tanla River. The river is also used for bathing, washing clothes, and swimming. There is no potable water available at the site, so many artisanal miners drink water from the river, which is highly polluted. Respondents at UCK had a high prevalence of complaints relating to gastrointestinal issues, such as diarrhoea, cramping, and blood in their stool. The Tanla River is one of the water bodies sampled for this project (see section 11 below).

Researchers were permitted by SCOMIKAS to survey the site, which consisted of groups of men and teenage boys who extracted ore from scores of trenches and tunnels, some of which were more than 30 meters deep. To facilitate conversations, most survey interviews were conducted inside the homes of respondents who worked at UCK. Most of the artisanal miners who worked at UCK lived in the Kasombo district. They typically arrived around 7am or 8am in the morning and presented a registration card to pass through a security entrance that was guarded by the mining police as well as security forces of SCOMIKAS. Most workers left between 5pm and 6pm. Surveyed individuals indicated that several hundred artisanal miners worked each night in the tunnels. “We sleep a few hours,” explained one teenage boy. “We keep digging until the bosses open the gate in the morning.” There were a few makeshift areas at the site where workers were able to rest. A small number of migrants slept in these areas.

Artisanal miners at UCK were paid by SCOMIKAS for their production based on weight and grade of the ore. Child respondents indicated that they had all dropped out of school due to financial pressures faced by their families. There were a few toilets at the site, but SCOMIKAS charged the artisanal miners a high fee of 500 CF ($0.20) to use them. Approximately 8,000 to 9,000 diggers worked at UCK, none of whom had safety equipment.

The following table presents the data from the artisanal miners at the UCK site:

Table 15: Labour survey, UCK

	UCK
Number of respondents	139
Forced labour	50.4%
Child labour	8.6%
Debt bondage	4.3%
Human trafficking	0.0%
Like the work	23.0%
Written agreement for job	0.0%
Began due to survival or lack of alt	86.3%
Average daily income	$4.14
Male	$4.28
Female	$2.18
Other source of income	4.3%
Average age	23.8
Male	94.2%
Female	5.8%
Avg years worked in artisanal mining	2.8
Began as a minor	25.2%
Family members in artisanal mining	2.8
Avg hours worked per day	10.5
Literate	82.0%
Avg years of school completed	4.6
Free to do other work	18.7%
Chronic physical ailment or injury	65.5%
Access to medical care	96.4%
Suffer threats or abuse	51.8%
Penalized for not working hard enough	52.5%
Would rather quit but cannot	71.9%
Belong to a trade union	0.0%

Workers at UCK rest under a makeshift structure; some migrants sleep here.

Research teams were able to survey a larger number (n=139) of artisanal miners working at the UCK mine due to a greater willingness of people to speak as compared to other sites. Roughly half (50.4%) of respondents were in conditions of forced labour: responses showed a higher prevalence of threats and abuse (51.8%) coupled with penalties, at times severe, for not working hard enough (52.5%). Threats, violence, and penalties were typically meted out by the security teams of the cooperative, or by the mining police. Surveyed individuals reported being physically and verbally abused. “They beat us with sticks,” explained one male digger. “If we displease them, they will beat us,” said another. Other penalties included non-payment of wages or restriction from entering the site to work. Child labour was found in 8.6% of survey responses, and there was a small amount of debt bondage (4.3%) at the site.

When they received payments, the male workers were paid relatively well, averaging $4.28 per day. Women and girls who washed stones were paid an average of $2.18 per day. About 1-in-4 (25.2%) respondents began working as artisanal miners as children. Workdays were long, at an average of 10.5 hours. 82.6% of respondents reported being literate, completing an average of 4.6 years of school. About two-thirds (65.5%) of surveyed individuals reported chronic illnesses or ailments, including respiratory diseases, neck and back injuries, dermatitis, hernias, and fractured bones. Gastrointestinal issues were very common among the men who drank from the Tanla River, as well as the women and girls who washed ore in it. Respondents indicated that the lack of access to clean drinking water caused GI issues. Artisanal miners were also charged fees for the use of a toilet. 71.9% of respondents indicated that they would rather quit working as artisanal miners but were unable to do so as they could not otherwise meet subsistence needs.

The artisanal miners at UCK were generally paid better than at other mining sites, but they were heavily surveilled, controlled, and coerced when they did not meet the expectations of the SCOMIKAS cooperative. Although women and girls only accounted for 5.8% of the surveyed individuals at the site, the number was sufficient to confirm a low level of income, as well as gender-based violence committed by the mining police. In the case of UCK, the managing cooperative maintained a strong control of the site and, per the respondents they used threats and violence to maximize the production of the artisanal miners.

F. Shabara

A massive open-pit artisanal mining area at Shabara.

The Shabara artisanal mining area is situated about 30 miles east of Kolwezi. It spans more than 20 square miles in a concession that has been owned by Glencore since 2015 as part of its Mutanda Mining (MUMI) operation. Shabara is north of the main highway near the village of Kawama. The concession is rich in copper-cobalt ore. When artisanal miners first began exploiting the area, the minerals were at surface level and easy to access, so the miners called the site, "Mapapa," meaning “flip-flop shoes,” since that is all the equipment a person needed to gather cobalt from the site.

Shabara is a mixed industrial/artisanal site, although most of the production is artisanal. The site is managed by the Coopérative Minière Artisanale du Katanga (COMAKAT). According to COMAKAT officials, the site produces between 15,000 to 17,000 tons of copper-cobalt ore each month, and there are between 18,000 to 20,000 artisanal miners who work at the site.

Access to the concession is guarded by mining police and private security. SAEMAPE officials are regularly onsite. Excavation takes place in enormous open pits that can be as large as 300 meters across, as well as in scores of tunnels.

There can be several thousand artisanal miners crammed in a single cavernous pit at any time, with barely room to move. Hammers, mallets, and rebar are used to break down boulder-sized ore into pebbles, which are loaded into raffia sacks and carried out of the pit and stored in large depots on site. Interviews with COMAKAT officials confirmed that most of the production from Shabara is sold to Chinese buyers.

The workers at Shabara were all men and boys, as no women are allowed to enter the site. None of the artisanal miners had safety equipment. There were several toilets available for the diggers to use without a fee. Potable water was also available. Most artisanal miners worked about ten hours a day, from 7am to 5pm. Most workers lived in Kawama and a few surrounding villages. Some had migrated from distant regions and live in nearby encampments.

Kawama village had a primary and secondary school, as well as a community health centre. There was considerable pressure on the village, given an influx of migrants into the area. Most dwellings were wooden and brick, built around dozens of termite mounds.

The following table presents the data from the artisanal miners interviewed at the Shabara site:

Table 16: Labour survey, Shabara

	Shabara
Number of respondents	178
Forced labour	52.2%
Child labour	8.4%
Debt bondage	16.9%
Human trafficking	1.7%
Like the work	18.0%
Written agreement for job	0.0%
Began due to survival or lack of alt	88.8%
Average daily income	$3.99
Male	$3.99
Female	-
Other source of income	7.3%
Average age	26.1
Male	100.0%
Female	0.0%
Avg years worked in artisanal mining	3.4
Began as a minor	16.3%
Family members in artisanal mining	2.5

(Continued)

	Shabara
Avg hours worked per day	9.9
Literate	91.0%
Avg years of school completed	4.7
Free to do other work	9.6%
Chronic physical ailment or injury	69.7%
Access to medical care	95.5%
Suffer threats or abuse	68.0%
Penalized for not working hard enough	65.2%
Would rather quit but cannot	59.6%
Belong to a trade union	0.0%

Research teams collected data from a total of 178 respondents at Shabara. Forced labour was identified for about half (52.2%) of these respondents, reflecting high levels of threats and abuse (68.0%) and penalties for not working hard enough (65.2%). Even though workers were interviewed onsite, many complained vocally about beatings and abuse. “We are beaten as slaves!” explained one respondent. “We are beaten without reason”, said another. Other punishments included the denial of water, use of the toilets, or eviction without pay. Under the guise of a well-regulated cooperative operation, the site had harsh conditions, chronic abuse, and coercive tactics used to extract maximum production from the workers.

Children accounted for 8.4% of surveyed individuals and 16.9% of responses involved debt bondage. The instances of debt bondage involved advances paid by COMAKAT to artisanal miners, who were coerced to work off the debts in exploitative conditions. There was also a small percentage of human trafficking (1.7%) at Shabara, involving recruiters who brought workers to Shabara with false promises, only to end up in forced labour conditions.

Although daily incomes averaged $3.99, many respondents complained that they were cheated on the grade of the ore they extracted. “COMAKAT will never pay more than 3% [grade],” explained one artisanal miner. Several interviewees stated that they had snuck out small pieces of ore and had it tested at depots near Kawama or along the main highway, which came back with readings of between 10% and 17%.

About 7-in-10 (69.7%) respondents reported a chronic illness or injury, second only to Mashamba East in terms of the major sites sampled in Lualaba province. Complaints ranged from coughs and

skin disease to broken bones, and lacerations. GI issues were prevalent as well, likely caused by drinking and washing in polluted water near Kawama (which was sampled for this project).

Almost 9-in-10 (88.8%) respondents began working as artisanal miners due to the lack of an alternative means of survival. A smaller portion of respondents began as children (16.3%) than other sites that were documented. Literacy rates were 91.0%, with an average of 4.7 years of schooling completed. Only 9.6% of surveyed individuals reported being free to do other work. About 6-in-10 (59.6%) indicated a preference of quitting the work but being unable to do so.

Like UCK, Shabara was a productive artisanal mining area with relatively better wages paid compared to other sites. Also like UCK, the managing cooperative was using threats, coercion, violence, and exploitative tactics to maximize production while minimizing labour costs. This dynamic reinforced a common theme among many artisanal mining cooperatives operating in the copper-cobalt provinces: profits at high cost to the artisanal miners.

G. Tilwezembe

Tilwezembe is one of the most notoriously violent, secretive, and exploitative artisanal mines in Lualaba Province. It is located about 18 miles east of Kolwezi, a little over a mile south of the main highway near the village of Mupanja. Mupanja is smaller than Kawama, but it is similarly bursting at the seams with an influx of migrants working at artisanal mines. Most homes in the village are made of brick with corrugated metal roofing. There is no functioning school in the village, and there is only one community health centre. The Lualaba River snakes southward just east of Tilwezembe. A hydroelectric dam in the area formed a lake called Lake Nzilo, or "new lake." The Lualaba River and Lake Nzilo, which were sampled for this project, are both heavily polluted by toxic effluents from nearby industrial mines.

Tilwezembe is owned 75% by Glencore and 25% by Gécamines. Industrial excavation ceased at Tilwezembe in 2008, and artisanal mining began soon after. The BBC aired an episode of its documentary series, *Panorama*, on April 15, 2012, that highlighted Glencore's role in child labour at Tilwezembe.[62]

The mine remains heavily guarded by FARDC, and access is impossible for outsiders. Interviews with individuals who worked inside Tilwezembe also proved challenging, due to intense surveillance in the area by FARDC and a fear on the part of workers to speak. Research teams managed to complete 23 surveys with individuals working inside Tilwezembe, and they reinforced the mine's bleak reputation.

The path to Tilwezembe, through the village of Mupanja.

Men and boys work at Tilwezembe under the management of two cooperatives: Coopérative Minière Maadini kwa Kilimo (CMKK) and Coopérative Minière KUPANGA (COMIKU). COMIKU is owned by Yves Muyej, one of the sons of the first governor of Lualaba province, Richard Muyej. CMKK was established by officials in former president Joseph Kabila's inner circle. Excavation is almost entirely by tunnels, with some digging in pits as well. There are a few areas in the mine in which independent "bosses" operate, most of whom are Congolese or Lebanese.

Based on information provided by surveyed individuals, about 13,000 to 15,000 artisanal miners work at Tilwezembe. Most of them work in groups to excavate tunnels, of which the researchers were told there were several hundred. Interviews also revealed that the primary buyers of the cobalt mined at Tilwezembe appear to be Chinese mining companies. Supply chain tracing of cobalt from Tilwezembe was too risky to undertake. Researchers did, however, observe large cargo trucks loaded with ore exiting Tilwezembe for the main highway, heading both west to Kolwezi and east to Lubumbashi.

The following table presents the data from the artisanal miners who worked at Tilwezembe:

Table 17: Labour survey, Tilwezembe

	Tilwezembe
Number of respondents	23
Forced labour	60.9%
Child labour	8.7%
Debt bondage	0.0%
Human trafficking	0.0%
Like the work	4.3%
Written agreement for job	0.0%
Began due to survival or lack of alt	87.0%
Average daily income	$3.24
Male	$3.24
Female	-
Other source of income	8.7%
Average age	21.2
Male	100.0%
Female	0.0%
Avg years worked in artisanal mining	2.6
Began as a minor	30.4%
Family members in artisanal mining	3.2
Avg hours worked per day	10.1
Literate	78.3%
Avg years of school completed	4.0
Free to do other work	13.0%
Chronic physical ailment or injury	65.2%
Access to medical care	100.0%
Suffer threats or abuse	82.6%
Penalized for not working hard enough	69.6%
Would rather quit but cannot	78.3%
Belong to a trade union	0.0%

Acknowledging that 23 respondents is a small sample, the data from these individuals nevertheless confirm Tilwezembe's reputation as a brutal place to work. 60.9% of respondents met the criteria for forced Labour, a function of threats and abuse among 82.6% of respondents and penalties among 69.6%. One surveyed individual summarized the kind of abuse the artisanal miners received: "They whip us and lock us in detention like slaves." Several artisanal miners described being locked inside a shipping container called a *cachot* ("dungeon") without food or water for up to two days. Other surveyed individuals described being whipped and beaten. Denial of payment for work was another common complaint.

Child labour was found in 8.7% of survey responses. Statements from interviewees indicated that more than 1,000 children work at the site. There were also reports of several large groups of children (20 or more) working together. Younger children from age 10 to 14 dug in trenches and pits, after which age they became strong enough to start digging in tunnels. There were no instances of debt bondage or human trafficking recorded in survey responses. Only 4.3% of respondents reported enjoying their work, the lowest of any major site documented. Almost 9-in-10 respondents (87.0%) respondents began working at Tilwezembe out of a lack of any alternative means of survival. Average incomes were modest at $3.24 per day. The average age at Tilwezembe was the youngest of any site documented at 21.2 years, although the smaller sample size must again be noted. About 3-in-10 (30.4%) respondents began working as artisanal miners as children. Literacy was lower than most sites at 78.3%.

Almost 2-in-3 (65.2%) surveyed individuals suffered from chronic illnesses or ailments similar to those documented at other artisanal mining areas, including fractures, neck and back injuries, hernias, and respiratory ailments. 78.3% of respondents indicated they would rather quit working as artisanal miners but felt they were unable to do so, second only to Kikwanda in Haut-Katanga province.

More research needs to be completed on the conditions at Tilwezembe. Reports of horrific injury, death, and violence have persisted at the site for years, under the auspices of an artisanal mining cooperative that is supposed to help improve conditions for artisanal miners. There is a well-developed system of transporting artisanal miners by motorbike in and out of the mine for work, and children can often be seen entering through the main security entrance (which is guarded by FARDC) in large numbers.

H. Tenke-Fungurume

The Tenke-Fungurume Mine (TFM) is the largest cobalt mining concession in the DRC. At more than 1,500 square kilometres, the concession is roughly the size of London. It is bordered to the south by the town of Fungurume and to the west by the town of Tenke. The northern border consists of hills and forest. TFM has its own residential commune for foreign workers, as well as a private landing strip.

The populations of Fungurume and Tenke, as well as several surrounding villages, have swelled from about 50,000 in 2015 to more than 420,000 in 2025, placing considerable pressure on housing, infrastructure, and employment. Thousands of residents earn a living through artisanal mining in the TFM mine, primarily in pits and tunnels. There are very few alternatives in the area. As one male respondent from Fungurume explained, "I do this work so I don't have to beg."

Residents in Fungurume spoke of a tacit agreement with the owner of the mine, China Molybdenum Company (CMOC), that they will not meddle with equipment or dig in excessive numbers, in exchange for access to the concession. However, there is ongoing friction between CMOC and the local population, especially when artisanal miners enter the site in large numbers. CMOC has often requested the assistance of the FARDC in expelling artisanal miners from the concession, leading to flare-ups in violence and gunfire.[63] Tensions have also run high between TFM and the residents of Fungurume relating to pollution from the mine, forced evictions, and protests that they have not fairly benefited from the profits CMOC has generated from its operations. Congolese employees and subcontracted workers at the TFM concession as well have lodged complaints about poor wages, forced overtime, and slave-like working conditions.[64]

CMOC acquired Freeport-McMoRan's 56% stake in TFM in 2016 for $2.65 billion, ending the presence of any US-based mining company in the DRC. In 2019, CMOC increased its ownership to 80% by purchasing an additional 24% stake from BHR Partners, with Gécamines retaining the remaining 20%. In 2022, disputes arose between CMOC and the DRC government over royalty payments and production reporting, leading to temporary government seizure of the mine. A resolution was reached in 2023, allowing CMOC to continue operations while agreeing to higher payments to the DRC government.[65]

In 2020, CMOC acquired the nearby Kisanfu concession for $550 million. Kisanfu is a significant untapped resource, as it contains one of the world's largest undeveloped reserves of cobalt and copper. In 2021, Chinese battery maker CATL, acquired a 25% stake in Kisanfu through a joint venture with CMOC, further consolidating China's stranglehold on the EV supply chain.

Combined, Fungurume and Tenke have numerous schools and community health centres; however, the facilities are deeply insufficient to meet the needs of the swelling populations of the towns. Both towns face considerable pollution from CMOC's mining operations. In particular, Tenke is situated just west of CMOC's processing facility, and large portions of the town are often draped in sulfuric acid dust that goes uncontained during mineral processing.

Children in Tenke covered in sulfuric acid dust that wafts over the town from the CMOC processing facility.

The following table presents the data from the artisanal miners who dig on the TFM concession:

Table 18: Labour survey, Tenke-Fungurume

	Tenke-Fungurume
Number of respondents	88
Forced labour	34.1%
Child labour	9.1%
Debt bondage	0.0%
Human trafficking	0.0%
Like the work	9.1%
Written agreement for job	0.0%
Began due to survival or lack of alt	78.4%
Average daily income	$3.46
Male	$3.57
Female	$2.05
Other source of income	11.4%
Average age	24.2
Male	93.2%
Female	6.8%
Avg years worked in artisanal mining	3.3
Began as a minor	35.2%
Family members in artisanal mining	2.8
Avg hours worked per day	10.3
Literate	72.7%
Avg years of school completed	3.8
Free to do other work	29.5%
Chronic physical ailment or injury	58.0%
Access to medical care	100.0%
Suffer threats or abuse	55.7%
Penalized for not working hard enough	36.4%
Would rather quit but cannot	69.3%
Belong to a trade union	0.0%

Of the 88 respondents surveyed, 31.4% of met the criteria for forced Labour and 9.1% for child labour. There were no instances of debt bondage or human trafficking among the individuals documented. About 1-in-10 (9.1%) respondents reported that they liked work as artisanal miners, and about 8-in-10 (78.4%) began working as artisanal miners due to a lack of an alternative means of survival. Average daily incomes were $3.46 for males and $2.05 for females. Women and girls earned money by washing ore in polluted streams outside of the concession, after which the sacks were primarily sold to depots managed by Chinese agents in Fungurume and along the main highway. Researchers observed CMOC trucks loading ore from these depots on three occasions and transporting them into the TFM concession.

11.4% of artisanal miners had an alternate source of income, which typically involved a small business or service in the towns, such as selling produce, pots and pans, or fixing mechanical equipment. 35.2% of respondents began working as artisanal miners as children. Days were long at 10.3 hours, which did not include the time it took to walk to and from digging areas inside the concession, which could be up to an hour in each direction. Injuries and ailments (58.2%) included the typical respiratory issues, fractures, skin problems, gynaecological and reproductive health issues, and urinary tract infections. About 7-in-10 (69.3%) surveyed individuals indicated they would rather quit working as artisanal miners but felt they could not do so due to a lack of alternatives.

The towns of Tenke and Fungurume are two more examples of the kinds of pressures placed on the local population in the copper-cobalt mining provinces by the scramble for cobalt. Pollution, population displacement, insufficient alternatives for survival, and friction between locals and mining companies has led to a destabilization in the livelihoods of the Congolese people in the area. Although researchers were not able to sample water bodies in the area for the project, they received numerous anecdotal reports of GI issues and skin diseases from those who bathe, swim, or wash clothes in the streams outside of the concession.

I. Other ASM sites in Lualaba Province

The research teams surveyed a total of 82 additional respondents in 55 other artisanal mining sites in Lualaba province. These sites were primarily in and around Kolwezi and remote areas in between Kolwezi and Fungurume.

Some of the sites were up to 15 miles north or south of the main highway in remote areas. Accessing these sites was challenging and time consuming, and workers were distrustful of outsiders, hence there were just a few respondents at each site. In some cases, only anecdotal information could be gathered. Had the teams had more time and resources to return repeatedly to these sites to develop relationships, more interviews would likely have been completed. Although the number of respondents documented from these sites is small, in the aggregate, they help complete the picture of the conditions under which artisanal miners live and work in Lualaba province.

Some of the additional artisanal mining areas visited were transitory sites, in which diggers excavated an area for a year or two until the deposit was exhausted. In most of these areas, families worked in units to excavate and wash the ore. The sacks of ore had to be transported by foot or bicycle to depots, or sold to négociants who transported them by motorbike or pickup truck. These areas were completely informal with no cooperatives managing them. It was challenging to generate an aggregate estimate of the total number of artisanal miners working in these areas; however, based on the reports of the artisanal miners and researcher observation, it is reasonable to estimate that a total of 85,000 to 95,000 artisanal miners worked at these sites. There were few, if any schools or community health centres near most of these areas.

