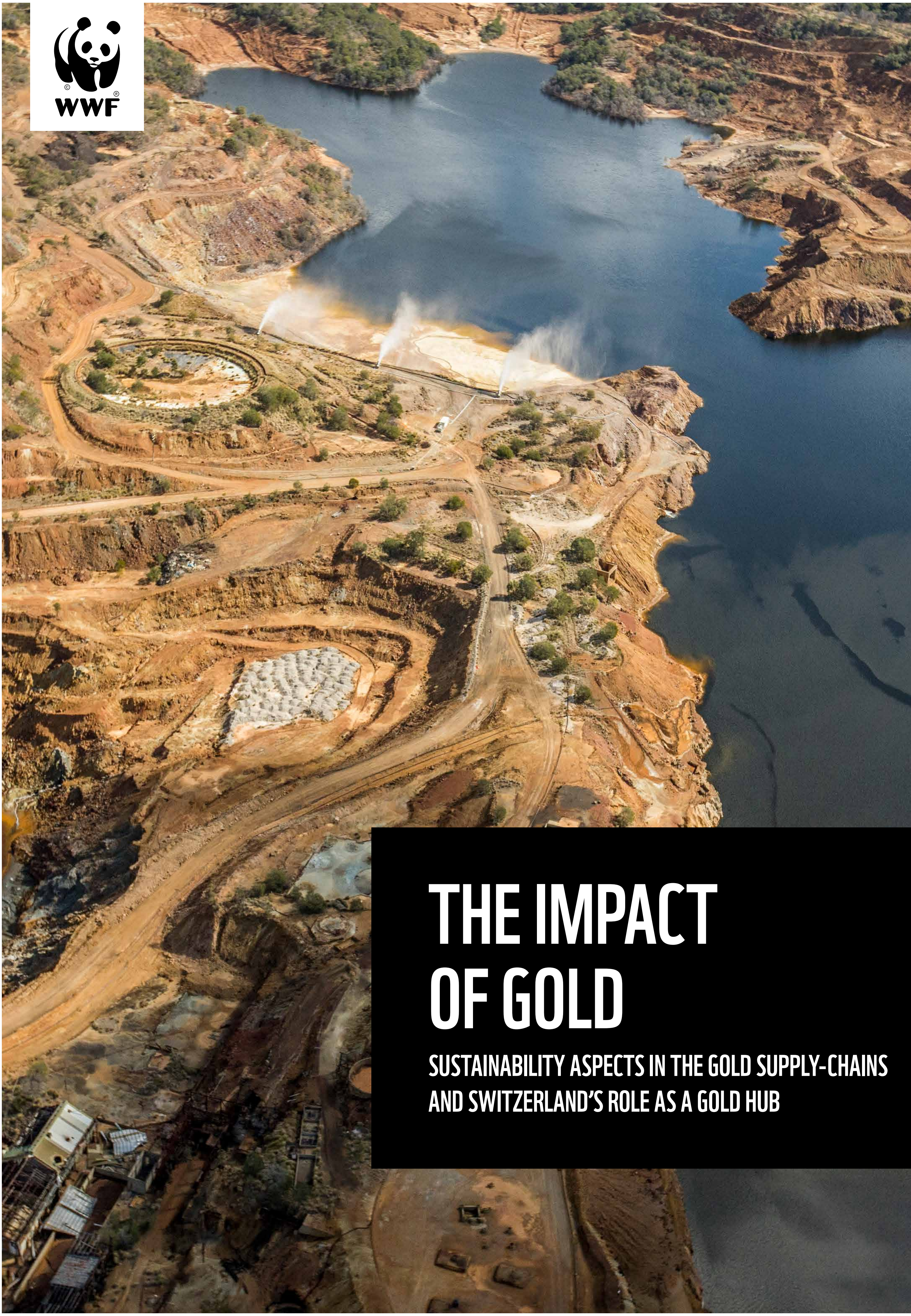

THE IMPACT OF GOLD

SUSTAINABILITY ASPECTS IN THE GOLD SUPPLY-CHAINS AND SWITZERLAND'S ROLE AS A GOLD HUB

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Authors:
Nino Schön-Blume (Oeko-Institut e.V.)
Peter Dolega (Oeko-Institut e.V.)
Matthias Buchert (Oeko-Institut e.V.)
Bernadette Bodenmüller (WWF Switzerland)
Mariella Meyer (WWF Switzerland)

Contributors:
Mark Pieth
Christoph Wiedmer (Gesellschaft für bedrohte Völker)
Marc Ummel (Swissaid)
Diana Culillas (Swiss Better Gold Association)
Michael Priester (Projekt Consult)
Tobias Kind-Rieper (WWF Germany)
Rebekah Church (WWF Germany)
Damian Oettli (WWF Switzerland)
Amandine Favier (WWF Switzerland)
Patrick Hofstetter (WWF Switzerland)
Holger Hoffmann-Riem (WWF Switzerland)
Valerie Passardi (WWF Switzerland)
Walter Wagner (WWF Switzerland)

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Remark: The impact of the global COVID-19 pandemic in 2020 strongly impacted the finance sector, retail revenues, and consumer behaviour. Therefore, in this study, data and statistics are purposely used from 2019, as the numbers from 2020 strongly deviate from the previous years and long-term trends. The enduring impact of the pandemic is difficult to predict, but this study assumes that a recovery towards pre-pandemic circumstances will occur.