A remote artisanal mining area documented in Lualaba province.

The data from the sites is presented below:

Table 19: Labour survey, other ASM sites in Lualaba Province

	ASM Sites
Number of respondents	82
Forced labour	25.6%
Child labour	11.0%
Debt bondage	0.0%
Human trafficking	3.7%
Like the work	12.2%
Written agreement for job	0.0%
Began due to survival or lack of alt	86.6%
Average daily income	$2.45
Male	$2.87
Female	$1.67
Other source of income	8.5%
Average age	23.8
Male	64.6%
Female	35.4%
Avg years worked in artisanal mining	3.1
Began as a minor	37.8%
Family members in artisanal mining	3.1
Avg hours worked per day	8.6
Literate	51.2%
Avg years of school completed	2.6
Free to do other work	14.6%
Chronic physical ailment or injury	56.1%
Access to medical care	68.3%
Suffer threats or abuse	69.5%
Penalized for not working hard enough	25.6%
Would rather quit but cannot	78.0%
Belong to a trade union	0.0%

25.6% of respondents were in forced labour in these sites, which was lower than any of the major sites documented in Lualaba province. Child labour was found among 11% of respondents, which was higher than any of the major sites documented. These results align with the nature of the work – families toiling together in remote, informal areas as a means of survival.

A small amount of human trafficking (3.7%) was present, mostly linked to children trafficked into artisanal mining areas to dig for cobalt. In some of these cases, individuals had been recruited and trafficked from several hundred miles away, including some from Zambia.

86.6% of respondents indicated that they began working as artisanal miners due to a lack of any alternative means of survival. Average daily incomes, as expected, were lower than larger artisanal mining sites in the province: $2.87 for males and $1.67 for females. Having to sell production to *négociants* rather than having direct access to markets or being paid by cooperatives put considerable downward pressure on incomes. Only 8.5% of surveyed individuals had an alternate source of income and 37.8% began working as children, higher than any formal site documented. Literacy was low at 51.2%, driven by the lack of schools in most of the areas. Access to medical care was low at 68.3%. Chronic ailments and injuries were reported in 56.1% of respondents. Threats were reported among 69.5% of respondents, typically from négociants pressuring worker for more production, though nothing as severe as the beatings and incarcerations reported by artisanal miners at some of the major sites. 78% of respondents indicated they would rather stop artisanal mining but had no alternative.

The findings from these more remote, informal sites complete the picture of artisanal mining for cobalt in Lualaba province as a largely poverty-driven, informal, underpaid, hazardous mode of subsistence.

2. Haut-Katanga province

Haut-Katanga province plays a crucial role in the country's mining industry and international trade. The province covers an area of approximately 132,425 square kilometres, slightly smaller than England. It shares borders with Zambia to the south, Lualaba province to the west, and Haut-Lomami and Tanganyika provinces to the north. It has international border crossings to Zambia at the towns of Kipushi and Kasumbalesa, which are used for the transport of minerals.

Cargo trucks can be lined up for miles waiting a week or more to cross the busy border points, spending much of this time running at idle and spreading fumes and grit into the surrounding villages. Haut-Katanga province is characterized by plateaus, rolling hills, and a savanna landscape. Several rivers, including the Lufira and numerous Congo River tributaries, flow through the province. Haut-Katanga is rich in copper, cobalt, nickel, and zinc, with additional deposits of gold, uranium, and lithium. The province has a population of approximately 5 million people, with diverse ethnic groups, including the Luba, Bemba, and Lunda. Despite its economic importance, Haut-Katanga faces challenges such as poverty, poor infrastructure, corruption, and political instability. Roads and power supply remain inadequate, affecting businesses and daily life. Government initiatives and foreign investments are gradually improving the region's development.

The capital city, Lubumbashi, is the second-largest city in the DRC with a population of about 2.5 million people. Lubumbashi contains seven communes: Lubumbashi, Kamalondo, Kenya, Katuba, Ruashi, and Commune Annexe. The city serves as a major commercial and industrial centre, hosting multinational mining firms like Glencore, Ivanhoe Mines, Zijin Mining, Congo Dongfang Mining, and China Molybdenum.

Lubumbashi was founded in 1910 by UMHK as a mining settlement under the name Élisabethville, after Queen Elisabeth of Belgium. Élisabethville quickly became the administrative and industrial centre of Katanga province, attracting thousands of Congolese labourers as well as European settlers. During the colonial period, Élisabethville grew into a well-planned city with European-style buildings, schools, and hospitals, but it remained a racially segregated society. The European population lived in well-maintained areas, while most Africans lived in poorer districts with limited access to services.

When the Democratic Republic of the Congo gained independence from Belgium on 30 June 1960, Élisabethville became a centre of political and military conflict. Shortly after independence, Moïse Tshombe declared the secession of Katanga from the newly formed DRC, supported by Belgium and Western interests that plotted to retain control over the region's mining wealth. From 1960 to 1963, Élisabethville served as the capital of the breakaway State of Katanga, leading to clashes between Katangese forces, the Congolese army, and UN peacekeepers. After heavy fighting, the secession was defeated, and Lubumbashi was brought back under central government control.

In 1971, as part of Joseph Mobutu's campaign to Africanise city names, Élisabethville was renamed Lubumbashi. Under Mobutu, the city remained a key mining and economic centre, but corruption, nationalization of industries, and economic decline weakened its growth. During the late 1970s, Lubumbashi witnessed major unrest, including the Shaba Wars (1977-1978) when exiled Katangese rebels launched invasions into the region. In 1997, Mobutu was overthrown by Laurent-Désiré Kabila, who led a rebellion from the eastern DRC with support from Rwanda and Uganda. Lubumbashi played a crucial role as a logistical base for the rebel forces. Today, Lubumbashi remains the mining capital of the DRC, making it one of the most important cities in the country.

The second primary mining town in Haut-Katanga Province is Likasi, located about 120 kilometres northwest of Lubumbashi and 200 kilometres east of Kolwezi. Likasi was founded in 1916 by the Belgians as Jadotville, after Jean Jadot, a Belgian engineer instrumental in the expansion of the railway and mining infrastructure in the region. The town has a population of around 700,000 people and consists of four communes: Likasi, Kikula, Panda, and Shituru.

As Likai grew over the decades, it became one of the most significant mining centres in the DRC, playing an important role in the extraction and processing of valuable minerals such as copper, cobalt, zinc, and manganese. Uranium from the nearby Shinkolobwe mine was used by the US in the nuclear bombs dropped on Hiroshima and Nagasaki during World War II.

Many of the artisanal mining areas in Haut-Katanga province are located in and around Lubumbashi and Likasi, as well as along the highway between the two cities. There are also sites near Kipushi, and in some of the very remote areas closer to the Zambian border.

Cargo trucks laden with minerals line the border road near Kipushi.

The summary data from sites documented in Haut-Katanga province appears below:

Table 20: Labour survey, Haut-Katanga province by site

	Kisunka	Nsase	Mpupé	Kaluka-Luku
Number of respondents	95	88	66	111
Forced labour	47.4%	72.7%	25.8%	18.0%
Child labour	8.4%	5.7%	9.1%	9.0%
Debt bondage	11.6%	0.0%	18.2%	0.0%
Human trafficking	0.0%	61.4%	0.0%	0.0%
Like the work	11.6%	14.8%	13.6%	14.4%
Written agreement for job	0.0%	0.0%	0.0%	0.0%
Began due to survival or lack of alt	75.8%	95.5%	90.9%	92.8%
Average daily income	$3.35	$2.43	$3.22	$3.31
Male	$3.64	$2.59	$3.22	$3.58
Female	$2.02	$1.32	-	$2.08
Other source of income	10.5%	2.3%	7.6%	15.3%
Average age	27.6	26.8	30.2	23.9
Male	82.1%	87.5%	100.0%	82.0%
Female	17.9%	12.5%	0.0%	18.0%
Avg years worked in artisanal mining	3.5	4.0	4.3	1.9
Began as a minor	21.1%	22.7%	18.2%	27.0%
Family members in artisanal mining	2.3	1.8	2.1	1.8
Avg hours worked per day	9.7	8.8	9.5	9.9
Literate	93.7%	84.1%	100.0%	97.3%
Avg years of school completed	5.3	4.4	5.5	4.7
Free to do other work	63.2%	2.3%	24.2%	28.8%
Chronic physical ailment or injury	64.2%	71.6%	59.1%	64.9%
Access to medical care	100.0%	15.9%	100.0%	100.0%
Suffer threats or abuse	54.7%	71.6%	28.8%	18.9%
Penalized for not working hard enough	49.5%	78.4%	24.2%	33.3%
Would rather quit but cannot	58.9%	79.5%	77.3%	61.3%
Belong to a trade union	0.0%	0.0%	0.0%	0.0%

(Continued)

	Kikwanda	Étoile	Other ASM sites
Number of respondents	77	38	61
Forced labour	13.0%	31.6%	23.0%
Child labour	9.1%	10.5%	11.5%
Debt bondage	0.0%	0.0%	0.0%
Human trafficking	0.0%	0.0%	4.9%
Like the work	11.7%	10.5%	8.2%
Written agreement for job	0.0%	0.0%	0.0%
Began due to survival or lack of alt	96.1%	92.1%	88.5%
Average daily income	$2.15	$2.22	$2.05
Male	$2.47	$2.40	$2.37
Female	$1.36	$1.63	$1.47
Other source of income	6.5%	13.2%	6.6%
Average age	21.6	22.1	24.0
Male	71.4%	73.7%	63.9%
Female	28.6%	26.3%	36.1%
Avg years worked in artisanal mining	1.9	2.1	3.0
Began as a minor	40.3%	26.3%	37.7%
Family members in artisanal mining	2.6	2.1	3.2
Avg hours worked per day	7.9	8.3	8.6
Literate	53.2%	60.5%	47.5%
Avg years of school completed	3.9	3.8	2.5
Free to do other work	3.9%	2.6%	9.8%
Chronic physical ailment or injury	75.3%	68.4%	50.8%
Access to medical care	37.7%	52.6%	62.3%
Suffer threats or abuse	20.8%	39.5%	55.7%
Penalized for not working hard enough	19.5%	34.2%	29.5%
Would rather quit but cannot	80.5%	73.7%	82.0%
Belong to a trade union	0.0%	0.0%	0.0%

A. Kisunka


A digging pit with tunnels at Kisunka.

Kisunka is located northeast of the city centre of Likasi. It has been operating as an artisanal mining area since 2005. Most of the deposits are exhausted, hence artisanal miners noted that they were earning markedly less than they had in previous years. Another repeated complaint among surveyed individuals was that they often went for three or four months without being paid, which put enormous financial stress on their families.

The Kisunka site is managed by three cooperatives and is patrolled by the Republican Guard. The three cooperatives managing the site are: Exploitation Minière Artisanale au Katanga (EMAK), Coopérative Minière du Katanga Kwa Kilimo (CMKK), Jamaa Letu et la Jeunesse (JLJ). The cooperatives register the diggers at the site and have unique registration cards that artisanal miners must present to gain entry. The official workday is from 8am to 5pm, although many respondents indicated they worked night shifts as well.

About 5,000 to 6,000 artisanal miners dig for cobalt at Kisunka, almost entirely in tunnels. The fear of tunnel collapse was palpable among the respondents, as the tunnels do not have supports of any kind. When one respondent was asked what he did to protect himself inside the tunnel, his reply was, “I pray to God.”

Women and girls are not permitted to enter the site, out of a superstition by the male artisanal miners that their presence will lower the grade of ore. Hence, the women and girls working at Kisunka wash the extracted ore outside of the mining area in polluted rinsing pools. The ore at the site tends to be a relatively low grade of 1.5% or 1%.

The working conditions at Kisunka were very poor. There was no drinking water, sanitation, or a toilet available for the artisanal miners who worked at the site. Diggers were caked in toxic grit from spending up to 18 hours at a time inside the tunnels. A heavy haze of dust and particulates suffocated the mining area. Most of the artisanal miners lived in the outskirts of Likasi, but some had migrated from other regions and slept under tarps along the perimeter of the site. Even the cooperative officials, who were rarely present, had only a wooden shed with a tarp roof as their office. Cooperative officials confirmed that most of the production from the site was sold to Chinese buyers.

The data from Kisunka is presented below:

Table 21: Labour survey, Kisunka

	Kisunka
Number of respondents	95
Forced labour	47.4%
Child labour	8.4%
Debt bondage	11.6%
Human trafficking	0.0%
Like the work	11.6%
Written agreement for job	0.0%
Began due to survival or lack of alt	75.8%
Average daily income	$3.35
Male	$3.64
Female	$2.02
Other source of income	10.5%
Average age	27.6
Male	82.1%
Female	17.9%
Avg years worked in artisanal mining	3.5
Began as a minor	21.1%
Family members in artisanal mining	2.3
Avg hours worked per day	9.7
Literate	93.7%
Avg years of school completed	5.3
Free to do other work	63.2%
Chronic physical ailment or injury	64.2%
Access to medical care	100.0%
Suffer threats or abuse	54.7%
Penalized for not working hard enough	49.5%
Would rather quit but cannot	58.9%
Belong to a trade union	0.0%

Researchers surveyed a total of 95 respondents in Kisunka, out of which 47.4% met the criteria for forced labour, 8.4% for child labour, and 11.6% for debt bondage. The researchers were not able to confirm any instances of human trafficking, despite the large number of migrants in the site. It appears that most of the migrants had made their way to the region without recruiters in the hopes of earning money digging for cobalt.

Only 14.8% of respondents indicated that they liked their work, and a very high 95.5% began working as artisanal miners out of a lack of any reasonable alternative means of survival. Average daily incomes were modest: $3.64 for males and $2.02 for females. In general, incomes in Haut-Katanga province were lower than in Lualaba province, in large part due to the lower average grade of copper-cobalt ore. Only 2.3% of respondents had an alternate source of income, so artisanal mining for meagre incomes was their only way to subsist. 21.1% of respondents began working as artisanal miners as children. Average workdays were almost ten hours. Literacy was 93.7% with 5.3 years of schooling completed on average, which was higher than any major site documented in Lualaba province and second only to Mpupé in Haut-Katanga. 63.2% of respondents reported that they were free to do other work, which was the highest of any major site documented.

64.2% of surveyed individuals reported chronic ailments and injuries, with a higher rate of complaints of respiratory diseases than other major sites. GI issues were also prominent complaints, likely caused by a lack of potable water and toilets. Many of the female respondents reported gynaecological problems, almost certainly as a consequence of washing ore in the polluted pools of water. All respondents reported that they had access to medical facilities either through the cooperatives or in Likasi. Threats (54.7%) and penalties (49.5%) came from cooperative officials and Republican Guard. Respondents complained especially of harassment, threats, and extortion of “fees” by Republican Guard soldiers. “At least one time each week, they will demand money from us”, observed one respondent.

Researchers reported that Kisunka felt like a zone of misery. They could not overstate the appalling nature of the conditions in which the artisanal miners worked for poor wages, especially the women and girls. As one of the women who slept under a tarp in the woods every night said, “Our lives are worse than animals.”

B. Nsase

The Nsase artisanal mining site is located inside a copper-cobalt mining concession owned by Nsase Mining SA. It is in a very remote area and access was a challenge. Researchers travelled on the main highway to about the half-way point between Lubumbashi and Likasi, then took a treacherous dirt road 22 miles south to reach the site. Nsase appears to have employed a private security force of soldiers to manage the site and pay the artisanal miners for their production. Soldiers were present at the site during the interviews, but they showed little interest in overseeing or listening to the conversations.

Nsase is a relatively new mining area that began operating in December 2021, after the discovery of a high-grade copper-cobalt deposit. Despite the remoteness of the site and challenges in accessing it, it was an important one to document as there are between 13,000 and 15,000 artisanal miners working as Nsase, making it almost certainly the largest single artisanal mining site in Haut-Katanga province.

The artisanal miners at Nsase primarily worked in family units, all of whom lived in shoddy encampments in the forested area around the mine. Men and teenage boys dug in deep trenches and tunnels, while women and children washed the ore. There were no schools or medical centres for at least 25 miles in any direction.

There were no toilets at the site, and it had only one well which had to serve the needs of up to 15,000 people. The entire community seemed sick from a range of ailments and diseases, particularly GI-related. Most respondents revealed that they only managed to bathe with well water once a week. Anecdotal evidence revealed that sexual assault was a serious problem in the area.

The data from Nsase can be found below:

Table 22: Labour survey, Nsase

	Nsase
Number of respondents	88
Forced labour	72.7%
Child labour	5.7%
Debt bondage	0.0%
Human trafficking	61.4%
Like the work	14.8%
Written agreement for job	0.0%
Began due to survival or lack of alt	95.5%
Average daily income	$2.43
Male	$2.59
Female	$1.32
Other source of income	2.3%
Average age	26.8
Male	87.5%
Female	12.5%
Avg years worked in artisanal mining	4.0
Began as a minor	22.7%
Family members in artisanal mining	1.8
Avg hours worked per day	8.8
Literate	84.1%
Avg years of school completed	4.4
Free to do other work	2.3%
Chronic physical ailment or injury	71.6%
Access to medical care	15.9%
Suffer threats or abuse	71.6%
Penalized for not working hard enough	78.4%
Would rather quit but cannot	79.5%
Belong to a trade union	0.0%

Researchers surveyed a total of 88 respondents in Nsase. The site had the highest rate of forced labour (72.7%) of any major ASM area documented, which was almost certainly a consequence of the high prevalence reported by the respondents of threats (71.6%) and penalties (especially violence) for not working hard enough (78.4%). It appears that most of the workers at Nsase were trafficked (61.4%) to work at the site. Traffickers appeared to be recruiters working for Nsase, as well as soldiers. Promises were made of being paid $5 or more per day with dormitory dwellings and a school for children, none of which proved to be true. Once at the site, the remoteness of the area made it all but impossible for workers to leave, and guards/soldiers kept the site under constant surveillance. Finally, child labour was documented in 5.7% of respondents, although the actual number was certainly higher as researchers anecdotally reported seeing well over 1,000 children at the site. Security at the site made it difficult for the researchers to speak with children.

95.5% of surveyed individuals began working at the site out of a lack of any reasonable alternative means of survival, the highest of any major site documented. Reported incomes were poor: $2.59 for males and $1.32 for females. The researchers suspected that payments were even lower than indicated, especially when a higher prevalence of child labour is considered. There were also many reports of delayed payments for up to several weeks. Finally, respondents indicated that they had to give most, if not all, of their earnings to the soldiers guarding the site, so that they could buy food and other supplies for the artisanal miners to use at the site.

Self-reported literacy was 84.1%, with an average of 4.4 years of school completed. Only 2.3% of respondents indicated that they were free to do some other work, which aligned with the remoteness of the site. 71.6% of respondents reported a chronic illness or injury, akin to those suffered by artisanal miners at other major sites. Although 15.9% of respondents said they had access to medical care, the closest facilities were at least 25 miles away. Respondents stated anecdotally that in the past they had to treat major injuries themselves. Almost 8-in-10 (79.5%) respondents stated that they would rather quit working as artisanal miners, but they felt they were unable to do so.

Respondents reported that once a week, cargo trucks came to the site to load the cobalt that had been extracted the previous week. It was not clear where the cobalt from the site was taken, although it was mostly likely destined for mineral processing facilities in Likasi or Lubumbashi – in other words, into the formal supply chain. Overall, Nsase had among the poorest working conditions of sites surveyed by the research teams. Up to 15,000 people were living in squalor, working in hazardous conditions, were paid very little, and were coerced by armed security to extract cobalt while experiencing an array of ailments.

C. Mpupé

Mpupé is a new artisanal mining area that began operating in March 2022. The site is located a few miles south of the main highway, a little more than half the way between Lubumbashi and Likasi. It consists of a large excavation area of pits, trenches, and scores of tunnels.

Between 4,000 and 5,000 people work at the site. Women and girls are not allowed in the excavation area, so they wash ore in rinsing pools outside the perimeter. There were no toilets at the site. There were two wells that were dug by the artisanal miners to provide drinking water.

Société Coopérative Minière du Katanga (SCMK) manages the artisanal miners at Mpupé. There was no office for the cooperative agents, and meetings were held under the trees. Artisanal miners ventured to the site from nearby villages and worked from around 7:30am to 5pm. Many of the tunnel diggers spent the night in the tunnels, sleeping for a couple of hours at a time then continuing to dig. Surveyed individuals described two tunnel collapses at the site in the previous 16 months, with somewhere between 40 and 50 artisanal miners buried alive.

The closest schools and medical clinics were located about nine miles away in the village of Luisha.

SCMK prohibited the research teams from speaking with women and girls outside the mining area, hence all the individuals documented from Mpupé were males. One of the prevailing themes that emerged from the interviews, which was echoed in towns like Fungurume and neighbourhoods like Kanina in Kolwezi, was that mining companies continued to acquire more and more land, which caused the displacement of more and more Congolese people, leaving them with fewer and fewer options to earn incomes. As one respondent declared, “All the hills are sold to the foreigners, and nothing is left for our survival.”

Tunnel diggers at Mpupé.

The data from the surveys at Mpupé is included below:

Table 23: Labour survey, Mpupé

	Mpupé
Number of respondents	66
Forced labour	25.8%
Child labour	9.1%
Debt bondage	18.2%
Human trafficking	0.0%
Like the work	13.6%
Written agreement for job	0.0%
Began due to survival or lack of alt	90.9%
Average daily income	$3.22
Male	$3.22
Female	-
Other source of income	7.6%
Average age	30.2
Male	100.0%
Female	0.0%
Avg years worked in artisanal mining	4.3
Began as a minor	18.2%
Family members in artisanal mining	2.1
Avg hours worked per day	9.5
Literate	100.0%
Avg years of school completed	5.5
Free to do other work	24.2%
Chronic physical ailment or injury	59.1%
Access to medical care	100.0%
Suffer threats or abuse	28.8%
Penalized for not working hard enough	24.2%
Would rather quit but cannot	77.3%
Belong to a trade union	0.0%

Research teams surveyed 66 respondents at Mpupé, out of which 25.8% were forced labour, 9.1% were child labour, and 18.2% were debt bondage. The debt bondage rate was the highest of any major site aside from Kasulo and Mutoshi in Lualaba province. The bondage was related to advances provided by the cooperative to artisanal miners, which were then worked off under forced labour conditions, including restrictions on movement and violence. About 9-in-10 (90.9%) respondents began working as artisanal miners out of a lack of any reasonable alternative means of survival. Average daily incomes were similar to Kisunka at $3.22 per day for a 9.5 hour workday.

The average age of the workers documented at Mpupé (30.2 years) was considerably more than all the other sites documented, which ranged from 21 to 26 years. The reasons for this variance are unknown and may have to do with the sample of workers willing to speak. Reported literacy was 100% with an average of 5.5 years of schooling completed, the highest of any major site documented. 24.2% of respondents indicated they were free to do other work and about 6-in-10 (59.1%) reported chronic illnesses or injuries akin to the maladies suffered by artisanal miners at other sites. Although the closest medical centre was several miles away, 100% of respondents said they had access to medical care.

Threats (28.8%) and penalties (24.2%) were lower than at most sites, although the researchers did receive reports of beatings when artisanal miners reportedly displeased the cooperative officials. The overall picture at Mpupé was one of poor working conditions, extreme hazard with tunnel collapses, and unsanitary conditions due to the lack of toilets. The treatment of women and girls remains unknown due to the inability to interview them.

D. Kaluka-Luku

Kaluka-Luku is a large artisanal mining area near the Ruashi mine on the eastern edge of the city of Lubumbashi. It is part of the broader CHEMAF concession at Ruashi. Between 8,000 and 10,000 artisanal miners work at this site and Ruashi, often alternating between them.

The Ruashi Mine is the second oldest mining concession in the DRC, dating back to 1919 when UMHK began excavating copper at the site. Joseph Mobutu nationalized Ruashi, along with nearby Étoile, in 1967, and by the 1990s the mine ceased operations following years of graft and mismanagement. In 2004, the Ruashi-Étoile concession was acquired by Metorex Limited, a South African mining company, in a joint venture with Gécamines.

After a few years of operations, Ruashi was sold in 2011 to Chinese mining giant, Jinchuan Group. The mine is adjacent to Lubumbashi's airport, and its enormous pit walls can be seen from the tarmac.

Residents from across Lubumbashi venture to the Kaluka-Luku mining area, where they dig for cobalt-bearing ore in pits and tunnels. They also dig inside the Ruashi mine, and per reports from surveyed individuals, all their production is sold to CHEMAF. Project researchers were prevented by the security teams of Jinchuan Group from entering Ruashi to confirm the presence of artisanal miners inside.

There is no managing cooperative at Kaluka-Luku. According to respondents, CHEMAF agents manage everything. The artisanal area does not have toilets or potable water. There are a few nearby streams that many artisanal miners use for drinking and washing.

The data from our surveys at Kaluka-Luku is presented below:

Table 24: Labour survey, Kaluka-Luku

	Kaluka-Luku
Number of respondents	111
Forced labour	18.0%
Child labour	9.0%
Debt bondage	0.0%
Human trafficking	0.0%
Like the work	14.4%
Written agreement for job	0.0%
Began due to survival or lack of alt	92.8%
Average daily income	$3.31
Male	$3.58
Female	$2.08
Other source of income	15.3%
Average age	23.9
Male	82.0%
Female	18.0%
Avg years worked in artisanal mining	1.9
Began as a minor	27.0%

	Kaluka-Luku
Family members in artisanal mining	1.8
Avg hours worked per day	9.9
Literate	97.3%
Avg years of school completed	4.7
Free to do other work	28.8%
Chronic physical ailment or injury	64.9%
Access to medical care	100.0%
Suffer threats or abuse	18.9%
Penalized for not working hard enough	33.3%
Would rather quit but cannot	61.3%
Belong to a trade union	0.0%

Researchers surveyed a total of 111 individuals, out of which 18.0% constituted forced labour and 9.0% were child labour. This was the third lowest rate of forced labour behind Kamilombe and nearby Kikwanda (see below). There were no instances of debt bondage or human trafficking uncovered. The lower rate of forced labour can be attributed to the fact that most workers at Kaluku-Luku reported that they were not subjected to abuse or threats (18.9%) or penalties for not meeting expectations (33.3%). The work was hazardous and backbreaking, but average daily incomes were among the highest in Haut-Katanga province ($3.58 for males; $2.08 for females), and many workers (15.3%) had an alternate source of income. 28.8% of respondents indicated they were free to do other work if they chose.

The workers at this site had a lower average number of years worked as artisanal miners (1.9) than most major sites documented, and they also had the lowest average number of family members involved in artisanal mining (1.8). The site had the feeling of being a more independent contractor model, with diggers coming and going to work as their needs required. It must be stressed that all artisanal miners reported that their production in and around Ruashi was sold to the mine, and that these sales were enforced by Ruashi security forces. However, it was not possible for our teams to confirm these reports directly, due to security risks.

Literacy at the site was high (97.3%) with an average of 4.7 years of schooling completed. All respondents had access to medical care, as there are a plethora of community health centres in Lubumbashi. There were also several schools within five miles of the site. Chronic illnesses or ailments were reported in 64.9% of respondents, primarily relating to GI issues from drinking stream water. Skin infections, rashes, and coughs were also commonly reported.

Kaluku-Luku and Ruashi were another example of the impossibility of disaggregating LSM and ASM cobalt production in the DRC, given the onsite commingling of sources of production.

E. Kikwanda

The Kikwanda artisanal mining area is located about 9 miles east of Lubumbashi in a rural area near the Luwowoshi River. Men and boys dig in groups of four or five to extract ore from pits and shallow tunnels up to fifteen meters deep. The extracted ore is washed in the Luwowoshi River by women and children, loaded into raffia sacks, and sold to *négociants*. The *négociants* transport the ore to Lubumbashi by pickup truck or motorbike to sell into the formal supply chain. There are no artisanal mining cooperatives operating in the area. Researchers were unable to determine exactly to which mining companies the ore was being sold, as the *négociants* were reluctant to speak.

Between 6,000 and 7,000 people work at Kikwanda. The mining area was a craterous zone of grit and rubbish, and the conditions around the river were particularly hazardous. At visual inspection, the water appeared highly polluted, and every female survey respondent complained of eye diseases, urinary tract infections, diarrhoea, and skin infections. There were between 700 and 800 children present, working in trenches and rinsing ore.

There are no schools, medical clinics, or toilets anywhere near Kikwanda. Most miners live in villages in the area, although some travel from Lubumbashi for a week or two at a time and live in makeshift encampments around the site. There are also a few run-down guest houses not far from the mining area where some of the artisanal mining families stay. In sum, Kikwanda was a particularly unpleasant site for artisanal mining.

The data from the surveys at Kikwanda are included below:

Table 25: Labour survey, Kikwanda

	Kikwanda
Number of respondents	77
Forced labour	13.0%
Child labour	9.1%
Debt bondage	0.0%
Human trafficking	0.0%
Like the work	11.7%
Written agreement for job	0.0%
Began due to survival or lack of alt	96.1%
Average daily income	$2.15
Male	$2.47
Female	$1.36
Other source of income	6.5%
Average age	21.6
Male	71.4%
Female	28.6%
Avg years worked in artisanal mining	1.9
Began as a minor	40.3%
Family members in artisanal mining	2.6
Avg hours worked per day	7.9
Literate	53.2%
Avg years of school completed	3.9
Free to do other work	3.9%
Chronic physical ailment or injury	75.3%
Access to medical care	37.7%
Suffer threats or abuse	20.8%
Penalized for not working hard enough	19.5%
Would rather quit but cannot	80.5%
Belong to a trade union	0.0%

Researchers surveyed a total of 77 respondents at Kikwanda, with 9.1% in child labour and 13.0% in forced labour. The individuals in forced labour were related to reports of threats and coercion from some of the *négociants*, who had established arrangements with some of the digging teams to meet a certain level of production. When the quota was not met, punishments followed.

Not many miners enjoyed the work (11.7%) and almost all of them (96.1%) began working as artisanal miners due to the lack of any reasonable alternative means of survival. Average daily incomes were among the lowest of any major site documented: $2.47 for males and $1.36 for females. These incomes were paid by the *négociants*, who paid sub-market rates for the ore they purchased, in the form of 40kg raffia sacks. It should be noted that the data on female wages came from those working in groups of women and girls on their own to rinse ore, as family units were typically paid by the *négociants* in the aggregate for each sack of ore.

The average respondent age was 21.6 years, a value that is skewed upwards by the difficulty in accessing the children working at the site. Nevertheless, the site had the highest prevalence of individuals who began working in artisanal miners as children at 40.3%.

Literacy rates at Kikwanda were the lowest of any major site documented at 53.2% with an average of 3.9 years of school completed. Only 3.9% of surveyed individuals indicated they were free to do other work, and 75.3% reported chronic illnesses and injuries, the highest of any major site documented. Many of these ailments related to exposure to contaminated water in the Luwowoshi River. One pressing area for future research would be to sample the river water for heavy metals and other toxins, similar to the sampling conducted for this project in water bodies around Kolwezi.

Only 37.7% of respondents stated they had access to medical care, and these were primarily the respondents who lived in Lubumbashi, as there were no medical clinics anywhere near the site. 80.5% of the respondents reported they would rather quit working as artisanal miners but felt they could not do so due to the lack of any alternative means of survival.

Like Nsase, the remoteness of Kikwanda led to particularly challenging conditions for the artisanal miners, who appeared to be barely subsisting on very poor incomes in a highly hazardous working environment.

F. Étoile

The Étoile Mine, also known as L'Étoile du Congo ("Star of the Congo") was the first mine established by UMHK, which started exploiting it for copper in 1911. The mine had the largest known copper deposit in the world at the time. Like all of UMHK's mines, Étoile was nationalized by Mobutu in 1967 and ultimately ceased operating due to mismanagement. The mine was resuscitated in 2003 when the rights were acquired by CHEMAF in a 95%/5% joint venture with Gécamines. CHEMAF began exploiting the mine in 2005, and it added a copper-cobalt processing facility in 2016, which contributed greatly to air pollution in the area. CHEMAF has expanded the Étoile concession several times since its initial acquisition, which has caused the displacement of several villages in the area. A few respondents reported that they had previously lived in displaced villages and had been left to fend for themselves to find new homes. "The Congolese people are only in the way of the mines", lamented one respondent.

In June 2024, CHEMAF agreed to sell Étoile to China North Industries Corporation (NORINCO), a Chinese state-backed defence and industrial giant. The proposed sale has faced opposition from the DRC government. As of May 2025, the sale remains unresolved.

Artisanal miners have been working in and around Étoile for decades. In fact, Étoile is the first mine at which artisanal mining was legally encouraged under Ministerial Order No. 009 on 19 February 1999, not long after Laurent Kabila seized the country in a coup. There are numerous villages around Étoile, none of which have schools, sanitation, electricity, or medical clinics. Many of the inhabitants of these villages dig in and around the Étoile mine. Most of the respondents reported that when they dug inside the mine, primarily in tunnels, CHEMAF agents purchased their production. When they dug outside the mining perimeter, there were négociants who purchased the production and, according to reports, sold the ore to CHEMAF. Researchers were not able to confirm these reports through direct observation.

The Étoile pit wall with a village in the foreground.

The data from the surveys at Étoile are included below:

Table 26: Labour survey, Étoile

	Étoile
Number of respondents	38
Forced labour	31.6%
Child labour	10.5%
Debt bondage	0.0%
Human trafficking	0.0%
Like the work	10.5%
Written agreement for job	0.0%
Began due to survival or lack of alt	92.1%
Average daily income	$2.22
Male	$2.40
Female	$1.63
Other source of income	13.2%
Average age	22.1
Male	73.7%
Female	26.3%
Avg years worked in artisanal mining	2.1
Began as a minor	26.3%
Family members in artisanal mining	2.1
Avg hours worked per day	8.3
Literate	60.5%
Avg years of school completed	3.8
Free to do other work	2.6%
Chronic physical ailment or injury	68.4%
Access to medical care	52.6%
Suffer threats or abuse	39.5%
Penalized for not working hard enough	34.2%
Would rather quit but cannot	73.7%
Belong to a trade union	0.0%

Of the 38 respondents around Étoile, 31.6% were in forced labour and 10.5% were in child labour. There was no debt bondage or human trafficking. The forced labour figures were driven by reports of threats and abuse by CHEMAF officials and security forces in 39.5% of respondents and harsh penalties in 34.2% of respondents.

Not many surveyed individuals enjoyed their work (10.5%) and more than 9-in-10 (92.1%) began working as artisanal miners due to the lack of any reasonable alternative means of survival. Average daily incomes were low: $2.40 for males and $1.63 for females. 13.2% of respondents indicated they had an alternate source of income, which primarily related to growing agricultural products for sale at local markets. Literacy was poor at 60.5% and only 3.8 years of schooling completed on average, which was not a surprise given the complete lack of schools in the area. Almost no respondents (2.6%) stated that they were free to do some other kind of work, although this data is likely a function of the fact that there was very little alternate work to do, aside from subsistence agriculture. Chronic illnesses and injuries were reported in almost 7-in-10 respondents (68.4%). There were reports of three tunnel collapses inside the Étoile concession in the preceding 20 months, but these could not be confirmed.

About half of the respondents reported having access to medical care (52.6%), although the nearest health centres were several miles away. More than 7-in-10 (73.7%) respondents indicated that they would rather quit working as artisanal miners but felt they were unable to do so.

The condition of the artisanal miners around Étoile was bleak. As the mine continued to expand, the inhabitants of the area had been pushed to the fringes and there were few, if any, options for survival other than digging in and around the mine. The incomes of these artisanal miners worked out to $0.29 per hour for men and $0.20 for women. It is not enough to survive.

G. Other ASM sites – Haut-Katanga province

Thirty-four other artisanal mining areas in Haut-Katanga province were sampled by the research teams. The sites were located in more rural and isolated settings, similar to Nsase and Kikwanda. Conditions were poor. Most artisanal miners worked in family units in and around villages or forested areas where an ore body had been uncovered. There were no schools or medical centres for miles around. There was no sanitation, no toilets, and no electricity. Incomes were the lowest of any areas documented.

Copper and cobalt from these mining areas made its way into the formal supply chain almost entirely via *négociants*. Sometimes, there were FARDC soldiers involved in the transport. Where there were threats, abuse, or coercion, it came from the traders and soldiers who demanded a production quota. Some surveyed individuals made mention of sexual assault, although no respondents were willing to discuss these events in detail. There were also reports from respondents of shattered spines, broken bones, and deaths in tunnel collapses.

An ASM site documented in Haut-Katanga province.

The data from the surveys conducted at these sites is below:

Table 27: Labour survey, other ASM sites in Haut-Katanga province

	Other ASM sites
Number of respondents	61
Forced labour	23.0%
Child labour	11.5%
Debt bondage	0.0%
Human trafficking	4.9%
Like the work	8.2%
Written agreement for job	0.0%
Began due to survival or lack of alt	88.5%
Average daily income	$2.05
Male	$2.37
Female	$1.47
Other source of income	6.6%
Average age	24.0
Male	63.9%
Female	36.1%
Avg years worked in artisanal mining	3.0
Began as a minor	37.7%
Family members in artisanal mining	3.2
Avg hours worked per day	8.6
Literate	47.5%
Avg years of school completed	2.5
Free to do other work	9.8%
Chronic physical ailment or injury	50.8%
Access to medical care	62.3%
Suffer threats or abuse	55.7%
Penalized for not working hard enough	29.5%
Would rather quit but cannot	82.0%
Belong to a trade union	0.0%

9. Artisanal miner estimates

An important aspect of this project was to provide a reasonable estimate of the total number of people working as artisanal miners in cobalt mining in the DRC. There are established methods for providing estimates for transient or difficult to capture populations, such as capture-recapture[66] or mixed-methods approaches.[67] Although I attempted to adopt a capture-recapture method for our estimates, the conditions proved too challenging, and in some cases, too dangerous for the research teams. More advanced methodologies would have required numerous visits to each mining area, which was not possible in some cases. In addition, some major mining sites were inaccessible, hence secondary estimates were required. Finally, there are many remote mining areas that our teams were not able to sample given limited time and resources.

Accordingly, I believe I have assembled reasonable estimates based on surveys conducted at most of the largest artisanal mining sites in Haut-Katanga and Lualaba provinces, along with 89 smaller artisanal mining areas scattered across the region. To derive my estimates, most major sites were visited at least two times. Each researcher surveyed the site to produce an estimate of the total workers at the site. In addition, the researchers obtained estimates from the survey respondents as to the total number of artisanal miners working at the sites. When there were cooperatives operating, the researchers obtained estimates from cooperative agents. The estimates were generally consistent and fell into a relatively narrow range, which was rounded down to be conservative (for instance, 7,200 was rounded to 7,000). These data produced a low and high estimate of total workers at each site. Added together, I was able to produce a total estimate of artisanal miners working in the copper-cobalt mining provinces. Although there are likely to be several dozen such sites, many of them would be transient and most of them would have between a few dozen to at most a few hundred total artisanal miners working at them, representing a few thousand workers in total, thereby fitting within the broad range of high-low estimates discussed below.

The data is presented in the following table:

Table 28: Artisanal Miner Estimates

		Estimated total workers	
Site	**Respondents**	**Low**	**High**
Lualaba			
Shabara	178	18,000	20,000
Kasulo	32	14,000	16,000
Mutoshi	90	15,000	16,000
KCC	88	5,000	6,000
Mashamba East	67	5,000	6,000
Kamilombe	63	7,000	8,000
COMMUS	45	6,000	7,000
UCK	139	8,000	9,000
Tilwezembe	23	13,000	15,000
Tenke-Fungurume	88	12,000	14,000
Other Sites (55)	82	85,000	95,000
Total Lualaba	**895**	**188,000**	**212,000**
Haut-Katanga			
Kisunka	95	5,000	6,000
Nsae	88	13,000	15,000
Mpupé	66	4,000	5,000
Kaluka-Luku	111	8,000	9,000
Kikwanda	77	6,000	7,000
Étoile	38	9,000	10,000
Other Sites (34)	61	40,000	50,000
Total Haut-Katanga	**536**	**85,000**	**102,000**
TOTAL		**273,000**	**314,000**

The total number of artisanal miners working in Haut-Katanga and Lualaba provinces is estimated to be between **273,000 and 314,000**. As artisanal mining is highly seasonal work, this data is presented as totals for the dry season, which would be considerably lower during the rainy months.

In addition, the site surveys of 1,431 individuals showed the following rates of exploitation among survey respondents: forced labour: 36.8%; child labour: 9.2%; debt bondage: 6.5%; and human trafficking: 4.4%. Less restrictive criteria on indicators of forced labour and child labour would have increased these figures. Overall, the data suggests a substantial population of people working as artisanal miners in the DRC, and a significant proportion of the miners surveyed working in conditions akin to slavery.

10. Geospatial analysis

Earth Observation (EO) and geospatial analysis offer tremendous potential to track an array of facets relating to copper-cobalt mining in the DRC, from site mapping and identification to environmental degradation and sociological impacts. For this project, we focused on three facets:

1. Identification of mining areas by different types (LSM, ASM)
2. Identification of ASM sites in remote areas
3. Tracking environmental impact of mining expansion around Kolwezi

Some of the results of these studies were published in two academic papers co-authored with Professor Doreen Boyd and other colleagues at the Rights Lab at the University of Nottingham. The first study (2020)[68] explored the ability of EO to identify mines by type and to locate ASM sites in remote areas. The second study (2022)[69] focused on using EO to assess the environmental impact of cobalt mining around Kolwezi.

A. Identification of mining areas by type

The ability to identify mining areas by type through EO offers a powerful tool for capturing the universe of mining activity in the DRC. The use of high-resolution (10-30m per pixel resolution) and very high-resolution (<10m per pixel resolution) optical imagery has time-tested applications in studies that map the extent of various mineral extraction sites in both urban and rural settings around the globe.[70] Data from Synthetic Aperture Radar (SAR) satellites can also provide information about Earth surface characteristics, while having the advantage of not being constrained by weather or daytime illumination.

SAR works by actively transmitting microwaves to the ground and receiving the backscattered signals (amplitude and phase). Interaction with the surface structure partially returns the pulses towards the sensor. The time between transmission and return, as well as the amplitude of the pulsed wave, are recorded by a receiving antenna. Wave amplitude offers information about the surface roughness, geometry, as well as surface material characteristics.[71]

SAR data has been widely exploited in the mining industry for monitoring millimetre ground shifting related to mineral extraction, primarily using a well-established technique based on Interferometric Synthetic Aperture Radar (InSAR).[72] InSAR is a remote sensing technique that utilizes the reflected phase data from SAR to detect changes in the Earth's surface over time. There are different InSAR techniques,[73] and for this study we used Differential Interferometric Synthetic Aperture Radar (D-InSAR). D-InSAR measures the difference in recorded phase from two SAR images acquired over the same region of interest at two different times. When validated by other global positioning data such as GPS measurements, millimetre-scale ground shifting can accurately reveal patterns of surface subsidence or uplift, due to mining activities or ground water movements. This information is typically used by mining operators to produce predictions of mining area stability and assess risks.