FOREWORD

For thousands of years gold has fascinated humankind. It was considered the sun god's metal in ancient Egypt and in Latin America. It was used to make jewellery, to store value and for many years most currencies around the world were based on gold reserves. And yet gold is frequently sourced under the worst conditions. Conflict, slave labour, child labour, forced prostitution and the most severe forms of environmental degradation still go hand in hand with gold mining in many parts of the world. In the Amazonas region (in Brazil or in the Madre de Dios Province of Peru) for example, illegal logging goes hand in hand with the spilling of toxic mercury into the environment, with vast areas of virgin forest lost every year, negatively impacting fragile ecosystems and indigenous populations alike.

Switzerland has a particularly strong relationship with gold: Not only is 50%–70% of the world's gold refined in Switzerland, but Swiss banks also play a crucial role in marketing bullion. Switzerland is also a primary hub for upmarket jewellery and watchmaking. Despite their reliance on this precious metal, the awareness of watchmakers, jewellers and end consumers of the risks involved with the gold supply chain is, however, still very low. Many of the largest manufacturers of Swiss watches continue to turn a blind eye and refuse to even acknowledge the challenges.

This report addresses the problems head on and serves to raise awareness amongst producers and consumers alike. I would like to congratulate WWF for publishing this study as I firmly believe that it will serve as a wake-up call for the sector and ultimately help to raise awareness and hopefully, an adequate response amongst governments, the industry and consumers.

Mark Pieth

Prof. em. at University of Basel


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1. EXECUTIVE SUMMARY

Switzerland is a central hub on many levels along the global gold supply chain. Of the seven large global gold refineries, four are in Switzerland. Swiss gold is a trademark that enjoys a great deal of trust among customers worldwide and is therefore highly regarded and recognised. Moreover, Swiss banks play a crucial role in the investment of gold and the Swiss jewellery and watch markets are key end-users of gold as well.

Watches, jewellery, and investments are by far the most important application sectors for gold and in all three of these sectors, Switzerland is among the world leaders. Nevertheless, the investment sector is the major source that maintains the demand for new gold and therefore mining operations while the watch and jewellery sectors have the highest demand for gold.

In 2018, WWF Switzerland published a study where the biggest Swiss watch companies were ranked based on their environmental performance. This rating demonstrated that most companies were not able to trace back along their supply chain to understand where the raw materials for their products were sourced. This new study focuses not on a ranking of individual companies but instead on providing a more in-depth investigation of the environmental and social impact on gold as well as Switzerland's role as one of the major global gold hubs; it thereby highlights the lack of transparency in the gold supply chain.

The environmental impacts and social challenges along the supply chain are systematically outlined. The key findings of the study are:

1 TON OF GOLD → 100 TONNES OF WASTE ROCK

— To extract 1 tonne of gold, an average of 100 000 tonnes of waste rock is produced. 1 000 kg of soil must be moved and processed to produce a 10 g gold ring.

1 KG OF GOLD → 12 500 KG OF CO_2

— The production of 1 kg of gold leads to the emission of 12 500 kg of CO_2 equivalent. This equates to approximately 42.25 million tonnes of CO_2 equivalent for all gold production globally in 2019, which is nearly three times the amount of all transportation-related emissions in Switzerland.

838 TONNES OF MERCURY EMISSIONS IN THE AIR

— In 2015, artisanal and small-scale gold mining (ASGM) mercury emissions to air amounted to ca. 838 tonnes, the single largest source of anthropogenic mercury emissions, at almost 38 % of the worldwide total. The mercury used on a large scale in ASGM poses significant health risks to workers and residents either directly or through the food chains.

ASGM FROM SUB-SAHARAN AFRICA & SOUTH AMERICA

— Sub-Saharan Africa and South America are the main regions for ASGM. Between 2010 and 2015, South America increased its mercury emissions by 163 %. This goes hand in hand with an increase in ASGM in the Amazon.

DAMAGE TO SOIL, WATER, FLORA & FAUNA

— The study shows in detail how gold mining causes substantial damage to soil, water and flora and fauna.

HARM ON FORESTS WILDLIFE

— Compared to other minerals, gold is by far the raw material most often mined in forest areas. These forests are often particularly valuable ecologically, which greatly increases the potential impact of gold mining on flora and wildlife.

LARGE-SCALE & SMALL-SCALE GOLD MINING BOTH CAUSE ENVIRONMENTAL PROBLEMS

— Analysis shows that large-scale gold mining (LSGM), which accounts for about 80 % of global gold mine production, also causes environmental problems. In general, LSGM impacts tend to be locally concentrated and massive as deposits are mined over longer periods of time. Due to the scale of the operations, impacts following accidents are often devastating. Tailings dam breaks resulted in some of the biggest environmental catastrophes in history. Hazardous substances contained in processing reagents as well as heavy metals and acid mine drainage (AMD) are crucial issues in LSGM.

SEVERE EFFECTS ON LOCAL POPULATIONS

— LSGM as well as ASGM can have severe effects on local populations, indigenous peoples, and workers. Resettlement or displacement in LSGM poses a significant threat to social sustainability. As an example, the development of the largest gold mine on Papua province in Indonesia led to a displacement of 15 000 residents who were mostly indigenous people.

To understand how gold is produced, different sources of gold are described and their individual characteristics are elaborated. To illustrate, the study traces the gold supply chain using the case study of Madre de Dios in Peru. This is a region heavily affected by illegal artisanal and small-scale gold mining activities.

Some progress has been made in Switzerland in recent years, especially in publishing import statistics on gold and reducing mercury exports. Nevertheless, due to the different legal framework compared to the USA and the EU, it is not possible to accurately track the trade flows of gold in Switzerland. This is particularly evident in, for example, the VAT exemption of imports of alloys (especially with silver) containing at least 2 % gold. This leads to a lack of transparency regarding the exact gold import flows into Switzerland and foregone tax revenue. In addition, the governmental demands of the USA and the EU for binding due-diligence obligations in the value chains for metals such as gold are currently more advanced. Switzerland is far behind in this respect compared to the other countries.