By using D-InSAR, mining types can be determined, and "hidden" areas of artisanal mining can be revealed in the landscape.[74] To obtain greater accuracy in more rural and densely vegetated landscapes where many ASM sites are located, we processed our data with an advanced D-InSAR method called Intermittent Small Baseline Subset (ISBAS). The ISBAS technique has proved useful in investigating surface motion related mining applications in the United Kingdom coalfields, where regional patterns of subsidence and uplift related to rising mine water have been detected for sites in Derbyshire and Leicestershire, Durham or South Wales, UK.[75] Using the these techniques, LSM and ASM sites were identified around Kolwezi. Before reporting findings relating to mine type, the following image provides a contextual overview of mining sites around Kolwezi, with its layered excavations, lakes, and reservoirs visible as well as the supporting infrastructure and urban sprawl.

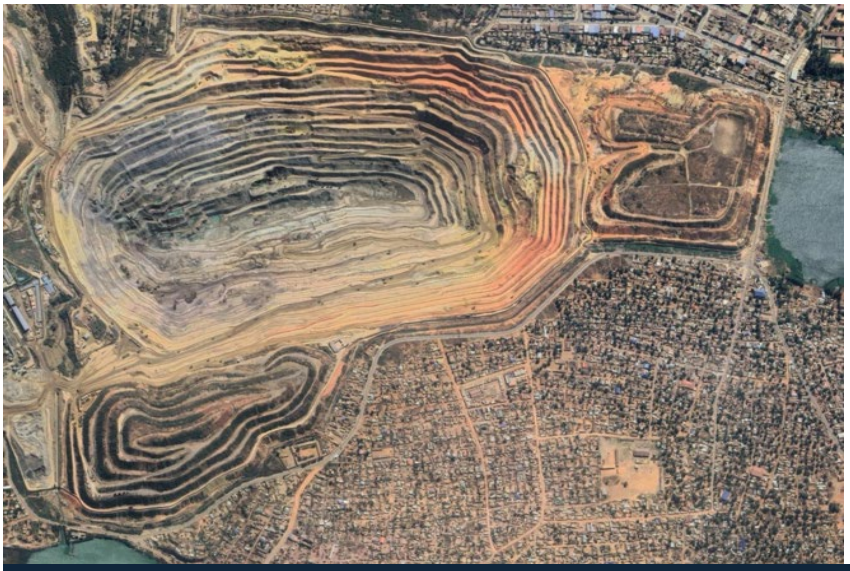
Map 4: Contextual Overview of Mining Sites Around Kolwezi

Google Earth (2025), Kolwezi mine, Kolwezi, Democratic Republic of the Congo, 10°43'30"S 25°26'5902"E, scale 1:4000m, camera 38 km, elevation 1469m [online]. Imagery from Airbus, Maxar Technologies, between 15/06/2022 - 30/04/2025. Available from: https://earth.google.com/web/ [Accessed October 2023].

Examples of each type of mining site are provided below:

1. Large-scale mining

LSM sites can be evaluated as uniform, terraced platform pit structures with steep slopes, large industrial infrastructure and building complexes, often surrounded by walls, as pictured in the following image:



Large-scale mining

- Uniform, terraced platform pit structures
- Steep slopes
- Industrial infrastructure and building complexes
- Can be surrounded by walls
- Can be in urban centre or more remote area

Easy to detect, require high to medium-high resolution imagery, automatic detection possible.

Google Earth (2025), Kolwezi COMMUS Open pit mine, Kolwezi, Democratic Republic of the Congo, 10°43'36"S 25°27'26"E, scale 1:600m, camera 6,061 m, elevation 1,3999m [online]. Imagery from Airbus, Maxar Technologies, from 09/06/2024. Available from: https://earth.google.com/web/ [Accessed October 2023].

2. Artisanal and small-scale mining

ASM sites can be more challenging to detect. They can be generally classified between surface mining (SM) and tunnel mining (TM). Surface mines have open-pit, irregular surface texture (lunar) appearances, cut by crevasses and ridden with craters created by constant removal and scraping of rock. SM sites vary in size and are often found adjacent to LSM sites or near bodies of water, which are used for washing and sorting. TM sites display a pockmarked appearance, where 10s to 100s of tunnel holes, each 1-2 metres in diameter are spread around an area in the proximity of LSM or SM sites or scattered across rural areas. In addition, pink tarp tents often cover the tunnel entrances.

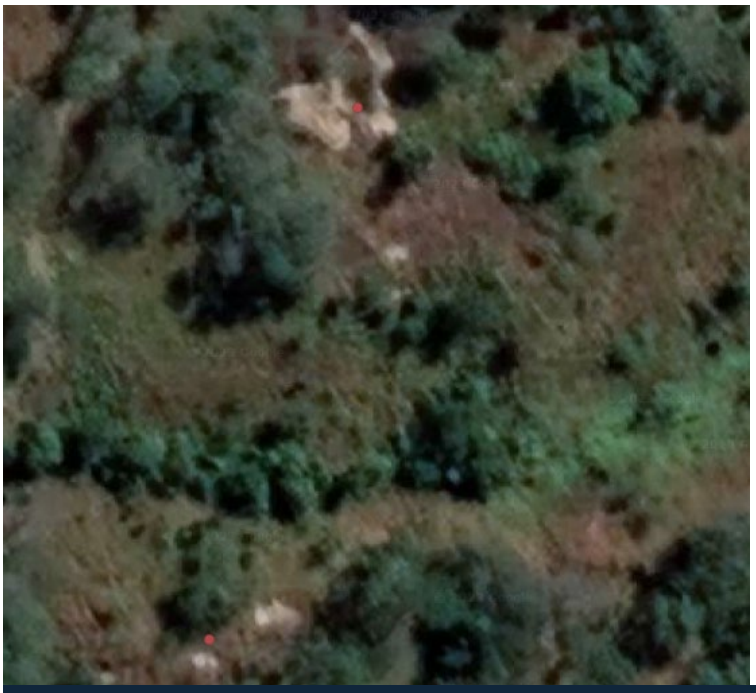
The following images demonstrate the differences between surface mining, remote surface mining, and tunning mining:

Surface mining

- Developed surface changes
- Lunar aspect, crevasses and craters from scratching
- Open pits
- Combination of mechanised and rudimentary digging
- Found in remote areas but connected by main roads

Easier to detect, require high to medium-high resolution imagery, automatic detection possible.

Surface mining image: Google Earth (2025), ASM Tunnel mining site South Kolwezi, Kolwezi, Democratic Republic of the Congo, scale 1:20m, camera 1,713 m, elevation 1,499 m [online]. Imagery from Maxar Technologies from 14/05/2020. Available from: https://earth.google.com/web/ [Accessed July 2023];

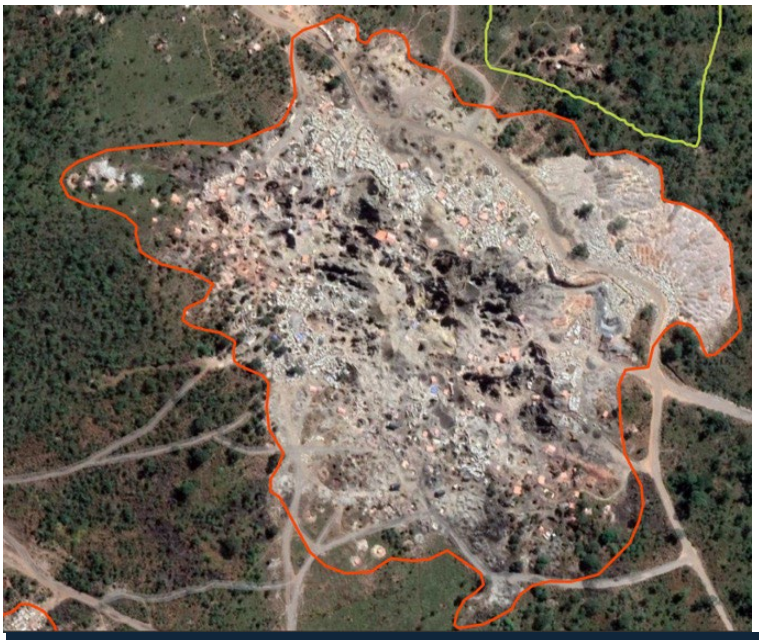


Remote/incipient surface mining

- Small sites: few tunnels / surface scratching
- Rudimentary techniques
- Found along dirt roads, rivers, streams, near small remote settlements but also deeper into forested areas, under trees
- Clusters are a precursor to development

Difficult to detect, require high resolution imagery, expert knowledge, human validation.

Remote/incipient surface mining image: Google Earth (2025), South Kolwezi ASM surface mine, Kolwezi, Democratic Republic of the Congo, 10°53'56"S 25°57'01"E, scale 1:300m, camera 3,980 m, elevation 1,511m [online]. Imagery from Airbus from 30/08/2020. Available from: https://earth.google.com/web/ [Accessed July 2023];



ASM tunnel mining

- Tunnel digging indicated by (pink tarps) or holes (tunnel openings)
- Swiss cheese landscape
- No of tunnels ranges from <10 to hundreds
- Entirely rudimentary
- Near settlements or peripheral or merging into the built area

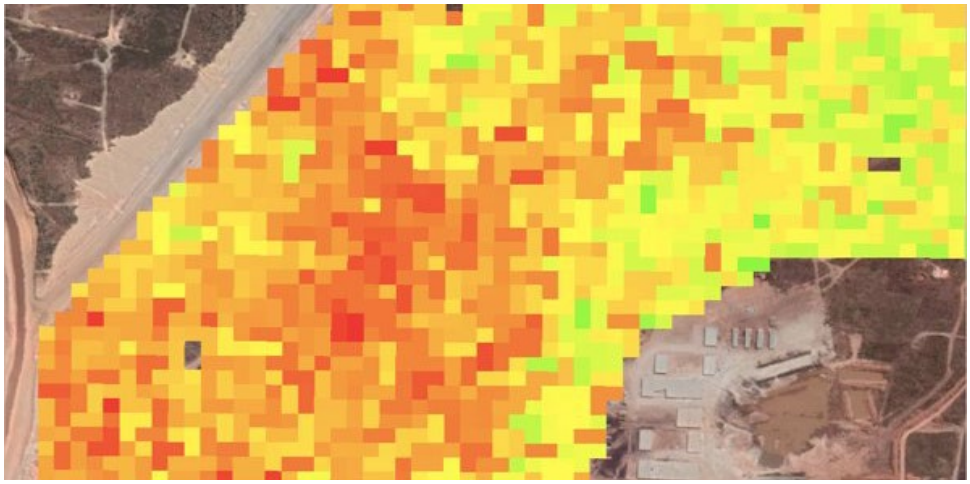
Easier to detect, require high to medium-high resolution imagery, automatic detection possible.

Remote/incipient surface mining image: Google Earth (2025), South Kolwezi ASM surface mine, Kolwezi, Democratic Republic of the Congo, 10°53'56"S 25°57'01"E, scale 1:300m, camera 3,980 m, elevation 1,511m [online]. Imagery from Airbus from 30/08/2020. Available from: https://earth.google.com/web/ [Accessed July 2023];

As tunnel digging is one of the deadliest activities undertaken by artisanal miners, and tunnel sites can be difficult to access on the ground, we explored the possibility of using ISBAS processing to generate a sort of "heat map" for surface activity consistent with tunnel digging.[76]

Following a series of statistical tests designed by our team,[77] we generated maps in which orange and red zones of surface motion indicated activity consistent with tunnel digging:

Figure 3: Sentinel-1 ISBAS surface motion (mm/yr)



This "heat map" was compared to a map of the same area from Google Earth VHR imagery over the same area presented, which confirmed the results. This was an extremely novel approach to understanding activity of artisanal miners in the DRC.

Figure 4: Google Earth comparison to Sentinel-2 "Heat Map"

Remote/incipient surface mining image: Google Earth (2025), South Kolwezi ASM surface mine, Kolwezi, Democratic Republic of the Congo, 10°53'56"S 25°57'01"E, scale 1:300m, camera 3,980 m, elevation 1,511m [online]. Imagery from Airbus from 30/08/2020. Available from: https://earth.google.com/web/ [Accessed July 2023];

These results were a useful confirmation that ASM activity for tunnel digging can be monitored through means of satellite-derived surface motion maps. Crucially, single tunnels are typically dug for exploration of mineral deposits. If a cobalt vein is found, multiple tunnels are then excavated at one location simultaneously, otherwise, the area is typically abandoned. Tunnel expansion can further be monitored with time-lapse analysis. The ability to detect ASM tunnel sites, especially in rural areas, can provide guidance to research teams on where to investigate, and potentially to inform NGOs on where to provide services to families and/or try to assist with the removal of children from dangerous tunnels.

In total, the EO-driven analyses of the Kolwezi area identified seven open pit mines, 177 surface mining areas, and 41 tunnel mining areas in and around the city in 2021. Applying the techniques we used for Kolwezi across the entire Copper Belt region would produce the first known universe of LSM and ASM copper-cobalt mining sites in the DRC. EO mapping to aid the categorization of LSM sites and ASM sites provides a range of benefits, such as the ability to map the universe of known mining sites, track expansion of artisanal mining areas (especially tunnel sites), and assist researchers/NGOs with ground efforts and interventions. This entire analysis can be done remotely.

B. Identification of ASM sites in remote areas

Many ASM sites are in remote areas that researchers might never encounter. The ability to identify remote ASM sites can be used to direct researchers where to expand ground investigations, or to direct NGOs where to deploy interventions and support. Identification of these remote sites further assists with understanding the universe of cobalt ASM sites in the DRC, and would theoretically assist with supply chain auditing and transparency.

Locations of potential visibly active ASM areas, as well as point locations of probable tunnel mining, were collected between 2022-2023, in a rural remote area located south of the Kolwezi-Fungurume alignment, transecting Lualaba and Haut-Katanga provinces. The landscape can be described as predominantly covered by thick tree cover, shrubland, and grassland. There are many remote settlements of small and medium sizes. The terrain is mountainous and inaccessible with little to no infrastructure.

Satellite imagery allowed for a comprehensive assessment of this area, revealing sprawling ASM activity connected through a network of new pathways and roads to the principal LSM sites, such as the Mutanda mine and surrounding sites between Kisenda and Kisanfu in the north, and the Likasi and Kambove mining area in the east (Map 6 below). These linkages between remote ASM and LSM sites further reinforce the flow of artisanally mined cobalt into the formal supply chain.

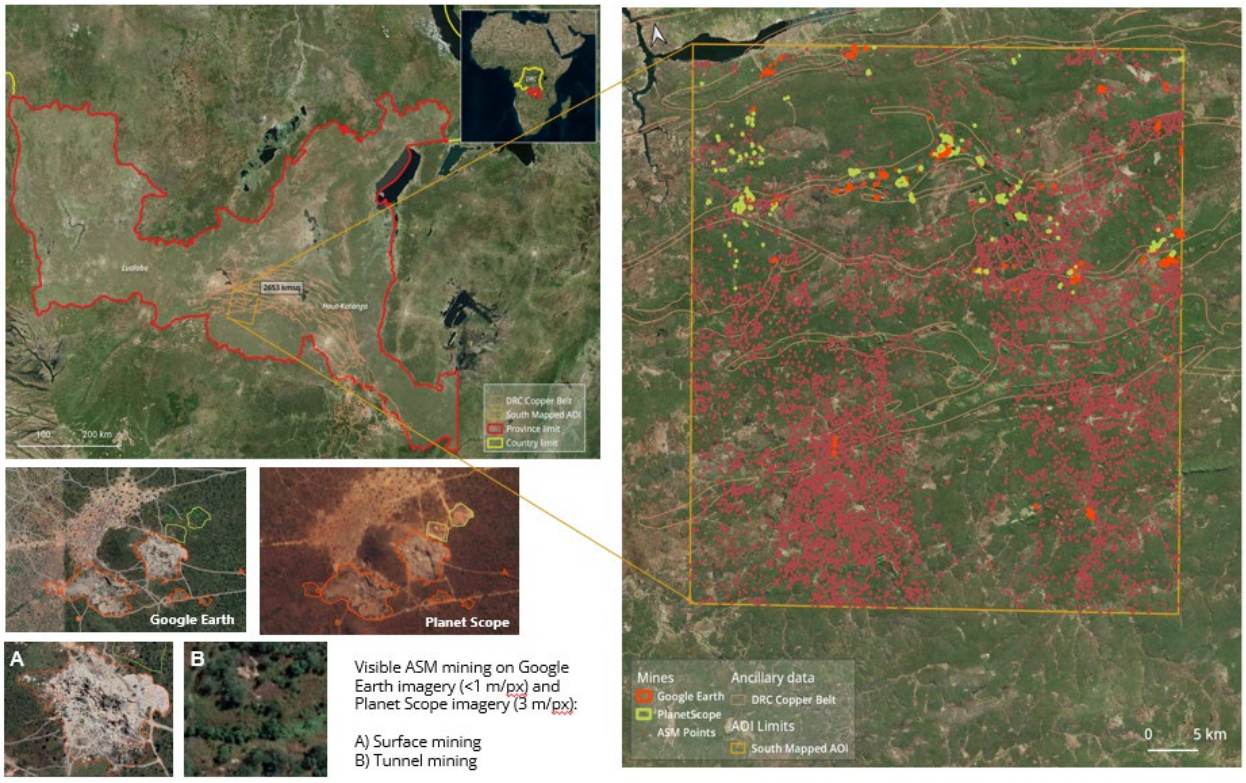
Mining perimeters and point locations of probable tunnel mining were manually identified and dated from two separate sources:

Google Earth (GE) imagery: very high-resolution imagery (< 1m/pixel) was assessed for signs of ASM as discussed above.[78] Locations where mining activity was incipient or evident, were further assessed against available temporal imagery, to determine their status as incipient, active, or extinct mines.

Planet Inc. PlanetScope imagery: high resolution (3-4.77 m per pixel) daily or monthly basemap imagery was assessed for signatures of bare soil that are typically associated with settlements and surface mining in the area. Imagery was sourced for the 2022-2023 wet months period, due to better contrast between lush vegetation and bare soil.[79]

A total of 8,220 points were inventoried as identified sites of potential tunnel mining and incipient or extinct surface mining. Furthermore, 355 locations of confirmed surface mining were collected. These sites are visualized in Map 5.

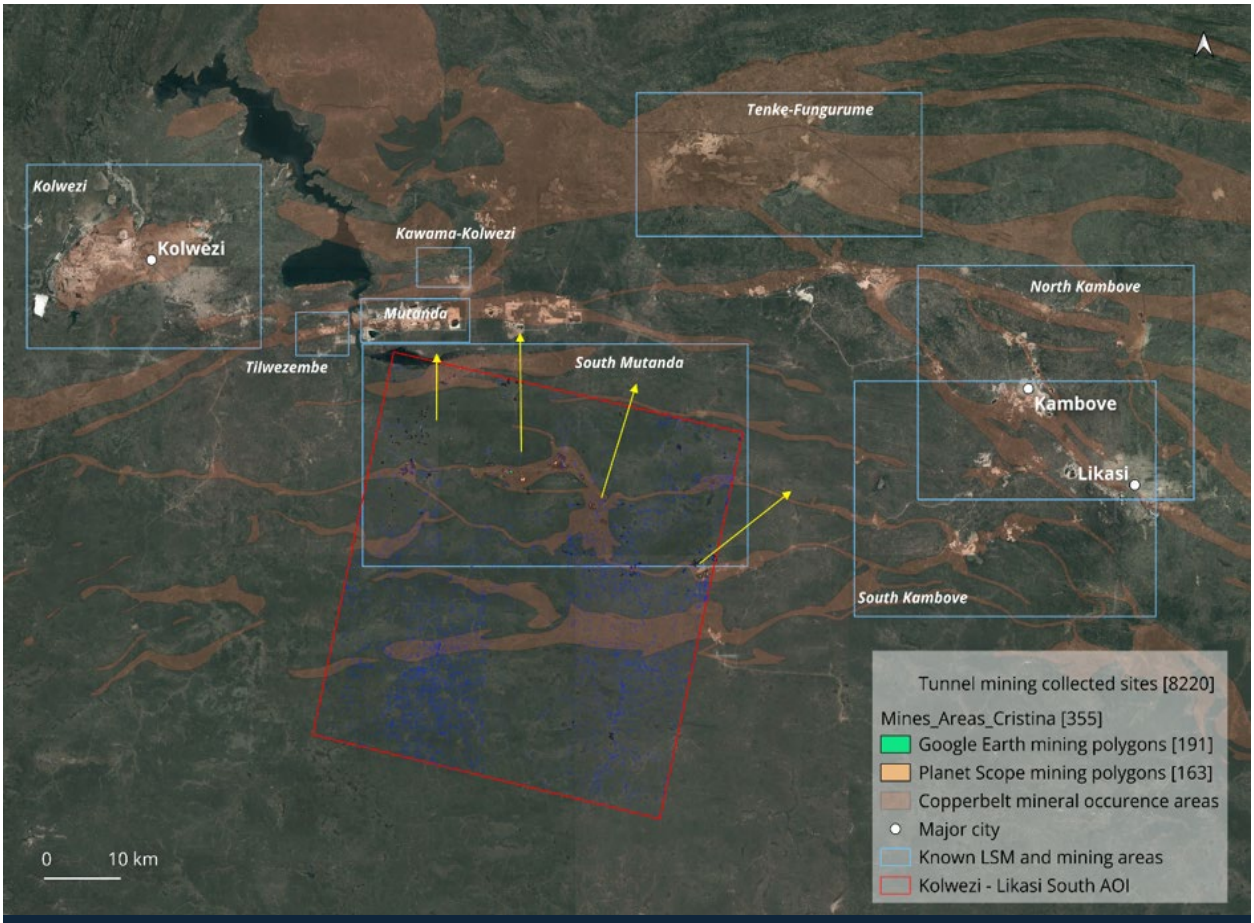
Map 5: Locations of the south Kolwezi-Likasi ASM sites



The map displays identified ASM points (tunnel mining) and mine polygons (surface mining) distribution and examples as identified during the 2022-2023 mapping exercise.
For the insets: Google Earth (2025), South Kolwezi ASM surface tunnelling, Mutebi, Democratic Republic of the Con-go, 11°05'47"S 26°10'54"E, scale 1:200m, camera 3,074 m, elevation 1,546 m [online]. Imagery from Airbus from 09/05/2021. Available from: https://earth.google.com/web/ [Accessed July 2023]. PlanetScope Imagery, 03/07/2023, © Planet Labs PBC.
For the basemap: Google Maps (2023), South Kolwezi, Democratic Republic of the Congo, Imagery © Land-sat/Copernicus from older-31/12/2020 [online]. [Accessed July 2023].

The distribution of tunnel points and confirmed surface mines paints a picture of sprawling ASM activity in the remote, mountainous region south of Kolwezi-Likasi. A comparative visual analysis of the same locations was performed for 2024 where imagery was available.[80] In the 2024 imagery, new connected dirt roads and signs of incipient surface mining are evident, while some previously delineated sites were abandoned and vegetated. At the border of Lualaba and Haut-Katanga, another alignment of surface mines, with signs of mechanised activity, deep open pits, and mixed ASM are also present and have significantly developed since 2020. Nearby small settlements show distinct signs of expansion and mining activity in their immediate vicinity. Dirt road connections link to the Mutanda and Tenke LSM sites in the North, as shown in Map 6.

Map 6: ASM sites mapped during 2022-2024



The map includes the principal connection directions towards established mining areas within the Kolwezi-Likasi line. For the basemap: Google Maps (2025), Kolwezi-Likasi mining belt and the South Kolwezi AOI, Democratic Republic of the Congo, Imagery © Landsat/Copernicus from older-31/12/2020 [online]. [Accessed April 2025].

Finally, Figure 5 visualises identified surface mining polygons from 2020 with overlapping imagery from Google Earth in 2024, which evidences further development of ASM at the border between Lualaba and Haut-Katanga. Tunnel mining is present and confirmed in the vicinity of mine clusters, whereas other locations require further validation.

Figure 5: Development of ASM activity from 2020 to 2024 at the Lualaba and Haut-Katanga Provincial border

For the basemap: Google Maps (2025), ASM mining at the Lualaba and Haut-Katanga provincial border, Democratic Republic of the Congo, Imagery © Landsat/Copernicus from older-31/12/2020 [online]. [Accessed 16/04/2025].

Overall, the geospatial analysis was highly effective at identifying ASM sites in remote areas, broadening our knowledge of the universe of such sites, and tracking development of ASM and LSM sites across time, including the crucial ground linkages between new ASM sites and established LSM sites, offering contextual evidence of the flow of ASM minerals into the formal supply chain.

C. Tracking environmental impact of mining

In addition to the categorisation and mapping of mining sites, we sought to use EO to measure the impact of copper-cobalt mining on the natural environment around Kolwezi from the dawn of the cobalt crush in 2009 to 2021.[81] Following the dramatic results of this analysis, an additional assessment was made of incremental impacts from 2021 to 2024.

The study used an object-based pixel classification method, which extracts similar groups of pixels (objects) that share similar spectral properties to classify them into land cover types, as defined below:

Cultivated land:	agricultural land, mixed grassland, low-cover herbaceous
Trees:	mature tree growth
Shrubs:	woody shrub species
Bare land:	dirt track, construction sites, sediment deposits, bare soil
Rooftop:	metal, clay, concrete building materials
Impervious surfaces:	asphalt, low albedo surfaces
Water:	rivers, lakes, ponds, streams, water retention areas
Shadow:	shadowed areas
Glare:	bright solar reflection
Exposed rock (mining area):	mine pits, rock piles, tailings, smelt waste, rockslides

The classification technique that was utilized, Support Vector Machine (SVM),[82] is a machine learning system that uses sets of training pixel groups obtained through a segmentation process that identifies object edges and textural changes in the image. The segmented objects are then split into training samples and test samples. Training samples are assigned a category to learn the spectral and textural properties of the pixel group, such as rooftop, exposed rock, trees, shrub, and so on. The samples are then computationally compared to the test samples and the model can predict the probability for the test sample to fall into each of the land cover categories.

The highest probability defines the final category of the sample; hence, maps of predicted land cover are outputted by the model for each of the image stacks collected. The accuracy of this classification was estimated to be between 85.2%-90.4%.

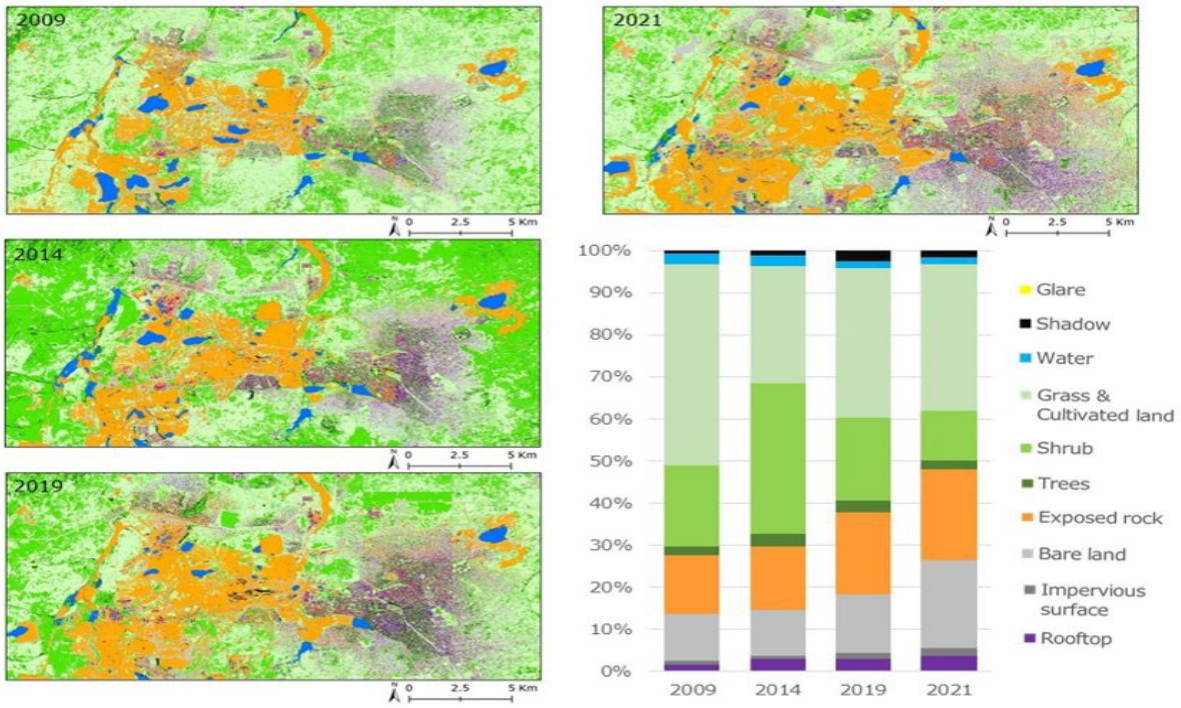
An overall analysis of the land cover dynamics for each of the analysed years revealed a dramatic change in landscape with growing regions of exposed rock (mining) and urban sprawl (built-up, rooftops) and sharply decreasing vegetation areas and loss of water bodies, as summarised in the following table:

Table 29: Kolwezi mining landscape impact, 2009-2021

	2009		2021			
	km^2	% Area	km^2	% Area	Change km^2	Change %
Cultivated land	168.6	47.8	122.9	34.8	-45.7	-27.1
Trees	7.6	2.2	7.3	2.1	-0.3	-3.9
Shrubs	67.8	19.2	41.7	11.8	-26.1	-38.5
Bare land	39.6	11.2	73.4	20.8	33.8	85.4
Rooftop	5.2	1.5	12.9	3.7	7.7	148.1
Impervious surfaces	3.2	0.9	6.6	1.9	3.4	106.3
Water	9.5	2.7	6.2	1.8	-3.3	-34.7
Shadow+glare	2.2	0.6	5.5	1.6	3.3	150.0
Exposed rock (mining area)	48.9	13.9	76.3	21.6	27.4	56.0
TOTAL	352.6	100.0	352.8	100.0		

A time-lapse pictorial representation of the data is included below:

Figure 6: Time-lapse representation of environmental impacts of mining activities around Kolwezi[83]

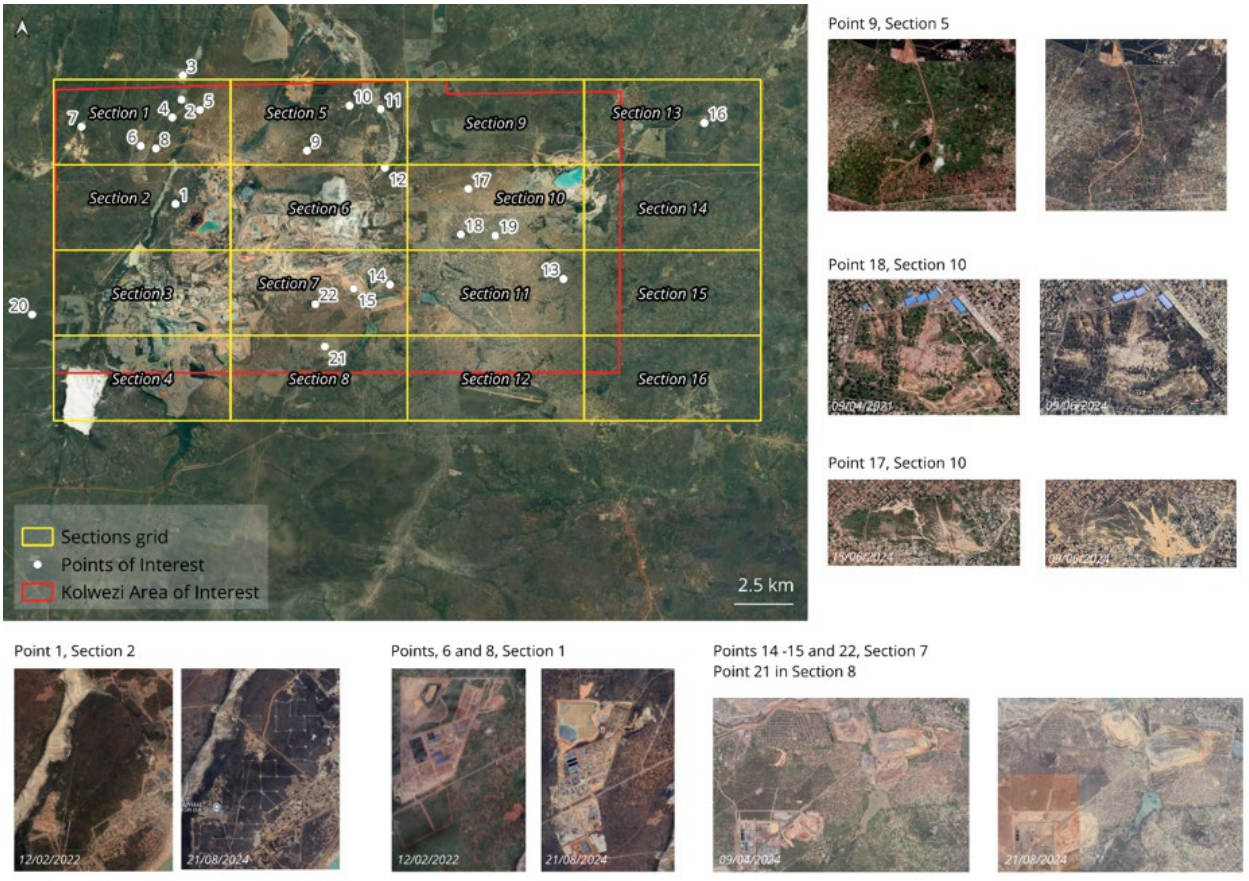


Twelve years of rapidly expanding LSM and ASM copper-cobalt mining had a dramatic impact on Kolwezi's environment. Cultivated land used for agricultural production decreased by 27.1%, representing a loss of 45.7km^2. Tree loss was 3.9%, shrub loss was 38.5%, and the loss of water bodies was 34.7%. At the same time, the mining area expanded from 48.9km^2 to 76.3km^2, an increase of 56%. The total copper-cobalt mining areas around Kolwezi in 2021 exceeded the size of Washington, DC (68km^2).

Finally, the sharp increase in rooftops from 5.2 km^2 to 12.9 km^2 (148.1%) demonstrates the migration of people into Kolwezi seeking to participate in the copper-cobalt boom. As the data from our labour surveys indicate, almost 9-in-10 of these respondents involved people who began to work as artisanal miners due to the lack of any alternative means of survival. In all likelihood, mining expansion in other cities across Lualaba and Haut-Katanga provinces has similarly pushed many people to the fringes and left them with almost no other options for survival.

Following the compelling results from our analysis covering between 2009 to 2021, we conducted additional analysis of the impact of mining operations in and around Kolwezi from 2021 to 2024. This analysis revealed minor, localised changes in land cover, within both the extraction perimeters of the mines and the fabric of the urban areas.[84] The analysed area of interest (AOI) was split into 16 sections, where points of interest (POIs) were marked if visible changes were observed. A map of the AOI with the Sections and POIs, along with visual details of the most relevant changes is provided in Figure 7.

Figure 7: Areas of observed land impact of mining operations in kolwezi, 2021-2024



For the basemap: Google Maps (2025), Mining Operations in Kolwezi between 2021-2024, Kolwezi, Democratic Re-public of the Congo, Imagery © Landsat/Copernicus from older-31/12/2020 [online]. [Accessed April 2025].

Recent access road development and surface scraping is visible in Section 2, Point 1, starting in August 2024, potentially signifying extensions to the mining activity within the perimeter of the mining block. Within Section 1, extensions of exposed rock are visible for the surface pits connected to the main mining sites in North-West Kolwezi (Points 2,3,5).

Changes in the urban structure of the North-West Kolwezi township are also visible (Point 7), as previous grassland has been replaced by residential building structures, signifying potential growth of economic and population activity coinciding with the mining expansion.

The most important change is observed in the development of a new LSM site, identified as Luilu Resources, in Section 1, Point 6. The site started development in late 2021 and its incipient phases were captured in the 2021 classification as exposed rock and bare land, yet, the full scale of expansion, including water basins and building structures were only visible from 2022 onwards, within clearly delimited boundaries. Surrounding greenery changed into bare land and exposed rock as more facilities were extended and mining commenced, with mechanised activity being clearly visible. Subsequently, the residential area immediately connected to this site has seen minor densification (Point 8). Growth in urban fabric is more evident in Section 5, Point 9, where shrubland, grass, cropland and tree cover has been replaced by residential structures, most likely in connection to the Metalkol site. However, the Metalkol site does not display significant change in development, with only minor surface mining activity and exposed rock extension east of the site (Point 10). Visible mining activity and changes are seen on the main river area crossing northern Kolwezi. Surface scraping has extended along the river reaches. Mining activity is evident in the river floodplain, changing the river channel (Section 5, Point 11 and Section 6, point 12).

Minor densification of the urban fabric can be observed in the eastern and southern Kolwezi town area (Section 11, Point 13), marking a potential increase in the resident population, in relation to extension of mining activity outside the analysed AOI. Minor expansion and deepening of the COMMUS mining concession is seen in 2024, affecting the residential area of Kanina (Section 7, Points 14 and 15). The expansion was followed by yet more forced evictions from the Kanina neighbourhood.[85] Furthermore, the COMMUS site in Section 8, Point 21 displays signs of development where bare land has been turned into exposed rock in the open pit.

Within the city of Kolwezi, despite no changes in landcover at the CDM concession in Kasulo, (Section 10, Point 18), tunnel digging activity (marked by pink tarps) appears to have diminished, evidenced by subsequent minor vegetation growth. It is possible that ore bodies in those areas

have been exhausted. Further across the urban area, new surface mining is marked by a growth in bare land and signs of surface scraping (Section 10, Points 17 and 19).

Unfortunately, consistent visual analysis of the areas surrounding the AOI was not possible, due to variation in imagery availability beyond the 2021 date. In some cases, such as eastern Kolwezi, 2022 imagery shows clear expansion of surface mining and subsequent urban sprawl (Section 15). Similarly, shrubland changes into bare land are seen in the north-eastern landscape outside of the AOI, in connection with the Mutoshi site (Section 13, Point 16). In the western side of the AOI, markings of future LSM expansion (impervious surfaces associated to enclosure and roads) are seen in 2024, signalling future mining development (Section 2).

In conclusion, these studies reveal how EO and geospatial analysis can be used for quantifying the true scale of mining and its impacts in the copper-cobalt provinces of the DRC. Understanding the past and present landscape dynamics of mining activity provides a reliable medium to inform sustainable strategies, guide research teams and NGOs, shape environmental protection policies, and help identify and protect vulnerable populations engaged in mining activities. This under-utilized tool within the field of human rights shows great promise for future analysis.[86]

Finally, it is vital to note that the devastating environmental impact of cobalt mining in the DRC is not constrained to the loss of arable land and water bodies alone, but also includes the contamination of the water bodies that have survived, which is discussed in the next section.

11. Water sample analysis

1. Overview

The environmental impacts of cobalt mining in the DRC are severe, but they remain inadequately measured. Deforestation, contamination of rivers and lakes, loss of arable land, and air pollution are all serious problems being faced by the local population, as foreign mining companies often treat the Congo like a toxic dumping ground. Pollution by mining contaminants can be caused by emissions of toxic particulates into the air (which fall on land, water, animals, and people), as well as the discharge of toxic substances into water bodies.

Industrial mining and processing of copper-cobalt ore produces numerous toxic discharges that can be very acidic, depending on the chemical nature of the treated ores. In particular, sulphuric acid and other industrial acids are used to separate metals in ore bodies. The resulting discharges are supposed to be contained, treated, and disposed of responsibly, but in the DRC, many foreign mining companies dump the toxic discharges into rivers, streams, and lakes without prior treatment. In addition, tailing dams on mining concessions are required to contain mining waste in solid or liquid form. Failure of the integrity of these dams has occurred numerous times across Haut-Katanga and Lualaba provinces, causing contamination of the surrounding towns and villages, as well as the ground water. Very little post-contamination cleanup tends to occur, escalating strife between local communities and foreign mining companies.

Acids and heavy metals released into the water supply enter the food chain and accumulate in the tissues of living organisms, such as aquatic life, birds, and humans. In many villages and urban areas surrounding mining concessions, it is no longer possible to procure drinking water, to go fishing, to water vegetable crops, or to bathe in the rivers.

Women and girls face particular risk, as they are generally responsible for collecting water from wells, rivers, and lakes, which is used in the household for cooking, cleaning, and bathing. Constant contact with contaminated water sources exposes women and girls to a range of ailments, including urinary tract infections, diarrhoea, and gynaecological issues.

The United Nations Human Rights Council Resolution 48/13[87] (adopted on 8 October 2021) formally recognized the human right to a clean, healthy, and sustainable environment. The resolution declared that having a clean environment is a fundamental human right. It further acknowledged that environmental degradation, including climate change and biodiversity loss, directly impacts human rights. The Resolution called on member states and international organizations to take stringent measures to protect this right.

Going one step further, on 28 July 2022, the United Nations General Assembly adopted Resolution A/RES/76/300,[88] which recognized the right to a clean, healthy, and sustainable environment as a universal human right. The resolution was passed with 161 countries voting in favour, 0 against, and 8 abstentions, including China. The resolution built on Resolution 48/13 by acknowledging the severe environmental crises facing humanity, including climate change, biodiversity loss, and pollution, and highlighted their disproportionate impact on vulnerable populations. The resolution called on states, international organizations, and businesses to strengthen their environmental commitments and integrate the right to a healthy environment into legal frameworks and policies. Advocates view the resolution as a tool to hold governments and corporations accountable for the kinds of environmental harm taking place in the DRC's mining provinces, which must first be demonstrated by more academic studies on the topic.

There have been several studies of the contamination of water by mining operations in the mining provinces of the DRC, all of which found severe pollution.[89] With the resources available, our intention was to make a modest contribution to these studies with additional data that would demonstrate the need for more research. In particular, a comprehensive study of the contamination of water bodies across Haut-Katanga and Lualaba provinces, coupled with soil and air sampling, and tied to health impacts in the sampled communities, is sorely needed.

The following section outlines a case study on the contamination of water centered in mining areas in and around Kolwezi linked to many of the sites investigated for the labour surveys. Researchers also conducted conversations with community members around these sites to gather anecdotal evidence of the health impacts of water pollution.

2. Sampling the sites

Researchers gathered water and sediment from lakes, rivers, and streams to test for heavy metal concentrations and pH levels.