Nevertheless, there is at least one example of a Swiss gold refinery that sources certified ASGM gold from Peru. However, the quantities involved are still quite small. The Society for Threatened Peoples (STP) emphasizes that the quantities of ecologically and socially-responsibly produced ASGM gold are still very small overall. In April 2021, two Swiss banks announced that they would use a new approach to ensure the precise tracing (from the mine to the gold refinery in Switzerland) of the gold sold to their customers with the help of a DNA marker. The next few years will show whether this new approach represents a breakthrough towards transparency in the gold supply chain.

The study concludes with recommendations based on the study that are directed at policy-makers, industry, banks, and consumers.

2. GOLD DEMAND: WHAT IS GOLD USED FOR?

2.1 SHORT HISTORY OF GOLD WITH HUMANITY

Gold is a transition metal with atomic number 79 and chemical symbol Au. It is one of the first metals known to mankind and was and is admired for its beauty and unique properties. The name 'gold' is derived from the Old English word for yellow 'geolo'. The chemical symbol Au is based on the Latin name for gold 'aurum', which means glowing dawn (Macdonald 2007).

Throughout human history, gold has played an important role in many cultures. It has been and is still used for ritual and symbolic purposes, for jewellery and decoration and as currency. Gold production in ancient Egypt peaked around 1452 BCE (Rosemarie Klemm and Dietrich Klemm 2013; Pieth 2019). Starting from around 1200 BCE, goldsmiths of the Chavin civilisation in the Andes in modern day Peru produced gold ornaments and other artefacts by hammering and shaping the metal. The world's first standardized gold coins, used as a way to value the cost of goods and labour, were introduced in Lydia, now in Turkey, between 643 and 630 BCE (Macdonald 2007).

2.2 OVERVIEW OF THE MODERN GLOBAL GOLD DEMAND

The global gold demand for each year from 2015 to 2020 is shown in Figure 2–1. The statistics are separated into the four applications for which gold is used: watches and jewellery, technology, investment, and central banks. Until 2019, the shares for each category remained on a similar level from year to year. As consumer and investor behaviour changes during a pandemic, especially for luxury goods such as gold watches or jewellery, the statistics from 2020 do not give an adequate picture of traditional global gold demand. Prior to the COVID-19 pandemic, almost half of the world's gold demand came continuously from the jewellery and watch sectors (between 2100t and 2460t). While gold used by central banks and in technology play a minor role, one third of gold demand comes from private investors. The chart highlights the special role gold holds among all metals, as it is primarily used for status purposes or as a financial investment.

The following chapters will look more closely at the largest demand sectors for gold.

Gold demand by application 2015 — 2020

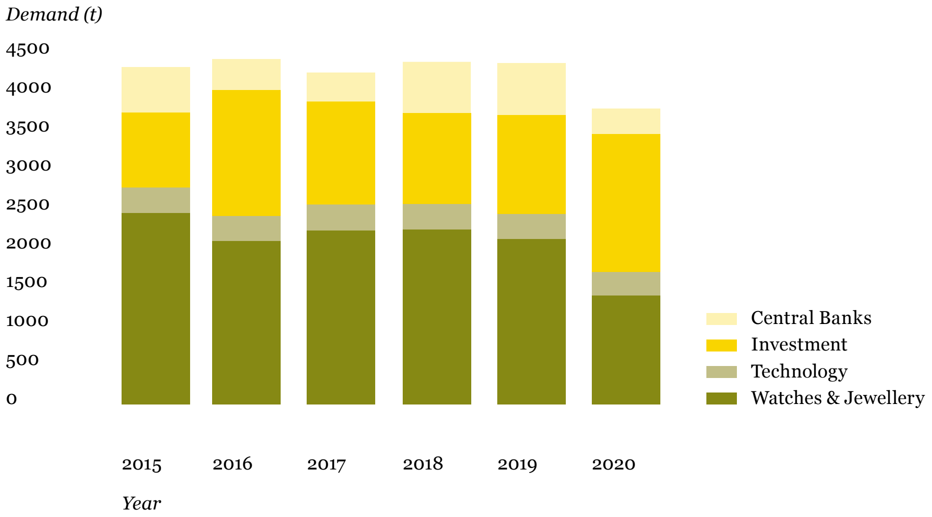


Figure 2-1: Gold demand by application, 2015 – 2020 (World Gold Council 2021f)

Global and Swiss export of watches in units and value 2019

EXPORT BY UNIT

98%

WATCH EXPORTS FROM THE REST OF THE WORLD

2%

WATCH EXPORTS FROM SWITZERLAND

EXPORT BY VALUE

40%

WATCH EXPORTS FROM THE REST OF THE WORLD

60%

WATCH EXPORTS FROM SWITZERLAND

Figure 2–2
Based on comtrade commodity codes 9101[1] and 9102[2]

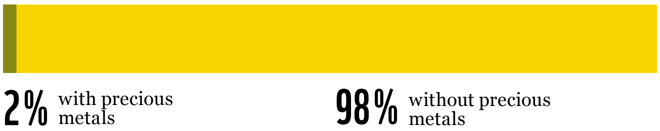
2.3 WATCH SECTOR

Swiss watches are renowned around the world and serve as status symbols. This is based on the high mechanical standards, precision, design, and aesthetic appeal of Swiss watchmaking. In addition, the preciousness and quality of the materials used as well as the traditional know-how that has been developed by the Swiss watch industry are well-known. The high cultural standing of watchmaking is highlighted by the fact that in 2020 UNESCO registered the craftsmanship of mechanical watchmaking on its Representative List of the Intangible Cultural Heritage of Humanity (UNESCO 2021).