The samples were taken from the following sites:

Table 30: Water sample site location

Water body	Nearby mining site(s)	Nearby communities
Lake Nzilo	Tilwezembe	Mupanja
Lualaba River	Tilwezembe	Mupanja
Wanselah		Smaller lakeside villages
Kawama (streams and wells)	Shabara	Kawama
Lake Golf	COMMUS	Kanina (south Kolwezi)
Kaitende River (near Musonoï)	COMMUS	Kanina (south Kolwezi)
Tshabula (streams and wells)		Kolwezi (south)
Lake Kabulungu	KCC-Mashamba-Kamilombe	Kapata (southwest Kolwezi)
Kapata (wells)	KCC-Mashamba-Kamilombe	Kapata (southwest Kolwezi)
Biwaya (wells)	KCC-Mashamba-Kamilombe	Biwaya (southwest Kolwezi)
Tanla River	UCK	Kolwezi (east)
Kalemba River (near Luilu)	*Mineral Processing Facility	Kolwezi (northwest)
Samukinda (Luilu River)	*Mineral Processing Facility	Kolwezi (north)
Streams near Kamoa-Kakulu		West of Kolwezi

The following map details the locations of these sites:

Map 7: Water sample site map

A. Water samples

Several samples of water were collected from each location. In the case of wells, water was collected from as deep in the well as possible. In the case of lakes, rivers, and streams, each sample was collected at least five metres from the shore. Samples were collected in a sterile 100ml polystyrene bottle. The samples were transferred into a microtube, transported in isotherm boxes, and stored at the University of Lubumbashi in a refrigerator at 4C prior to laboratory analysis. The pH measurements were conducted *in situ* in the sampled body of water, using the Eutech PH 450 portable pH-meter.

B. Sediment samples

Sediment samples were harvested from random areas along the beds of streams, lakes and rivers, at least five metres from the shore, by scraping at the sediment surface. Each sample was stored in a sterile plastic bag, transported in isotherm boxes, and stored at the University of Lubumbashi in a refrigerator at 4C prior to treatment and analysis. The sediment samples were treated by oven drying, crushing, and sieving.

3. Processing of samples

All the collected samples were processed in the laboratory of the Toxicology and Environment Unit of the University of Lubumbashi under the oversight of Professor Céléstin Banza.

A. Water samples

To analyse the water samples, they were first transferred into microtubes and mineralized with concentrated nitric acid (HNO3) in a digester before toxicological analysis.

B. Sediment samples

Sediment samples were first oven dried at 65C for 48 hours. Oven drying is required as metal concentrations are expressed as micrograms per kilograms (µg / Kg) of dry weight. The dried samples were then ground using a GEEPAS electric grinder, sieved, and stored in minigrip bags. The samples were then weighed, stored into microtubes and mineralized with concentrated nitric acid (HNO3) in a digester before toxicological analysis.

4. Toxicological analysis

In each sample, heavy metals were quantified by means of inductively coupled argon plasma spectrometry (ICP-MS) with an Agilent 7500 instrument. Mean values for concentrations of heavy metals were compared to maximum levels set as guidelines in river water by the World Health Organization (WHO). The heavy metals assessed were: cobalt, manganese, nickel, copper, zinc, arsenic, cadmium, lead, and uranium.

5. Results

A. Heavy metal concentrations in water

The average values in µg/L of heavy metals found in the water samples collected can be found in the following table:

Table 31: Water Sample Heavy Metal Concentrations

Heavy metal	Average µg/L	WHO Recommended maximum[90]	Variance
Co (cobalt)	9,530	N/A *UK/US typically <10	953x
Mn (manganese)	5,455	400	13.6x
Ni (nickel)	757	70	10.8x
Cu (copper)	26,114	2,000	13.1x
Zn (zinc)	2,542	N/A *above 1,000 toxic	2.5x
As (arsenic)	139	10	13.9x
Cd (cadmium)	39.7	3	13.2x
Pb (lead)	2,361	10	236x
U (uranium)	41.4	30	1.4x

The results of the analysis were disturbing. Most values ranged from 10 to 14 times the WHO recommended maximum exposure for humans. Although the WHO does not set limits for cobalt in drinking water, in the US and UK levels are typically lower than 10 µg/L. Our samples averaged 953 times this amount. Lead concentrations were also extreme at 236 times the WHO recommended maximum.

The deleterious health impacts of chronic exposure to heavy metals cannot be overstated, all of which are worse for children and developing foetuses.[91] Some of these effects include:

Cobalt: Chronic exposure to high levels of cobalt in water can lead to damage to the heart muscles and heart failure, blood clots, stroke, swelling in the legs and abdomen, tremors and muscle weakness, tingling or numbness in hands and feet, cognitive impairment, goitre, hypothyroidism, and cancer.

Manganese: Chronic exposure to high levels of manganese in water can lead to tremors, muscle stiffness, impaired coordination, slow or slurred speech, gait disturbances, liver toxicity, and renal impairment.

Nickel: Chronic exposure to high levels of nickel in water can lead to kidney damage or kidney failure, high blood pressure, and cardiovascular disease.

Copper: Chronic exposure to high levels of copper in water can lead to nausea and vomiting, abdominal pain, diarrhoea, headache, dizziness, fatigue, haemolysis (destruction of red blood cells), liver failure, renal impairment, headaches, dizziness, tremors, difficulty walking, and cardiovascular issues.

Zinc: Chronic exposure to high levels of zinc in water can lead to nausea and vomiting, abdominal pain and cramping, diarrhoea, headache and dizziness, fatigue and lethargy, haemolysis, immune suppression, copper deficiency, and kidney damage.

Arsenic: Chronic exposure to high levels of arsenic in water can lead to nausea, vomiting, abdominal pain, and diarrhoeas (may be bloody), toxic shock, confusion or delirium, seizures, multiple organ failure, several forms of cancer (bladder, kidney), peripheral neuropathy, cognitive impairment, reduced fertility, diabetes, kidney damage, and death.

Cadmium: Chronic exposure to high levels of cadmium in water can lead to nausea and vomiting, abdominal pain and diarrhoeas, kidney damage or failure, prostate cancer, kidney cancer, and bladder cancer.

Lead: Chronic exposure to high levels of lead in water can lead to abdominal pain, nausea and vomiting, headache, dizziness, fatigue, seizures, coma, cognitive impairment, weakness and numbness in the extremities, kidney disease or failure, heart disease and stroke, reproductive issues, and neurodevelopmental disorders.

Uranium: Chronic exposure to high levels of lead in water can lead to organ failure, cancer, and death.

Additional research is required to measure these potential health impacts of exposure to heavy metals in these frontline communities in the scramble for cobalt.

B. pH measurements

pH levels of the water samples were measured for the same sites in and around Kolwezi. The WHO recommends that drinking water should have a pH level between 6.5 and 8.5 for optimal health. pH measurement ranges from 1 to 14, with a score of 7 being neutral, less than 7 acidic and greater than 7, alkaline. Most of the sites sampled had pH values well below 6.5, indicating high levels of acidity.

Water with a pH lower than 6.5 poses risks to human health, including nausea, vomiting, diarrhoea, kidney damage, and osteoporosis. Children, infants, and pregnant women are particularly vulnerable to the effects of acidic water. In addition, highly acidic water can cause harm to aquatic organisms. The blood and tissues of fish and other aquatic organisms lose sodium and oxygen as a result of acidic water. Although the acidity of these streams and rivers may not kill fish, the added stress stunts their growth and makes them less competitive for food. Fish eggs do not hatch at pH 5.0 or lower due to acidic water poisoning.

The pH levels in the water at sites sampled include:

Table 32: Water sample pH levels

Site	Sediment pH	Water pH
Lake Nzilo	6.2	6.0
Lualaba River	6.6	6.7
Wanselah	6.5	6.5
Kawama village	5.7	5.5
Lake Golf	5.8	5.9
Kaitende River	5.4	5.6
Tshabula	5.4	5.0
Lake Kabulungu	6.0	6.9
Kapata	5.3	5.5
Biwaya	5.7	5.9
Tanla River	3.4	3.0
Kalemba River	3.4	3.0
Samukinda	5.3	5.2
Kamoa-Kakulu	4.3	4.0

Note: 1 <pH <7 (acidic); pH = 7 (neutral); 7 < pH < 14 (alkaline).

The dumping of heavy metals and other toxic effluents by foreign mining companies into water bodies in and around Kolwezi has rendered every site that was sampled below the minimum recommended pH level by the WHO of 6.5. Some sites, such as the Tanla River near UCK and the Kalemba River near the Luilu mineral processing facility were “hyper acidic,” (pH below 4), which does not permit the survival of aquatic life.

Indeed, anecdotal evidence from communities in these areas confirmed that the water bodies once teemed with fish and crabs, but they have vanished in recent years. The loss of aquatic life harms the incomes of fishermen, which has caused some families to remove children from school, who end up working as artisanal miners to help the family survive. It is a vicious cycle of environmental and human degradation.

Residents of Kapata and Biwaya villages, who avail of a few water sources in the area including Lake Kabulungu complained of nausea and diarrhoea after drinking the water, and they also complained of rashes when they used it for bathing. “The mines have destroyed our water”, complained one resident. “Our crops do not grow. We are always sick”, lamented another. Likewise, residents of Kanina near the COMMUS mine who availed of water from Lake Golf (pH 5.9) for washing and bathing complained of upset stomachs and diarrhoea. Just to the south at Tshabala village, the downstream water supply in the Kaitende River was even more acidic (pH 5.0). Community members complained of chronic upset stomachs, headaches, and rashes.

Lake Kabulungu near Kapata village, with adjacent contaminated crops.

Complaints of polluted water that smells bad and causes a range of ailments were echoed in communities across the sampled areas. “Now we have diseases we never had before”, declared one resident near the Kalemba River. Another resident in Musonoï near the Kaitende River articulated a regrettable reality echoed by many community members with whom we spoke: “The NGOs tell us not to live near a mine because it is bad for our health. The mines are everywhere. Where are we supposed to live?”

Further east from Kolwezi, water sources near the Shabara site at the village of Kawama were highly acidic with a pH 5.5. Deeper water sources around the village of Mupanja near Tilwezembe came in with pH’s of 6.7 (Luabala River) and 6.0 (Lake Nzilo). Dead fish could often be seen floating at the surface. Water sources to the north of Lake Nzilo near Wanselah were right at the threshold of being too acidic, with pH levels of 6.5. Fishermen here also complained of a lower stock of fish and crabs in recent years, which had caused depressed incomes and led many to migrate to the southwest to work in artisanal mining in Kolwezi.

The dumping of toxic waste and heavy metals into the streams, rivers, and lakes in and around Kolwezi has contaminated most of the water sources relied on by the local population. Water sources near mineral processing facilities are particularly acidic and toxic. The high concentrations of heavy metals and the highly acidic nature of the water is devastating to the health of the people of Kolwezi who rely on these water sources for drinking, cooking, and bathing. The impact on aquatic life is also severe. Additional study of other water sources across Lualaba and Haut-Katanga provinces, especially near major mining concessions and their processing facilities, is needed to establish a data set that can guide policy efforts to hold companies and governments accountable for the destructive impacts of mining the metals that enable the global north to pursue a greener future.

12. Recommendations

As demonstrated by the research conducted for this project, artisanal mining for cobalt in Haut-Katanga and Lualaba provinces of the Democratic Republic of the Congo involves a range of hazardous and exploitative working conditions. Artisanal miners, especially children, suffer numerous injuries and negative health consequences, while earning meagre incomes. Furthermore, the environmental damage caused by mining operations is considerable. All of these areas require urgent attention by stakeholders across the cobalt supply chain.

The following recommendations emerge from the data obtained during this project. They are also informed by the artisanal miners surveyed by the researchers, who have very clear ideas on what would be most helpful to them.

1. Consumer-facing technology and EV companies

Key recommendations to assist consumer-facing technology and EV companies with improving the conditions in their cobalt supply chains would include:

- Work with academics, civil society, and artisanal mining communities in the copper-cobalt mining provinces to complete an accurate map of mineral supply chains, with particular scrutiny paid to the ways in which ASM cobalt enters corporate supply chains. Make this mapping publicly available;
- Based on this mapping, support an independent due diligence initiative on cobalt supply chains that is conducted by Congolese academics, civil society, and artisanal mining communities, to ensure that downstream partners are adhering to national and international laws on human rights and environmental sustainability;
- Encourage those supply chain partners who fail to uphold these laws to address the shortcomings, and refuse to do business with them until they do so;
- Invest at least 0.5% of net profits to support communities whose labour and mineral resources are required for the products sold; these resources should be used to support the kinds of recommendations made in this report, as well as those that emerge following engagement with artisanal mining communities in the DRC and other countries at the

bottom of rechargeable battery supply chains. The supply chain only exists because of the immense demand for cobalt at the top, and that is where ultimate accountability resides for addressing the problems;

- Maintain a permanent corporate presence in the copper-cobalt provinces to engage with local stakeholders and ensure adherence to zero-tolerance policies on forced labour, child labour, and other abuses;
- Adhere to UN Guiding Principles of responsible exit when considering ending or moving business operations from a mining site or region, including undertaking stakeholder consultation to identify and address any adverse impacts resulting from the decision to exit.[92]

2. Foreign mining companies

Key recommendations to assist foreign mining companies in reducing the human rights and environmental harms caused by the industrial mining of cobalt in the DRC would include:

- Clean up all existing environmental damage and contamination linked to your operations and, to the greatest extent possible, repair the damage that has been caused;
- Following United Nations norms,[93] obtain Free, Prior, Informed Consent from local communities prior to displacement and ensure adequate housing and compensation to them, including to those who have been previously displaced;
- Investigate fully the harm that has been caused to women and girls by water pollution in surrounding communities, and establish medical clinics to address and treat the gynaecological impacts they are facing;
- Ensure these medical clinics are staffed with physicians who can treat the broader health impacts caused by toxic contamination of water, air, and soil in surrounding communities;
- Ensure all toxic effluents are contained, treated, and properly disposed of, and that no further contamination in surrounding communities occurs; publish your efforts annually.

3. The Congolese government

Key recommendations for the Congolese government would include:

- Drastically increase the number of copper-cobalt ZEAs to a supply that adequately supports the hundreds of thousands of artisanal miners in Haut-Katanga and Luabala provinces;
- Formalize the artisanal mining sector by providing workers with contracts, health benefits, and living wages that allow families to keep children in school and improve their standard of living. Provide artisanal miners with safety equipment, such as boots, masks, gloves, and protective headgear;
- Establish and enforce occupational health and safety regulations specific to ASM, and provide ASM workers access to safety training and first-aid services;
- Establish transparent, safe grievance mechanisms that allow artisanal miners and community members to complain of human rights and environmental abuses, with annually published reports on the number of complaints and their outcomes;
- Establish a system of mobile courts with trained lawyers and judges that can move through artisanal mining communities, address and adjudicate conflicts that arise between these communities and foreign mining companies;
- Abolish artisanal mining cooperatives and replace them with a single trade union;
- Provide free education until 18 years of age, as stipulated under Congolese law. Build and support enough schools to educate all children, including providing students with two healthy meals a day;
- Ensure sufficient resources and training to a dedicated force of labour inspectors to monitor and enforce labour laws in artisanal mining areas;
- Adequately fund and support community health centres in rural areas;
- Promote vocational training, develop alternative employment programs, and support microfinance programs for small business development;

- Enforce constitutional provisions relating to forced labour and child labour with strict penalties for violations;
- Provide resources for government agencies and academic researchers to ensure effective monitoring of the environmental practices of mining companies, while conducting regular testing of the environmental and human rights impact of mining operations;
- Annually collect data on water, air and soil contamination, as well as deforestation and publish the results.

All of the aforementioned efforts can and must receive financial support from the consumer-facing technology and EV companies that rely so heavily on the Congo's mineral resources.

4. Researchers and foreign NGOs

A few specific areas of research to be pursued by academics and foreign NGOs would include:

- Ongoing examination of labour conditions in the artisanal mining sector of the DRC: this should include more data on labour exploitation in the copper-cobalt provinces, as well as studies on conditions in the eastern Congo in the context of the 2025 M23 invasion;
- Supply chain mapping of 3TG minerals is particularly important, to help dispel the notion promulgated by consumer-facing technology and EV companies that their supply chains of these minerals are untainted by militia violence, child labour, and modern-day slavery. Rwanda has diminimus reserves of these minerals, yet is somehow the largest exporter of them in the world. The reason is clear and must be rigorously documented;
- Use Earth Observation to produce a full universe of ASM sites in the DRC, so that they can be investigated and tracked, especially with ground assistance from local NGOs;
- Use Earth Observation to continue assessing the environmental impact of cobalt mining in the DRC, particularly as relates to deforestation and the loss of agricultural land and water bodies over time;
- Expand research on the contamination of water, air, and soil by mining operations, with mapping to link the pollution to specific offenders;
- Conduct research on the health impacts to frontline communities of pollution and toxic dumping across the copper-cobalt mining provinces.

5. Western governments

- Strengthen supply chain transparency and due diligence requirements of consumer-facing tech and EV companies with more robust legislation; laws should include strict and severe penalties as opposed to simple reporting requirements, including a potential import ban;
- Support formalization of the artisanal mining sector in the DRC with financial and technical assistance;
- Help establish an independent system of third-party supply chain verification that relies on Congolese civil society and local academics;
- Fund the kinds of vital research efforts described in previous recommendations;
- Invest in local infrastructure and community development projects in mining areas;
- Work with the Congolese government to strengthen labour rights and anti-corruption measures;
- Use trade agreements, foreign aid, and other national policies to incentivize companies that invest in ethical sourcing from the DRC.

These recommendations represent a starting point for stakeholders interested in addressing the human rights and environmental impacts of cobalt mining in the DRC.

Appendix I: A modest proposal, "Clean Stone"

Although the two ASM "model mines" in Kolwezi (CDM and Mutoshi) did not achieve their stated goals, they were positive steps conceptually. Imagine a scenario in which there are several hundred copper-cobalt ZEAs in Haut-Katanga and Lualaba provinces which are all run like "model mines", including adherence to international standards on human rights and sustainability. The benefits to the local population would be substantial. Hundreds of thousands of Congolese people could earn decent and dignified livelihoods from artisanal mining, children could remain in school, health outcomes would improve, and communities would be strengthened. It cannot happen overnight, and the model needs to be deployed, tested, and refined before it can be scaled. To that end, a modest proposal is put forth for a truly human rights-centred ASM model mining NGO: "Clean Stone".

The purpose of Clean Stone would be to return a greater share of the Congo's mineral wealth to its poorest people. Human rights principles and environmental sustainability would be the foundation of the mission, with a particular focus on the security and health of women and children. The project would include:

- Fixed and fair wages, best-of-class safety equipment and training, and insurance schemes for artisanal workers;
- Skills-training for families of employees to promote diversified livelihoods and household finances;
- Creation of micro-credit lending and community-based saving-group schemes to empower and stabilize local communities;
- Allocation of at least 10% of net profits of the operation to investment in local communities, including new schools, expanded sanitation, adult literacy programs, reproductive, neo-natal health programs, new medical centres, and expansion of the electricity grid.

The first phase of the initiative would be to establish a DRC-based non-profit entity to manage the operation. The entity would be led by individuals with proven experience in the ASM sector, of which there is no shortage in the DRC. An advisory board would include members of civil society and the ASM community.

The entity would then secure an existing ZEA or obtain a new ZEA from the provincial government. Capital requirements of this phase would be between $200,000 and $300,000.

The second phase of the initiative would be to conduct a geological survey of the ZEA, hire security, purchase equipment and PPE for artisanal miners, fence the ZEA and build a depot, conduct human rights training for staff and workplace training for employees, and purchase transport trucks. Building a small-scale processing facility on site would also be essential to avoid cross-contamination of ore at larger processing facilities in the DRC. Alternatively, Clean Stone could pursue commercial relationships with refiners based in western countries and use blockchain technology to ensure its ore is processed and tracked separately to ensure integrity of the minerals. Capital requirements for this phase, including the small-scale processing facility, would be between $500,000 and $700,000.

The third phase would involve the commencement of artisanal mining operations. Mined ore would be secured in the Clean Stone depot until it could be processed and exported to a commercial-grade refiner in the West. Before too long, Clean Stone could become a self-sustaining operation based on its mining revenues. Once the model is proven, it could be scaled through investment from any number of stakeholders, such as the Congolese government or consumer-facing technology and EV companies. Pending the security situation in the eastern Congo, the model could eventually be expanded to the region for the extraction and processing of 3TG minerals.

A successful initiative could achieve the following:

1. **The world's first "clean" cobalt supply chain** - achieved through a rigorous, human-rights centred artisanal mining operation in the DRC;
2. **Harm-reduction for women and girls** – who otherwise suffer a pandemic of sexual assault, negative health impacts, and lost educational opportunities;
3. **Decreasing fatal and serious accidents in artisanal mines** - linked to the skill-trainings, best-of-class safety practices, and compliance of artisanal miners with advanced techniques of safe mining exploitation, including supports, rock-bolts, and ventilation shafts for tunnels;
4. **Improve the reputation of the DRC's artisanal mining sector** - achieved with the newly established culture of compliance with human rights standards in the mining sites across the DRC;
5. **Improvement of the life quality of the mining workforce** - linked to increased remuneration and skills-training of artisanal miners and their families, as well as investment in local communities;
6. **Socio-economic development** - achieved by investing at least 10% of net profits into communities to build/rehabilitate schools, medical clinics, water and sanitation, and expand the electricity grid;
7. **Decrease in child labour** - linked to: 1) the return to school of child labourers who no longer need to work in the mines as their parents receive adequate remuneration; and 2) overall increase in community development, income, health, and security.

Clean Stone is an ambitious proposal, and numerous details would have to be worked out, but the catastrophe facing the people and environment in the copper-cobalt provinces of the DRC can only be remedied with bold vision. A more detailed vision for Clean Stone with further scoping and local collaborative engagement will be completed and published by the end of 2025 as part of this current research project. Indeed, the notion of Clean Stone was born from artisanal miners themselves, one of whom told the author,

"We have our own dreams. If you can help us, we can achieve them."

Appendix II: Select literature review

A review of a selection of some of the primary reports, articles, and investigative pieces on cobalt mining in the DRC is included below.

1. **Amnesty International. 2016.** ***"This is What We Die for": Human Rights Abuses in the Democratic Republic of the Congo Power the Global Trade in Cobalt.*** **Access:** https://www.amnesty.org/en/documents/afr62/3183/2016/en/

    - The report highlights how children as young as seven work in hazardous conditions in artisanal cobalt mines in the DRC, facing risks such as fatal accidents, toxic exposure, and extreme exploitation. None of the children interviewed had any sort of protective equipment, such as gloves or face masks. They complained of being frequently ill. Often, when working in the mines, children went the whole day without eating. Living or working in these areas exposed children to physical abuse, drug abuse, sexual exploitation, and violence. Several children claimed to have been beaten or had seen other children beaten by security guards at industrial mines. Many miners, including adults, worked long hours and only earned around CF 1,000 to 2,000 per day [~$1 to $2 at the time].

    - The report further traces cobalt from copper-cobalt mines to major global tech and automotive companies, revealing a lack of supply chain transparency and corporate accountability. The study points out how companies fail to conduct due diligence to ensure ethical sourcing. The authors call for stronger regulations, corporate responsibility, and greater transparency to end child labour and improve working conditions.

2. **Amnesty International. 2023.** ***Recharge for Rights: Human Rights Abuses in the Supply Chains of Electric Vehicle Manufacturers.*** **Access:** https://www.amnesty.org/en/documents/pol10/7391/2023/en/

    - The report evaluates the human rights due diligence policies of 13 major EV manufacturers concerning their mineral supply chains, particularly cobalt sourced from the DRC. The study reveals widespread human rights abuses, including child labour and hazardous working conditions, associated with cobalt extraction in the DRC. It highlights that companies like BYD, Mitsubishi, and Hyundai have inadequate policies to address these issues. In contrast, Mercedes-Benz demonstrated moderate due diligence efforts.

The authors urged automakers to leverage their influence to improve working conditions and ensure ethical sourcing practices, rather than avoiding DRC-sourced cobalt, which could harm local communities reliant on mining.

3. **Amnesty International and The Initiative pour la Bonne Gouvernance et les Droits Humains. *Powering Change or Business as Usual?* 2023. Access:** https://www.amnesty.org/en/documents/AFR62/7009/2023/en/

    - The study documented how the expansion of four industrial mines in the DRC has resulted in forced evictions: COMMUS, Mutoshi, Metalkol, and Kamoa-Kakula. The four case studies illustrate how many communities in and around Kolwezi have become collateral damage of energy transition mining. The study describes in detail "what happened after multinational mining companies began developing or expanding cobalt and copper mines, and the human rights abuses caused by the eviction of neighbouring communities." Specifically, in the name of energy transition, multinational mining companies forcibly evicted communities from their homes and farmlands and failed to meet their responsibility to respect human rights. The Congolese government also failed to implement or enforce legal protection. The report argues that mining companies operating in Kolwezi should take immediate action to provide meaningful remedy for the harm they have caused and, to avoid future harm, revise their eviction and resettlement policies and practices.

4. **Banza Lubaba Nkulu, C., Casas, et al. 2018. "Sustainability of artisanal mining of cobalt in DR Congo." *Nature Sustainability*, 1(9), 495-504. Access:** https://www.nature.com/articles/s41893-018-0139-4?utm_source=chatgpt.com

    - The study assesses the environmental and health impacts of artisanal cobalt mining in the DRC. The findings reveal elevated levels of toxic metals in frontline communities, leading to numerous health risks. The authors advocate for sustainable mining practices and regulatory interventions to mitigate these adverse effects.

5. **Banza, M.A.; Atibu, E.K.; et al. 2022.** ***"Contamination by heavy metals from mining activities: An ecological impact assessment of Mura and Kimpulande Rivers, Democratic Republic of the Congo."*** **Access:** https://www.sciencedirect.com/science/article/pii/S2589471422000110?via%3Dihub

   - The study examines the environmental and social implications of artisanal cobalt mining in the DRC. The authors highlight that while artisanal mining provides livelihoods for many, it often leads to environmental degradation and human rights abuses. They advocate for formalizing the sector through regulatory frameworks, technological interventions, and community engagement to enhance sustainability. The study emphasizes the need for collaboration among governments, industries, and NGOs to ensure ethical sourcing and improve the well-being of mining communities.

6. **Burgis, T. 2019.** ***"Congo, child labour and your electric car."*** **Financial Times. Access:** https://www.ft.com/content/c6909812-9ce4-11e9-9c06-a4640c9feebb

   - The article delves into the troubling nexus between cobalt mining in the DRC and the global EV industry. The article highlights that nearly a third of the DRC's cobalt production comes from artisanal miners who often operate without proper safety equipment, exposing them to severe health risks such as respiratory diseases and musculoskeletal injuries. The prevalence of child labour is highlighted, with children as young as seven participating in mining activities, thereby missing educational opportunities and perpetuating cycles of poverty.

7. **DHS program USAID.** ***Congo Democratic Republic DHS, 2013-14 – Key Findings*** **(English). Access:** https://dhsprogram.com/pubs/pdf/SR218/SR218.e.pdf

   - The study found that Congolese women face significant barriers to economic opportunities and empowerment, including high rates of gender-based violence and discrimination. Early marriage and high fertility rates represent challenges, where women and girls without any education have a fertility rate twice that of women who complete secondary school (7.4 children compared to 2.9). More than half of women (52%) reported having experienced physical violence, and almost a third have experienced sexual violence (27%), most commonly committed by their current partner.

8. **Faber, B., Krause, B., & Sánchez de la Sierra, R. 2017*. "Artisanal mining, livelihoods, and child labor in the cobalt supply chain of the Democratic Republic of Congo. Department of Economics, Working Paper Series."* Institute for Business and Economic Research, UC Berkeley. Access:** https://escholarship.org/uc/item/17m9g4wm

   - The researchers conducted extensive surveys across mining communities in the DRC's copper-cobalt belt, aiming to understand the economic well-being, health conditions, and the pivotal role of artisanal mining in local livelihoods. Their findings reveal that a significant portion of the population relies on ASM as a primary income source, especially during economic child labour within the cobalt mining sector. The research indicates that 11% of children in these communities are involved in mining activities, exposing them to hazardous working conditions, negative health impacts, and limited educational opportunities. The study also examines the structure of the cobalt supply chain, emphasizing the disparity between the earnings of artisanal miners and the profits accrued by traders and companies further downstream.

9. **Frankel, T. C. 2016, September 30. Cobalt mining for lithium ion batteries has a high human cost. *The Washington Post*.**
   Access: https://www.washingtonpost.com/graphics/business/batteries/congo-cobalt-mining-for-lithium-ion-battery/

   - This investigative article uncovers the human cost behind cobalt mining, focusing on child labour and unsafe working conditions. It connects the demand for lithium-ion batteries in global markets to the exploitation occurring in DRC mines, urging consumers and companies to acknowledge and address these ethical concerns.

10. **International Labour Organization. 2019. *Child Labour in Mining and Global Supply Chains*. International Labour Office. Access:** https://www.ilo.org/publications/child-labour-mining-and-global-supply-chains

    - The report examines the widespread use of child labour in the mining sector, particularly in countries like the DRC. It highlights the harsh and dangerous conditions children face in artisanal mining, including exposure to toxic substances, hazardous labour, and extreme exploitation. Many children work long hours in mines extracting minerals such as cobalt, gold, and tin, which are essential to global supply chains for electronics, jewelry, and renewable energy.

The report critiques weak enforcement of labour laws and inadequate corporate due diligence, which allow child labour to persist. It calls for stronger international regulations, corporate accountability, and social protection measures to eliminate child labour in mining.

11. **International Labour Organization. 2023. *Understanding informality and child labor in Sub-Saharan Africa*. Access:** https://www.ilo.org/publications/understanding-informality-and-child-labour-sub-saharan-africa

    - The report examines patterns of child labour, child employment, and informality across 22 Sub-Saharan countries, utilising household survey data from 197,418 children aged 10–17, representing approximately 78.2 million children. The study revealed that child labor remains a significant issue in Sub-Saharan Africa, with a substantial proportion of children engaged in work that hinders their education and development. The majority of working children are employed in the informal sector, often without formal contracts or legal protections. Agriculture is identified as the predominant sector employing children, followed by services and industry. This sectoral distribution underscores the rural nature of child labour in the region. Older children (15–17 years) were more likely to be involved in labour compared to younger ones (10–14 years). Additionally, boys were generally more engaged in child labour than girls, although this trend varies across specific countries and sectors. Finally, children involved in labour activities were less likely to attend school regularly, highlighting a negative correlation between child labour and educational attainment.

12. **Kara, S. 2023. *Cobalt Red: How the Blood of the Congo Powers Our Lives*. St. Martin's Press.**

    - Drawing on the voices of artisanal cobalt miners in the DRC, *Cobalt Red* exposes the human cost of cobalt mining. Through firsthand investigations, Kara reveals the brutal conditions faced by Congolese miners, including child labour, hazardous working environments, and extreme exploitation. Workers endure long hours in unsafe tunnels, without protective gear, while earning only a few dollars a day. The book also traces cobalt's journey from these dangerous mines to the global supply chains that fuel smartphones, EVs, and renewable energy technologies. Kara criticizes multinational corporations for failing to enforce ethical sourcing policies and urges greater transparency and accountability. He highlights the devastating environmental and social consequences of cobalt extraction, calling for urgent reforms to protect Congolese communities.

13. **Kayembe-Kitenge, T. 2020. *Incidence of low birth weight and proximity to mining in Lubumbashi and Kipushi, DR Congo*. Environmental Health Perspectives, 128(4), 047003. Access:** https://doi.org/10.1289/ehp5354

    - The study investigated the relationship between mining activities and the incidence of low birth weight in Lubumbashi and Kipushi. The researchers analyzed 202,028 births in Lubumbashi during the observation period, with 145,512 (72%) recorded in the studied health zones; among these, 11,448 were LBW. The findings indicate that areas closer to mining operations had higher rates of LBW, suggesting a potential association between mining-related environmental factors and adverse birth outcomes.

14. **Makal, Didier. 2024. *"Impunity and Pollution Abound in DRC Mining Along the Road to Energy Transition." Mongabay*. Access:** https://news.mongabay.com/2024/05/impunity-and-pollution-abound-in-drc-mining-along-the-road-to-energy-transition/.

    - The report highlights the significant environmental and social issues caused by mining in the DRC, particularly concerning cobalt and other minerals crucial for the global energy transition. It underscores the rampant pollution, human rights abuses, and lack of accountability within the industry. The author points out that despite the DRC's rich mineral resources, the government has struggled to enforce environmental regulations and address the exploitation of workers.

15. **Mbunga, B.K.; Gjengedal, E.L.F.; Bangelesa, F.; et al. 2022. *"Heavy metals in children's blood from the rural region of Popokabaka, Democratic Republic of Congo: a cross-sectional study and spatial analysis."* Access:** https://www.sciencedirect.com/science/article/pii/S2589471422000110?via%3Dihub

    - The study examines the presence of toxic heavy metals in children's blood in a remote region of the DRC. Researchers conducted blood tests on children to measure levels of harmful metals such as lead, cadmium, and cobalt, assessing potential health risks. The study found alarming concentrations of these metals, which are linked to serious health issues, including developmental disorders, neurological damage, and organ dysfunction. Using spatial analysis, researchers identified environmental and industrial sources of contamination, including mining activities and pollution from natural geological deposits. The study highlights the urgent need for public health interventions, stricter environmental regulations, and further research to mitigate exposure risks.

The findings underscore the broader health crisis linked to heavy metal contamination in the DRC, emphasizing the vulnerability of children in rural mining-affected regions.

16. **Mununga Katebe, F., et.al. 2023. "Assessment of Heavy Metal Pollution of Agricultural Soil, Irrigation Water, and Vegetables in and Nearby the Cupriferous City of Lubumbashi, Democratic Republic of Congo."** ***Agronomy***, **13(2), 357.**
Access: https://doi.org/10.3390/agronomy13020357

    - The study examined the contamination levels of heavy metals (As, Cd, Cr, Cu, Pb, Co, and Zn) in soil, irrigation water, and vegetables in Lubumbashi's urban gardens. The findings revealed that 79.3% of the gardens were unpolluted, while 20.7% were severely polluted, with copper and cadmium concentrations reaching up to 1,355 mg/kg and 236 mg/kg, respectively, significantly exceeding WHO thresholds. Additionally, 57% of water sources were contaminated with lead, and 100% of vegetable samples contained copper and cobalt levels above recommended limits, highlighting serious health risks for the city's inhabitants.

17. **OECD.** ***Cobalt: Demand-Supply Balances in the Transition to Electric Mobility.*** **Organisation for Economic Co-operation and Development, 2019. Access:** https://publications.jrc.ec.europa.eu/repository/bitstream/JRC112285/jrc112285_cobalt.pdf

    - The report analyses the growing demand for cobalt, driven by the rise of EVs and battery technologies. The report highlights concerns over cobalt supply constraints, geopolitical risks, and ethical sourcing issues, particularly in the DRC. The study examines production trends, recycling potential, and alternative battery chemistries that could reduce reliance on cobalt.

      While technological advancements may lower cobalt dependency, the report stresses that demand is likely to remain high in the future. It calls for responsible sourcing strategies, improved supply chain transparency, and investments in sustainable mining practices. Governments, manufacturers, and policymakers are urged to develop long-term solutions, including circular economic initiatives and regulatory frameworks, to ensure stable cobalt supplies while addressing environmental and social challenges.

18. **Patterson, S., & Wexler, A. 2018.** ***"Despite cleanup vows, smartphones and electric cars still keep miners digging by hand in Congo."*** **The Wall Street Journal. Access:** https://www.wsj.com/articles/smartphones-electric-cars-keep-miners-digging-by-hand-in-congo-1536835334

- The authors investigate the persistent reliance on artisanal cobalt mining in the DRC despite commitments from major technology and automotive companies to improve supply chain ethics. The article highlights that, despite public pledges from companies like Apple Inc. and Volkswagen AG to audit suppliers and address these issues, cobalt sourced from artisanal mines continues to enter the global supply chain. The investigation focuses on the Mutoshi mine in Kolwezi, where miners, including children, descend underground without helmets, shoes, or protective gear. This mine's owner is part of the supply chain for several multinational corporations, underscoring the challenges in tracing and verifying the origins of cobalt used in consumer electronics and electric vehicles.

19. **RAID and CAJJ. 2021. T*he Road to Ruin? Electric vehicles and workers' rights abuses at DR Congo's industrial cobalt mines*. Access:** https://raid-uk.org/wp-content/uploads/2023/03/report_road_to_ruin_evs_cobalt_workers_nov_2021.pdf

    - The report reveals that workers in the DRC's cobalt mines often face exploitation and labour rights abuses, contradicting multinational mining companies' claims of producing "clean" and "sustainable" cobalt. Key findings include the use of subcontracting models that undermine workers' rights, inadequate safety measures, suppression of freedom of association, and incidents of racism and degrading treatment. Across the five mines investigated (KCC, Metalkol, TFM, SICOMINES, and SOMIDEZ), 57% of the 26,455 workers were hired through subcontractors rather than being directly employed by the mining companies. Unlike directly hired employees, workers hired via subcontracting companies "do not accumulate benefits such as annual pay rises, increased annual leave entitlements, and have no right to a décompte final (final pay)." Additionally, the report highlights the underfunding of the DRC's labour inspectorate, hindering effective enforcement of labour standards. The report further emphasizes the need for EV manufacturers and other companies in the cobalt supply chain to conduct thorough human rights due diligence and ensure fair labour practices. It also calls for stronger regulatory oversight to protect workers' rights in the DRC's cobalt mining industry.

20. **RAID and AFREWATCH. 2024. *Beneath the Green - A critical look at the environmental and human costs of industrial cobalt mining in the DRC*. Access:** https://raid-uk.org/wp-content/uploads/2024/03/Report-Beneath-the-Green-DRC-Pollution-March-2024.pdf

- The report examines the environmental and human costs associated with industrial cobalt mining in the DRC. Focusing on several large copper-cobalt mines in Lualaba province, including Mutanda and Tenke-Fungurume, the report highlights significant issues such as hazardous working conditions, including child labour, and environmental degradation resulting from mining activities. These practices have led to pollution of local water sources and soil, adversely affecting the health and livelihoods of nearby communities. The report underscores the need for stricter environmental regulations and enforcement, as well as corporate accountability to ensure sustainable and ethical mining practices that protect both the environment and the rights of local populations. Some of the key findings include: 1) 56% of those interviewed said women are increasingly experiencing gynaecological and reproductive issues; 2) 72% reported recurring skin diseases; 3) 56% expressed serious concerns about the health of their children; 4) nearly all respondents said that contaminated water was negatively impacting their income and pushing them further into poverty; 5) nearly 60% said the loss of income brought about by the water pollution has forced them remove their children from school as they could no longer afford school fees; 6) 59% said they have been forced to reduce their food intake to one meal a day; and 7) 75% say they could no longer afford healthcare or medicine when sick.

21. **Sovacool, B.K. 2021. "When Subterranean Slavery Supports Sustainability Transitions: Power, Patriarchy, and Child labor in Artisanal Congolese Cobalt Mining." Extr. Ind. Soc. 8, p. 271–293. Access:** https://www.researchgate.net/publication/347678756_When_subterranean_slavery_supports_sustainability_transitions_power_patriarchy_and_child_labor_in_artisanal_Congolese_cobalt_mining

- The author examines the dynamics within the ASM sector in the DRC. The study focuses on the exploitation and human rights abuses associated with cobalt mining.

  Through extensive field research, including 23 semi-structured expert interviews, 48 community interviews with miners, traders, and residents, and visits to 17 mining sites, processing centers, and trading depots, the study uncovers systemic exploitation by various actors, including government officials, police, traders, and local communities. A significant finding of the research is the pronounced gender-based exploitation within the ASM sector.

Women and girls often face severe vulnerabilities, including hazardous working conditions, social marginalization, sexual abuse, and involvement in prostitution. The study also highlights the pervasive issue of child labour in cobalt mining, including numerous instances of child debt bondage.

22. **UNU-CRIS. 2023.** ***Supporting Sustainable Mining Practices and Pathways in the Congo Region*****. Access:** https://cris.unu.edu/supporting-sustainable-mining-practices-and-pathways-congo-region

    - The report addresses the critical need for sustainable mining in the DRC and Central Africa. It highlights the responsibility of industrial mining entities to adopt best practices that mitigate environmental and socio-economic challenges, thereby enhancing community and ecological resilience. The report proposes an action-oriented framework based on four key areas: 1) integrated approaches, 2) multi-stakeholder collaboration, 3) regulatory norms, and 4) robust planning, monitoring, and evaluation protocols. Emphasizing landscape perspectives, community engagement, and continuous collaboration between the mining industry and scientific community, the framework also underscores the importance of transparency and contingency planning.

      The study also highlighted how women undertake a variety of responsibilities and positions across the supply chain, in particular, "ground jobs such as gathering, sorting and washing minerals, and/or providing services to the mining community such as cooking, running a small business, and engaging in the sex trade." Mining-value chains must be gender-sensitive including a more significant focus on mitigating the health and wellbeing-related impacts. Large-scale operations and ASM are often led by foreign companies that have the "potential to develop, publish and implement company-level policies, and these commitments should be reflected across the company standards, guidelines and processes."

23. **U.S. Department** of Labor. 2023. *Child labour and working conditions in artisanal and small-scale cobalt mining in the Democratic Republic of the Congo*. Bureau of International Labor Affairs. Access: https://www.dol.gov/sites/dolgov/files/ILAB/DRC-FL-Cobalt-Report-508.pdf

    - The report examines labour conditions in the cobalt mining sector of the DRC, with a focus on child labour and worker exploitation. The report highlights that children as young as six years old are involved in cobalt mining, often exposed to dangerous conditions, including

toxic dust, cave-ins, and extreme physical labour. Many of these children work to support their families due to economic hardship, lacking access to education and basic health services. In addition, the report discusses broader labour rights violations, including exploitative wages, gender disparities, and unsafe work environments. It emphasizes the need for stronger enforcement of labour protections, corporate responsibility in supply chains, and international efforts to improve mining conditions. Recommendations include increased oversight, social programs for affected communities, and stricter ethical sourcing policies to ensure cobalt mining does not rely on child labour or exploitative practices.

24. **Wu, J., & Wong, J. 2024.** ***Child Labour in Cobalt Mining*****.**
Access: https://am.jpmorgan.com/content/dam/jpm-am-aem/global/en/insights/child-labour-in-cobalt-mining.pdf

- The report by JP Morgan Asset Management provides an economic and corporate overview of the cobalt sector, with particular attention paid to child labour and human rights issues. The report focuses on OECD standards and risks to supply chain stakeholders, while stressing the health risks children face, including exposure to toxic metals leading to respiratory issues and birth defects. The authors emphasise the importance for companies to assess human rights and child labour risks in their cobalt supply chains. It highlights the necessity of implementing the OECD due diligence framework. The authors also note that investors are increasingly engaging with companies to ensure responsible cobalt sourcing. The report notes that while many companies are taking positive steps, there remain areas for improvement, especially as regulatory scrutiny intensifies.

Endnotes

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[49] Data from: https://www.sneresearch.com/en/insight/release_view/371/page/0

[50] Research and Markets. (July 31, 2023). *Market value of cobalt worldwide from 2021 to 2023, with a forecast for 2030 (in million U.S. dollars)* [Graph]. In *Statista*. Access: https://www.statista.com/statistics/1172037/global-cobalt-market-size/

[51] Reuters. (March 7, 2023). "Forecast cobalt supply, demand, and market surplus worldwide in 2023 and 2024 (in metric tons)" [Graph]. In *Statista.* Access: https://www.statista.com/statistics/1287968/forecast-global-cobalt-supply-and-demand/

[52] Kara, Siddharth. 2023. *Cobalt Red: How the Blood of the Congo Powers Our Lives*. St. Martin's Press. New York.