While Swiss watches do not take up much of the global market in terms of quantity, they dominate global revenue streams: only 2 % (20.7 million) of watches exported in 2019 came from Switzerland, but these watches generated nearly 60 % (USD 25 billion) of the global trade value of all watch exports, as is demonstrated in Figure 2–2 (United Nations 2021). The main importing countries of Swiss watches are the USA, Hong Kong, China, and Singapore.

The statistics in Figure 2–2 show the extraordinary role of Switzerland in the global watch market. Swiss watches are known for their high standard, quality, and precision. While watches containing precious metals only make up a small portion of all watches produced, they are of high value, as depicted in Figure 2–3. In 2019, only 2 % of all exported watches from Switzerland contained precious metals (Figure 2–3 upper chart), but generated 34 % of the total Swiss watch export value (Figure 2–3 lower chart) (United Nations 2021). These figures highlight the importance of precious metals for the value and the revenue of Swiss watches.

2 % of the watches exported from Switzerland contained precious metals (2019)



Watches with precious metals generated 34 % of the Trade Value of all watches exported from Switzerland (2019)

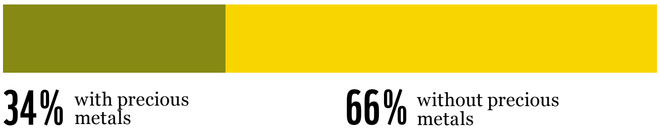


Figure 2–3: Export and trade value of watches in Switzerland containing precious metals (United Nations 2021).
Based on comtrade commodity codes 9101[1] and 9102[2]

The position of Switzerland as the most important producer for luxury watches had solidified in recent years. While the total number of Swiss watches sold has declined in the last couple of years, more highend watches with a higher value were sold (further information can be found in appendix 8.1). As a result, the trade value of exported watches from Switzerland increased from 2018 to 2019 although the number of exported watches declined (compare Figure 2–4). Consequently, the average value of a Swiss watch increased to a record high USD 998 in 2019. According to the Federation of the Swiss Watch Industry, the growth in the watch sector has been driven by precious metal and bimetal watches. It is expected that the importance of precious metals for the Swiss watch industry is likely to increase even further (WWF Switzerland 2018; Verband der Schweizerischen Uhrenindustrie FH 2019, 2021).

[1] 9101: wristwatches, pocket watches and other watches, including stopwatches, with case of precious metal or of metal clad with precious metal
[2] 9102: wristwatches, pocket watches and other watches, including stop watches, other than those of heading 9101

Watches by price range

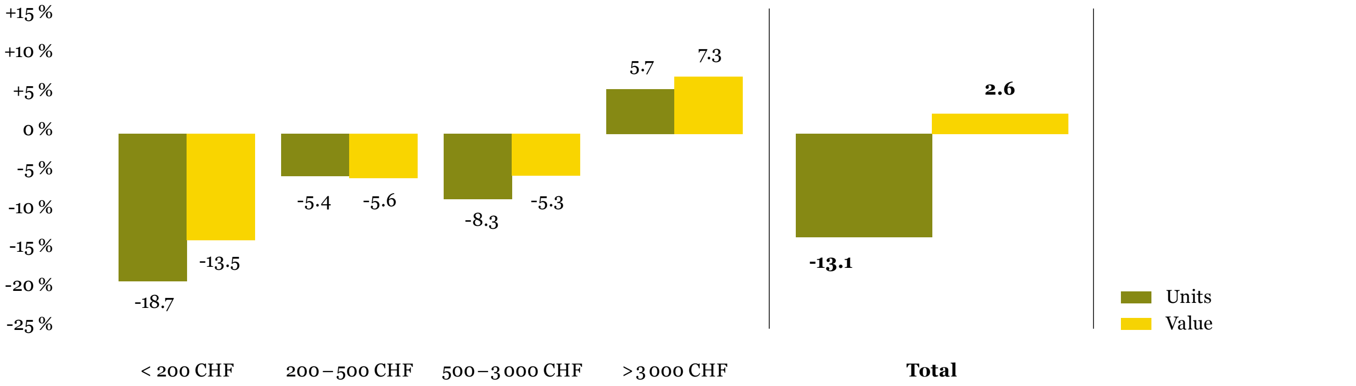


Figure 2–4: Watches by price range and development of unit sales and value 2018 to 2019 (Verband der Schweizerischen Uhrenindustrie FH 2019)

Switzerland's anchor position in the watch market is reflected in the companies that lead the sector in terms of sales. Of the ten largest global companies, five are headquartered in Switzerland; the three largest are Swatch Group, Rolex and Richemont. Often, several watch brands are owned by these large companies. In addition, some of the major Swiss watch brands are part of large luxury conglomerates based outside Switzerland, such as Swiss watchmaker Tag Heuer, which is owned by LVMH in France. In 2019, Swiss watch compa-nies held a market share of 45 %. A more detailed overview of estimated market shares of the biggest brands is given in Figure 2–5. In the appendix 8.2, the brands associated with the largest companies can be found (Table 8–1) (MarketWatch 2021; Goulard 2021).

Even though the range of materials used for watches have increased in recent years. Yet, as ceramics, polymers, and even natural resources like bamboo are being employed more frequently, the watch market is still dominated by metals. While stainless steel is the most common material for all price ranges, luxury watches often use precious metals like silver, platinum, and gold, with gold being the most widely used precious metal (Verband der Schweizer Uhrenindustrie 2021b).