[53] The Faraday Institution (2023). *Building a Responsible Cobalt Supply Chain*. Access: https://www.faraday.ac.uk/wp-content/uploads/2023/01/Faraday_Insights_7_Jan23_Final.pdf

[54] The ILO Forced Labour Convention No.29. Access: https://normlex.ilo.org/dyn/nrmlx_en/f?p=NORMLEXPUB:12100:0::NO::P12100_ILO_CODE:C029

[55] See, "ILO Indicators of Forced Labour." Access: https://www.ilo.org/sites/default/files/wcmsp5/groups/public/@ed_norm/@declaration/documents/publication/wcms_203832.pdf

[56] See: https://www.ilo.org/topics/child-labour/what-child-labour#:~:text=A%20hazard%20is%20anything%20with,the%20risk%20will%20be%20lower.

[57] The ILO Worst Forms of Child Labour Convention, No. 182. Access: https://normlex.ilo.org/dyn/nrmlx_en/f?p=NORMLEXPUB:12100:0::NO::P12100_ILO_CODE:C182

[58] Supplementary Convention on the Abolition of Slavery, the Slave Trade, and Institutions and Practices Similar to Slavery. Access: https://www.ohchr.org/en/instruments-mechanisms/instruments/supplementary-convention-abolition-slavery-slave-trade-and

[59] UNODC. United Nations Convention against Transnational Organized Crime. Access: https://www.unodc.org/unodc/en/organized-crime/intro/UNTOC.html

[60] Details of the laws and codes discussed in this section can be found at, The University of Nottingham Rights Lab and Monash University Castan Centre for Human Rights Law. Antislavery in Domestic Legislation. Access: https://antislaverylaw.ac.uk/country/democratic-republic-of-the-congo/

[61] See for instance, https://www.amnesty.org/en/latest/news/2023/09/drc-cobalt-and-copper-mining-for-batteries-leading-to-human-rights-abuses/

[62] '*Panorama* questions over Glencore mines,' available at: https://www.bbc.com/news/17702487.

[63] For example, see: https://politicalviolenceataglance.org/2020/10/27/the-future-of-conflict-in-mining; and also: https://www.amnesty.org/en/latest/press-release/2019/07/democratic-republic-of-congo-fungurume-mines/

[64] See for instance, "Like Slave and Master: DRC miners toil for 30p an hour to fuel electric cars," 8 November 2021. Access: https://www.theguardian.com/global-development/2021/nov/08/cobalt-drc-miners-toil-for-30p-an-hour-to-fuel-electric-cars

[65] See: https://www.mining-technology.com/news/cmoc-congo-royalties-dispute/

[66] The capture-recapture methodology is a statistical technique used to estimate the size of a population, particularly when it is impractical to count every individual. It is commonly applied in ecology, epidemiology, and social sciences. The process for making the calculation involves: 1) Capture & Marking: A sample of individuals from the population is captured, marked, and then released back; 2) Recapture: After some time, another sample is captured, and the number of previously marked

individuals in this second sample is recorded; 3) Estimation: Using the proportion of marked individuals in the second sample, researchers estimate the total population size using the Lincoln-Petersen estimator or more advanced models. The formula for calculating the estimate is: N=M×C/R, where: N = Estimated total population; M = Number of individuals marked in the first sample; C = Total individuals captured in the second sample; R = Number of recaptured (marked) individuals in the second sample. The method assumes a closed population (no births, deaths, immigration, or emigration) and equal capture probabilities.

[67] A mixed-method approach combines quantitative and qualitative research techniques to improve the accuracy of estimating a transient population. By integrating multiple approaches, researchers can capture a more reliable estimate. In this case, quantitative methods would be supplemented with context-driven qualitative methods to produce an estimate.

[68] See: Brown, C.; Daniels, A.; Boyd, D.S.; Sowter, A.; Foody, G.; Kara, S. "Investigating the Potential of Radar Interferometry for Monitoring Rural Artisanal Cobalt Mines in the Democratic Republic of the Congo." Sustainability 2020, 12, 9834. https://doi.org/10.3390/su12239834.

[69] See: Brown, C.; Boyd, D.S.; Kara, S. "Landscape Analysis of Cobalt Mining Activities from 2009 to 2021 Using Very High Resolution Satellite Data (Democratic Republic of the Congo)." Sustainability 2022, 14, 9545. https://doi.org/10.3390/su14159545

[70] See for instance:

1. Kamga, M.A.; Nguemhe Fils, S.C.; Ayodele, M.O.; Olatubara, C.O.; Nzali, S.; Adenikinju, A.; Khalifa, M. "Evaluation of land use/land cover changes due to gold mining activities from 1987 to 2017 using landsat imagery, East Cameroon." GeoJournal 2020, 85, 1097–1114.
2. Obodai, J.; Adjei, K.A.; Odai, S.N.; Lumor, M. "Land use/land cover dynamics using landsat data in a gold mining basin-the Ankobra, Ghana." Remote Sens. Appl. Soc. Environ. 2018, 13, 247–256.
3. Ngom, N.M.; Mbaye, M.; Baratoux, D.; Catry, T.; Dessay, N.; Faye, G.; Sow, E.H.; Delaitre, E. "Mapping Artisanal and Small-Scale Gold Mining in Senegal Using Sentinel 2 Data." GeoHealth 2020, 4, e2020GH000310.
4. DeWitt, J.D.; Chirico, P.G.; Bergstresser, S.E.; Warner, T.A. "Multi-scale 46-year remote sensing change detection of diamond mining and land cover in a conflict and post-conflict setting." Remote Sens. Appl. Soc. Environ. 2017, 8, 126–139.
5. Rosen, P.A.; Hensley, S.; Joughin, I.R.; Li, F.K.; Madsen, S.N.; Rodriguez, E.; Goldstein, R.M. "Synthetic aperture radar interferometry." Proc. IEEE 2000, 88, 333–382.

[71] Wave return time is further used to determine the distance between the sensor and the targeted surface. By dividing this distance to the known complete wave cycle (wavelength), researchers can determine at what fraction on the wave cycle the returning signal would be (on a peak or on a trough). This fraction is calculated as a value called 'phase' which stands at the base of InSAR techniques. SAR systems are 'coherent' systems, meaning that the expected phase value for a single ground target will be the same each time the satellite pulses are transmitted from the same viewpoint in orbit, therefore

the signal is 'in phase'. Phase coherence is not always possible in practice as obtaining data from the same viewpoint is difficult, hence phase differences known as 'phase shifts' are measured between two separate acquisitions over the same area to reveal changes due to apparent variations of surface elevation. If the distance between two acquisition viewpoints (baseline) is less than a kilometre, the topography related 'phase shift' can be corrected using a Digital Elevation Model (DEM) and by accounting for atmospheric variations in-between.

Any remaining 'phase shift' can be attributed to surface deformation and measured using D-InSAR. For more detail, see: 1) Woodhouse, Iain H. 2006. *Introduction to Microwave Remote Sensing*. CRC Press. Boca Raton, FL; and also 2) European Space Agency, ESA. *How does interferometry work?*. Access: ESA - How does interferometry work?; and also, European Space Agency. *User Guides - Sentinel-1 SAR - Interferometry - Sentinel Online - Sentinel Online*. Access: User Guides - Sentinel-1 SAR - Interferometry - Sentinel Online - Sentinel Online (copernicus.eu).

[72] For more discussion, see: Massonnet, D.; Feigl, K.L. "Radar interferometry and its application to changes in the Earth's surface." Rev. Geophys. 1998, 36, 441–500.

[73] For instance, repeat-pass InSAR, in which images from the same satellite at different times are compared, and differential InSAR (DInSAR), which isolates small changes over time by removing topographic effects. Persistent Scatterer InSAR (PS-InSAR) and Small Baseline Subset (SBAS) techniques improve accuracy by analysing long-term surface changes using stable radar targets.

[74] For more detail, see: Yuan, W.; Wang, Q.; Fan, J.; Li, H. "Mining land subsidence monitoring using Sentinel-1 SAR data." International Archives of the Photogrammetry. Remote Sens. Spat. Inf. Sci. 2017, 42, 655–658; and also, Hu, Z.; Ge, L.; Li, X.; Zhang, K.; Zhang, L. "An underground-mining detection system based on DInSAR." IEEE Trans. Geosci. Remote Sens. 2012, 51, 615–625.

[75] See for instance:

1. Sowter, A.; Bateson, L.; Strange, P.; Ambrose, K.; Syafiudin, M.F. "DInSAR estimation of land motion using intermittent coherence with application to the South Derbyshire and Leicestershire coalfields". Remote Sens. Lett. 2013, 4, 979–987.
2. Gee, D.; Bateson, L.; Sowter, A.; Grebby, S.; Novellino, A.; Cigna, F.; Marsh, S.; Banton, C.; Wyatt, L. "Ground motion in areas of abandoned mining: Application of the intermittent SBAS (ISBAS) to the Northumberland and Durham Coalfield, UK." Geosciences 2017, 7, 85.
3. Bateson, L.; Cigna, F.; Boon, D.; Sowter, A. "The application of the Intermittent SBAS (ISBAS) InSAR method to the South Wales Coalfield, UK." Int. J. Appl. Earth Obs. Geoinf. 2015, 34, 249–257.
4. Novellino, A.; Athab, A.D.; bin Che Amat, M.A.; Syafiudin, M.F.; Sowter, A.; Marsh, S.; Cigna, F.; Bateson, L. "Intermittent SBAS ground motion analysis in low seismicity areas: Case studies in the Lancashire and Staffordshire coalfields, UK." *In Seismology from Space: Geodetic Observations and Early Warning of Earthquakes; Royal Astronomical Society*: 2014. Burlington House. London.

5. Gee, D.; Bateson, L.; Grebby, S.; Novellino, A.; Sowter, A.; Wyatt, L.; Marsh, S.; Morgenstern, R.; Athab, A. "Modelling groundwater rebound in recently abandoned coalfields using DInSAR." Remote Sens. Environ. 2020, 249, 112021.

[76] Eighty-two Copernicus Sentinel-1 Interferometric Wide Swath Single Look Complex (Level 1) images were acquired for a period between 6 March 2017 and 26 January 2020. The method involved the extraction of vertical surface motion, characterised as subsidence or uplift. As the AOI is highly vegetated and experiences seasonal variability, a threshold of coherent ('in phase') pixels was set at 0.45. From pairs of images with sufficient coherency, 1651 interferograms were produced. A temporal baseline of 365 days, a maximum distance between pixels of 100m and a corresponding DEM at 90m were used to correct for topographic effects. The resulting interferograms were then filtered and "denoised" through a process called "multi-looking," which improves the quality of the pixel correlation values between the pair of images used to generate each interferogram, but trades on the spatial resolution producing larger pixel sizes. These smoothed interferograms were used in calculating the topographic height and the displacement of the ground towards the sensor viewpoint for each coherent pixel. The final values of vertical surface motion were produced by geometrically translating the Line-of-Sight (LOS) velocity and error through simple trigonometry for each pixel at 20 m of spatial resolution for a high percentage of pixels (>91 % in the North tile and >95 % in the South tile).

The resulting surface motion maps have shown distributed patterns of subsidence (negative values) and uplift (positive values) in the forementioned period. Across the North tile, LOS velocity values ranged between -17.69 mm/yr (0.35 mm/yr error) to +8.31 mm/yr (1.54 mm/yr error), with an average of -1.87 mm/yr (0.96 mm/yr error). Notable localised subsidence was correlated with LSM sites. In the South tile, LOS velocity ranged between -7.91 mm/yr (0.36 mm/yr error) and +4.55 mm/yr (1.64 mm/yr), with an average of -0.61 mm/yr (1.05 mm/yr error).

[77] To compare between the vertical movement observed by the satellite and the validated location of the mines, a series of statistical tests were designed by the authors. First, a set of random non-mine locations were generated in an area where mining activity was not detected, by matching the number of mine locations previously collected. For both datasets, a series of descriptive variables were extracted (mean, standard deviation, minimum, maximum values) from overlapping these locations with the ISBAS outputs. A series of statistical tests (Wilcoxon, Kruskal-Wallis) were used for analysing if there were any statistically significant differences between the two mine sets (using the Wilcoxon tests) and between mine types (using Kruskal-Wallis tests). The results shown that significant differences between the descriptive variables were found between the pairs of mine datasets, while only the mean, standard deviation and minimum differed between LSM and ASM. Based on the significant statistical differences between the various mining types, a closer look at ASM sites was taken to explore subsidence (negative values) as a clear indicator of mining. By further analysing the minimum and mean values against a control value (threshold) extracted from the paired non-mine areas, the outputs revealed that subsidence values below the set threshold were a clear indicator of mining activity that was active (54 SM and 14 TM sites detected based on the mean, 40 SM and 10 TM sites detected based on the minimum and 32 SM and 6 TM when overlapped).

[78] Given the remoteness of the region, variation exists between image tile dates, with the newest imagery at the time being available for 2020 and the oldest for 2011. Variation in spatial resolution

between tiles (newer imagery has improved spatial resolution), as well as coloration differences at mosaicking, cloud cover and shadow/glint artefacts, are sources of introduced errors in the interpretation of the data. Expert knowledge was used to determine the possibility of a site to point towards ASM activity, especially where there was unclear indication (i.e. tunnel mining under tree cover).

[79] Where possible, to avoid mislabelling surface mining as settlements, the data was compared to positions in Google Earth.

[80] Satellite imagery availability in the area, in the absence of governmental security restrictions, is tied to tasking received by satellite operators from mining companies or other customers with economic/research interests in the area. Thus, while Planet Data collects daily data, Google Earth data is updated depending on imagery periodically purchased by Google LLC and available, previously tasked very high-resolution data from its vendors.

[81] VHR EO optical datasets from three satellites at pixel resolutions of approximately 0.5m allowed for appropriate visual and spectral analysis. The time series was constructed from imagery acquired for the May-July (dry season) months of the years of 2009, 2014, 2019 and 2021, to reduce errors due to seasonal variations. A pre-processing workflow was used to ensure the construction of a time-series stack where all images were spectrally harmonised and spatially correlated. In addition, two vegetation-health descriptive indices, the Normalised Difference Vegetation Index (NDVI) and the Normalised Difference Water Index (NDWI) were calculated for each year in the time series.

Similar techniques were conducted in the following studies: 1) Dupin, L.; Nkono, C.; Burlet, C.; Muhashi, F.; Vanbrabant, Y. “Land Cover Fragmentation Using Multi-Temporal Remote Sensing on Major Mine Sites in Southern Katanga (Democratic Republic of Congo).” Adv. Remote Sens. 2013, 2, 127–139; and 2) Kranz, O.; Lang, S.; Schoepfer, E. “2.5D change detection from satellite imagery to monitor small-scale mining activities in the Democratic Republic of the Congo.” Int. J. Appl. Earth Obs. Geoinf. ITC J. 2017, 61, 81–91.

[82] For more detail, see: Qian, Y.; Zhou, W.; Yan, J.; Li, W.; Han, L. “Comparing machine learning classifiers for object-based land cover classification using very high-resolution imagery.” Remote Sens. 2014, 7, 153–168; and also Thanh Noi, P.; Kappas, M. “Comparison of Random Forest, k-Nearest Neighbor, and Support Vector Machine Classifiers for Land Cover Classification Using Sentinel-2 Imagery.” Sensors 2018, 18, 18.

[83] Image from Brown, Chloe, Doreen S. Boyd, and Siddharth Kara. 2022. "Landscape Analysis of Cobalt Mining Activities from 2009 to 2021 Using Very High Resolution Satellite Data (Democratic Republic of the Congo)" Sustainability 14, no. 15: 9545. https://doi.org/10.3390/su14159545, under the terms and conditions of the Creative Commons Attribution (CC BY) license (http://creativecommons.org/licenses/by/4.0/).

[84] For consistency, only dry season (May-July) imagery was visually assessed for determining the change in urban landscape, and all available imagery was assessed for exposed rock differences. As water bodies and greenery vary with the season, these were assessed in relation to the urban and mining changes.

[85] See: https://www.amnesty.org/en/latest/news/2023/09/drc-cobalt-and-copper-mining-for-batteries-leading-to-human-rights-abuses/

[86] For a discussion of the application of EO for this kind of analysis, see Todd Landman, Colabuono-Mcdonagh, L., and Doreen Boyd, (2024) 'Earth Observation for Human Rights (EO4HR),' in Giles Foody and Doreen Boyd (eds) *Earth Observation and Remote Sensing*, Volume 9: Applications, Amsterdam: Elsevier. Online version published on 12 December 2024; full print publication scheduled for June 2025.

[87] See: https://docs.un.org/en/A/HRC/RES/48/13.

[88] See: https://documents.un.org/doc/undoc/gen/n22/442/77/pdf/n2244277.pdf

[89] See Appendix I for references to some of these studies.

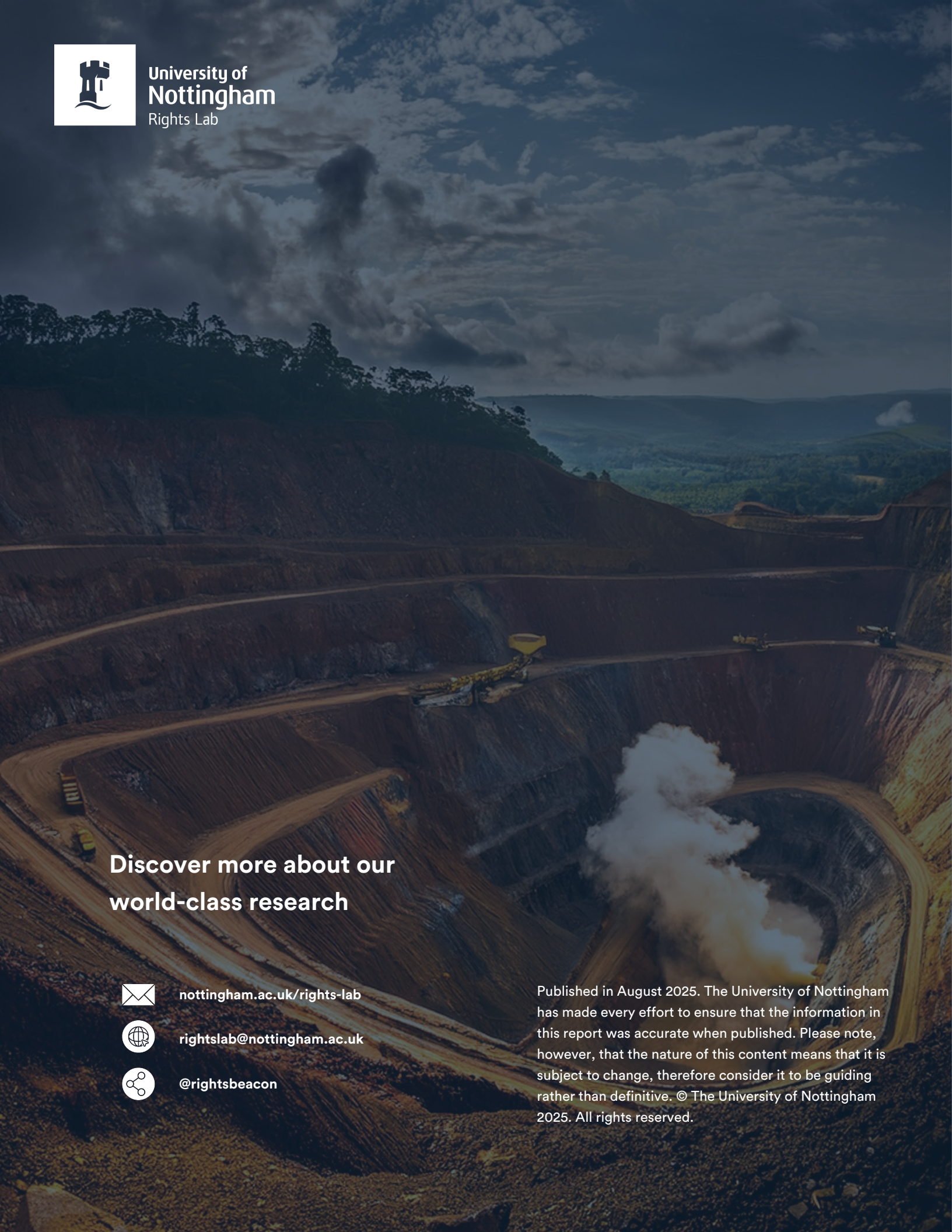
[90] See: https://www.who.int/teams/environment-climate-change-and-health/water-sanitation-and-health/water-safety-and-quality/drinking-water-quality-guidelines

[91] For more detail, see: "Prevalence of exposure of heavy metals and their impact on health consequences," available at: https://pubmed.ncbi.nlm.nih.gov/28643849/; and also, "Water Quality Degradation Due to Heavy Metal Contamination: Health Impacts and Eco-Friendly Approaches for Heavy Metal Remediation," available at: https://pmc.ncbi.nlm.nih.gov/articles/PMC10611083/#:~:text=Contaminated%20water%20with%20heavy%20metal,effects%20on%20the%20reproductive%20system.

[92] For UN Guiding Principles on responsible exit, see: https://www.ohchr.org/sites/default/files/documents/issues/business/bhr-in-challenging-contexts.pdf.

[93] See: "Mining Companies Must Obtain Free, Prior, Informed Consent, Partner with Indigenous Peoples to Ensure Responsible, Ethical Land Use, Speakers Tell Permanent Forum," available at: https://press.un.org/en/2025/hr5491.doc.htm#:~:text=23%20April%202025-,Mining%20Companies%20Must%20Obtain%20Free%2C%20Prior%2C%20Informed%20Consent%2C%20Partner,development%20finance%20for%20Indigenous%20communities

See also: "Basic Principles and Guidelines on Development-Based Evictions and Displacement," available at: https://www.ohchr.org/sites/default/files/Guidelines_en.pdf



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