Watch prices based on different materials vary between manu-facturers, different models, and different versions of the same model. Different materials lead to price differences of up to 550 % for the same type of watch (Rolex Website 2021). For example, the Rolex model 'DATEJUST 31' can be bought for USD 7300 in 'Oystersteel', an austenitic stainless steel with high nickel, chromium, and molybdenum content. The bimetallic version of the same model, composed of Oystersteel and white gold, costs USD 12 300, while the version composed primarily of yellow gold costs USD 33 500 (Rolex Website 2021). Yet the movement and features of the watches are the same. These price differences cannot be explained solely based on the price of the used materials, but rather on the symbolic and emotional appeal of a golden watch (see Appendix 8.3). Figure 2–6 roughly summarises the common watch components and examples of typical materials used for the parts.

Market share in the global watch market 2019

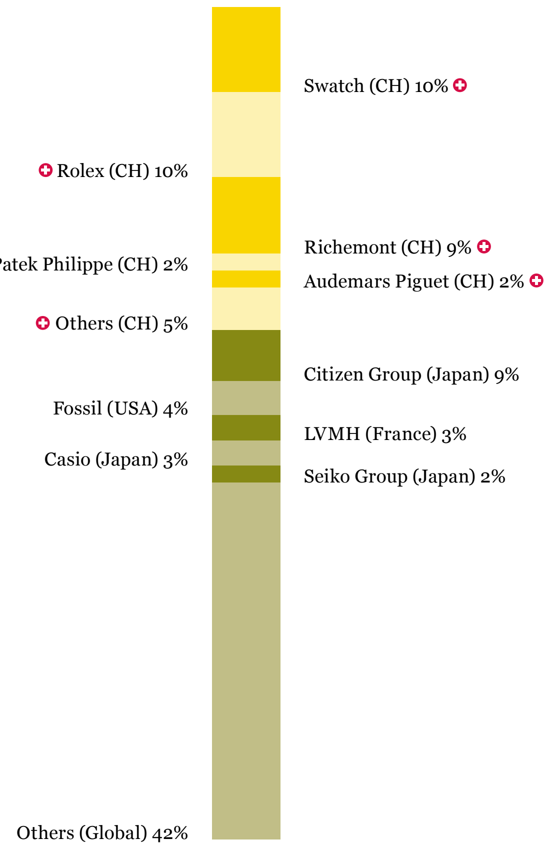


Figure 2–5: Overview over the largest companies in the watch market in 2019 (MarketWatch 2021)

Overview parts of a watch

1 Case
Metals, Precious Metals or Bimetallic

2 Bezel
Metals, Precious Metals or Ceramics

3 Lug
Metals, Precious Metals or Bimetallic

4 Crown/Pusher
Metals or Precious Metals

5 Bracelet/Strap
Leather, Rubber, Plastic, Metals, Precious Metals or Bimetallic

6 Hands

7 Buckle
Steel, Precious Metal, Aluminum

8 Crystal (front glas)
Sapphire crystal

9 Inside
Can consist of more than 300 parts

10 Movement (engine)
Different special alloys (INVAR Fe-Ni36%., Nickel Silver), copper, up to 50 jewels to reduce friction, silicon, ceramics, carbon

© iStock

2.4 JEWELLERY SECTOR

Jewellery are items worn for personal adornment and have a long tradition in human societies. While a wide variety of materials are used for jewellery, precious metals, especially gold together with gemstones, are of fundamental importance to the jewellery sector as it is today. Besides gold and gemstones, materials used for jewellery include metals like platinum, silver, copper, and steel, as well as natural materials like leather or feathers. Regardless, gold jewellery holds the largest share of the USD 278.5 billion global jewellery market at around 42 %. The main types of gold jewellery sold today are rings, necklaces, bracelets and earrings (Grand View Research 2019). Even though jewellery has a purely decorative function, the modern and historical importance of gold for jewellery making highlights people's emotional attachment to this precious metal and the positive attributes associated with it.

In comparison to the watch market, the jewellery market is much more diverse with more companies and countries involved. Still, Switzerland plays a significant role in the jewellery sector, as it was the fourth largest exporter of jewellery in 2019, with a trade value of USD 11 642 million, which was equivalent to 10 % of the global trade value of exported jewellery. Only the jewellery exports of the United Arab Emirates, India and China/Hong Kong/Macau generated a larger trade value in 2019.

On a national level, the jewellery sector was an important industry in Switzerland during 2019, making up 4 % of Swiss exports. The destinations of Swiss jewellery were primarily China/Hong Kong (31 %) and France (20 %) (United Nations 2021). The large jewellery companies are international players in the luxury goods industry sector, often owning multiple global brands. Joining the international market leaders LVMH, Rajesh Exports, Chanel and Chow Tai Fok, the largest Swiss jewellery company is the Richemont Group, owning several jewellery brands including Cartier (Goddiess 2021; Shahbandeh 2021).

☞ Gold alloys used in watches and jewellery

The gold commonly used for watches and jewellery is 18 carat (ct). A carat is a traditional fractional measure of the purity of gold alloys. Pure gold contains 24 carats. Consequently, the aesthetic and mechanical properties of 18 ct gold are partly defined by the alloying elements and their composition. Figure 2–7 gives an overview of the differing alloys and the elements used (Catellier 2020; Verband der Schweizerischen Uhrenindustrie FH 2020).

GOLD	PURITY in carat (CT)
Pure (>99.9 %)	24 ct
75.0 %	18 ct
58.5 %	14 ct
41.6 %	10 ct
37.5 %	9 ct

MAIN ALLOYS (25 %)	Common name
Nickel, silver or/and palladium	White gold
12.5 % copper + 12.5 % silver	Yellow gold
22.25 % copper + 2.25 % silver	Rose gold
Copper	Red gold

2.5 INVESTMENT SECTOR

Historical background

It is not surprising that the history of currencies and the financial sector are closely linked to gold. The first standardized currency using gold coins is attributed to Lydia (in modern-day Turkey) and dated between 643 and 630 BCE. From then until the beginning of the 20th century, gold was essential to the way currencies functioned, either directly as metal for coins or as gold parity. Gold parity means that the value of all banknotes in circulation are at least partly covered by physical gold. Therefore, for many centuries, central banks built up and kept large gold reserves, which guaranteed a steady demand for gold.

Through catastrophes (World War I and II, etc.) and turbulences (formation of the Western and Eastern blocs, etc.) of the first half of the 20th century, the importance of gold as a direct metal of coinage was diminished. The Bretton Woods Agreement of 1944 tied most currencies, including the US dollar (USD), directly to gold in a system called the 'gold standard' with fixed exchange rates. This made it possible to establish the US dollar as the main global anchor currency and maintain gold as an integral part of the monetary system. In 1971, pressured by a variety of economic, political, and global factors, the United States suspended this direct and fixed convertibility, essentially terminating the Bretton Woods Agreement. These transformations changed the nature of investments in gold. Until the 1970s, gold was a safe investment with little risk, but also little possibility for gains. But as the gold price became exposed to fluctuations, both gains and losses were possible. The last major currency to take the step and become independent from gold was the Swiss franc (CHF) in 2000 (Macdonald 2007).

Since the 2008 financial crisis, there is a renewed interest in gold as a form of investment, both from private persons and institutions like central banks. A motive for investing in gold, besides the hope for rising gold prices, is its status as a safe and riskaverse investment. Gold is said to preserve its value even during a crisis and is less affected by inflation and deflation. Therefore, gold is often used in an investment portfolio to minimise risk and fluctuation (Eoin H. Macdonald 2007; Tony Warwick-Ching 1993).

Gold for investment in numbers

Figure 2–8 gives an overview of the share the different forms of investment make up. Historically, official institutions such as central banks have held large amounts of gold, primarily to cover for the money in circulation. Nowadays for central banks, gold functions as a longterm store of value that diversifies the investment portfolio with a relatively small associated risk (World Gold Council 2021a). Private entities can also buy physical gold, which is stored either privately or more commonly in the vault of a bank or security firm. By purchasing physical gold[3], private individuals or companies directly own gold as their property and store it in one or more vaults situated around the world. The location of the vault in which the gold is stored determines the applicable jurisdiction, and many investors never physically encounter the gold they own. The gold is usually in the form of ingots, which for investment purposes are called 'bullions' or 'bars'. Typical weights for gold bars are 12.44 kg or 1 kg depending on the market and demand. Official gold coins are a common way of owning smaller amounts of gold. In contrast, medal coins represent collector items, whose value is strongly influenced by supply and demand.

Another gold investment possibility is gold-backed Exchange Traded Funds (ETFs), which are securities designed to track the gold price. When owning shares in a gold ETF, one does not actually own any physical gold. Instead, the ETF owner becomes the beneficiary of a debt owed by the trust and backed by its gold. Gold ETFs are a new investment tool and have been around since about 2003. Furthermore, multiple Digital Gold Currencies (DGC) represent another form of gold related investment. A DGC is an electronic form of money which is backed by reserves held in vaults by private agencies. It is also possible to invest in or buy shares of mining companies that produce or trade gold. Most physical investment gold is stored in vaults from the Bank of England for other central banks or private investors. It is estimated that about one fifth of all gold held by the world's governments is stored in London. The London Bullion Market Association (LBMA) states that in June 2021 a total of 9 587 tonnes of gold were held in vaults in London and valued at USD 543.5 billion. The amounts from 2020 represent new alltime highs and highlight the continued importance of gold for the finance sector (London Bullion Market Association 2021).

[3] For physical gold as an investment, a distinction is made between allocated and non-allocated gold. An investor in allocated gold is the outright owner of a certain amount of physical bullion. Unallocated gold remains the property of the bank; the investor is essentially a creditor of the bank. See https://www.bullionbypost.co.uk/index/gold-investment/allocated-vs-unallocated-gold/.

Demand Investment by category over time

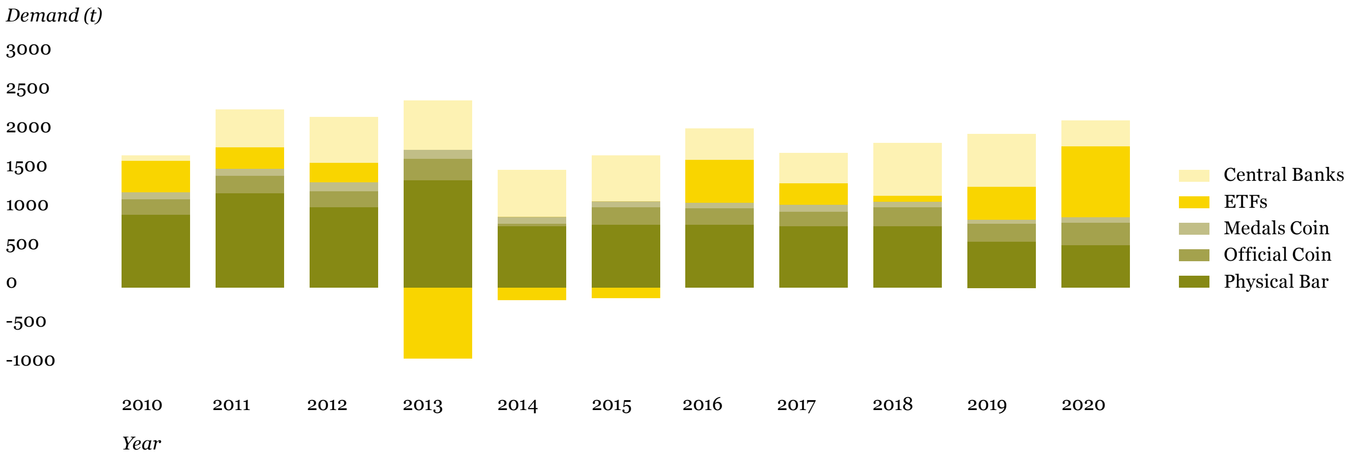


Figure 2–8: Development of different physical gold investments over time (World Gold Council 2021g).

Gold is virtually indestructible and therefore all the gold ever mined throughout history still exists in varying forms and uses. Though only approximations, it is estimated that, through the end of 2020, in total 201 296 tonnes of gold had been mined in the world over all history and make up the 'above-ground stock'. Leaving aside a small amount which has been lost or is unaccounted for, this is all the gold available and circulating today. Of that, around twothirds were mined in the last 70 years.

Development of above-ground gold stock in tonnes

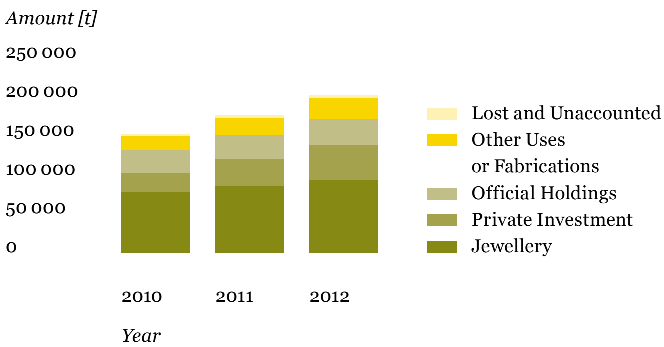


Figure 2–9: Above Ground Stocks of Gold at the end of 2004, 2013 and 2020 (Hewitt et al. 2015; World Gold Council 2021b)

All this gold brought together would form a cube of pure gold measuring around 22 metres on each side. Most of the gold still available is in the form of jewellery and watches (46 % or 93 251 t) as can be seen in Figure 2–9. Official holdings, primarily from central banks, take up a share of 17 % (34 211 t), while gold owned by private investors make up 22 % (44 384 t). This means, that 39 % of all the gold ever mined is held for investment purposes. In addition, gold used in other applications make up 13 % (25 848 t) of the above-ground stock. Finally, it is estimated, that 0.02 % (3 600 t) of gold have been lost over time (Hewitt et al. 2015; World Gold Council 2021b).

In Figure 2–10 the development of the above-ground stock of physical gold since 2004 is shown. In that period, the above ground stock grew by 48 296t, from 153 000 t to 201 296 t. This means that 24 % of the global gold in circulation was mined between 2004 and 2020. The biggest share of that growth came from the amount of gold stocked in the private investments sector, which grew by the largest quantity (42 %, 20 284 t), followed by the jewellery sector (30 %, 14 751 t). Official holdings, the other investment related category, was responsible for 11 % (5 111 t) of the consumption of newly sourced gold. This means that, out of the 48 296 t of gold newly sourced since 2004, more than half of it (25 395 t) went into the two investment-related categories 'official holdings' and 'private investment'. Therefore, the investment sector is the major source that maintains the demand for new gold and therefore mining operations (Hewitt et al. 2015; World Gold Council 2021b).

Increase in gold stocked per sector (2004 – 2020)

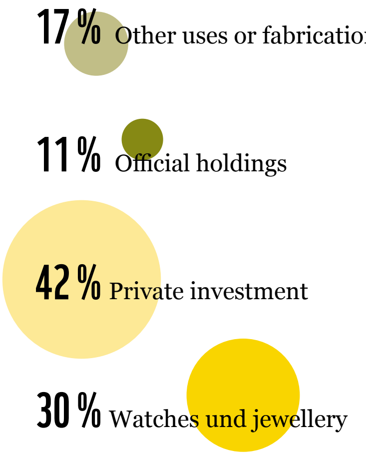


Figure 2–10: Share in the gold stocked per sector from 2004 to 2020 (World Gold Council 2021e; Hewitt et al. 2015).

The importance of Switzerland for gold in the investment sector

Swiss actors play an historically important role in the gold investment sector and are still relevant today. Two major official institutes are important. The Swiss National Bank manages the 8th largest central bank gold reserve, with 1 040 t (World Gold Council 2021a). In addition, the Bank for International Settlements (BIS) is based in Basel, acting as the gold broker for central banks and itself holding gold reserves (Bullion Star 2021b; LBMA 2021)[4]. With regards to gold trading, one of the main gold markets is based in Zurich, controlling the global gold trade together with the London gold market, the New York gold market, and the Hong Kong gold market.

Furthermore, large private Banks from Switzerland act as major international gold bullion dealers with international offices. The most important one is UBS, the largest Swiss banking institution and the largest private bank in the world. UBS is a market member of the LBMA and conducts a full spectrum of gold activities in the wholesale market, from trading gold on a 'spot and forward' basis, to offering 'gold swaps'[5] and 'interest rate swaps' on gold, through to offering gold storage facilities and physical metal handling services all around the globe. Until 1998, UBS owned Argor Sa, one of the leading Swiss refineries. Oher important private banks in the gold trade include Credit Suisse, Zürcher Kantonalbank (ZKB) and Raiffeisen Bank (Bullion Star 2021b; LBMA 2021).

In 2014, the private gold stock of Switzerland was estimated to be 2 500 t, a significantly larger gold amount than the central bank stores. In the meantime, business with physical gold have grown strongly during the COVID-19 pandemic. Sales increases are said to be between 60 % and 100 % (Bütler 2021).

In April 2021, the two Swiss banks Raiffeisen and Zurich Cantonal Bank (ZKB) announced they would use a new method to ensure precise tracing from the mine to their customers with the help of a DNA marker (Raiffeisen ZKB 2021). The next few years will show whether this new approach will create true transparency in the gold value chain.

☞ LBMA Good Delivery standards

The London Bullion Market Association (LBMA) was established in 1987 and defines itself as 'the global authority on precious metals'. The LBMA maintains a 'Good Delivery List' for gold and silver. On this list, accredited gold and silver refineries are listed that meet certain acceptance criteria set by the LBMA. These rules contain requirements regarding the fineness, weight, dimensions, appearance, marks, and production of gold and silver bars. The Good Delivery Bars standards set by the LBMA have established themselves as the standard for gold traded on the large international markets. Furthermore, banks and especially central banks rely on it for their gold reserves and investment gold. To maintain and monitor the Good Delivery List, the LBMA has appointed five companies as Good Delivery Referees. Three Referees are from Switzerland, namely Argor-Heraeus SA, Metalor Technologies SA and PAMP SA. The other two referees are Rand Refinery (PTY) Ltd from South Africa and Tanaka Kikinzoku Kogyo from Japan. In addition, LBMA-certified companies need to adhere to Responsible Gold Guidance standards set by the LBMA. These standards are supposed to help enforce best practices in the gold industry. However, they do not require disclosure of the origins of the gold nor of the applied audit and testing procedures. This makes it impossible to assess the effectiveness of these standards (LBMA 2021; Bericht des Bundesrates 2018).

[4] As of March 2015, the BIS held 108 tonnes of its own gold on its balance sheet as an investment asset, and over 350 tonnes of gold deposits on behalf of central bank customers. It's unclear as to how much of the BIS' own gold and custody gold is stored with the Swiss National Bank in Berne, as the BIS chooses not to confirm its gold storage arrangements when asked.

[5] Gold swaps: Gold swaps are contracts that exchange financial instruments (such as assets, liabilities, currencies, securities, or commodities). They are non-standardized contracts that are traded over the counter. Most swaps involve cash flows based on a notional principal amount. Swaps are also used in the gold market. Usually, swaps in the precious metals markets are for ward swaps and refer to purchasing bullion spot and selling the metal forward (from the borrower's perspective), or selling the metal spot and buying bullion forward (from the lender's perspective). It means that gold is borrowed (lent) against a currency. The gold swap rate for a gold-to-U.S. dollar exchange is the gold forward offered rate (https://www.sunshineprofits.com/gold-silver/dictionary/gold-forwards-gold-swaps/).

3. GOLD SUPPLY SITUATION: WHERE DOES GOLD COME FROM?

3.1 DIFFERENT SOURCES OF GOLD

Mining for gold can be clustered into two main groups: large-scale industrial gold mining (LSGM) and artisanal and small-scale gold mining (ASGM). While the first group is highly mechanised and provides most of the production output, the latter is often informal, employs many more people, and is often associated with social and environmental issues such as child or forced labour (World Gold Council 2018). This study differentiates gold mining into the two main categories: LSGM and ASGM.

Large-scale gold mining (LSGM)

Around 80 % of the global primary production output for gold stems from LSGM (O'Neill and Telmer 2017). In general, LSGM covers large, legally operated mining projects that extract raw materials. Accordingly, the sector requires permits and is subject to regulatory controls and inspections. Projects must have adequate health and safety standards and, depending on the regulatory situation, environmental and social standards need to be applied. Depending on the regulatory framework of the country, strict rules need to be applied throughout the extraction process from exploration to operation and closure & rehabilitation.

LSGM is much more capital-intensive than ASGM (World Gold Council 2018). The development of a mine is both technically and financially very challenging and can take up to about 8 years from exploration to actual production (Centre for Energy, Petroleum and Mineral Law & Policy 2021). Large scale mines usually need heavy machinery for production, such as trains, trucks, loaders, trams, or conveyors belts (Reuters 2020).

Artisanal and small-scale gold mining (ASGM)

Artisanal and small-scale gold mining is a major economic contributor in at least 81 developing countries. The sector provides income for ca. 10 to 15 million miners. Moreover, around 100 million people depend on the sector worldwide (O'Neill and Telmer 2017; Society for Threatened Peoples 2018; Kyaw et al. 2020). The ASGM industry employs about 90 % of gold miners worldwide and produces ca. 20 % (400 – 600 tonnes per year) of primary gold. Small-scale gold mining is an important source of income, especially in many developing countries (O'Neill and Telmer 2017; Society for Threatened Peoples 2018; Kyaw et al. 2020).

ASGM can be defined as mineral extraction with a low level of mechanisation and capitalisation and high labour intensity. Usually, it is done by local miners to provide local livelihoods or subsistence, or to create small businesses either at a group or individual level. Very often the purpose is to create employment, which often takes place in conditions of informality (Villegas et al. 2012). This definition reveals some risks inherent to the practice. As the ASGM sector is often informal, no or limited regulatory control is in place and transparency is an issue. Another issue for ASGM is the formalisation processes themselves, which are often lengthy, complex or missing completely. This elaborates the transition from an informal to a formal operation.

There are some legal forms that should be distinguished from each other. Hunter et al. 2017 separate ASGM into illicit, informal, legal, and certified. Illicit miners are described as an unacceptable problem due to contributions to serious abuses associated with the extraction, transport, or trade of minerals. Informal miners are the most prevalent form of ASGM; they are not fully consistent with applicable laws, but in many cases their mines are not associated with the most severe forms of human-rights violations. Informal miners are often aiming to become formalized. Formal ASGM operators are significantly rarer, and the miners are enabled by laws, infrastructure, policies, and their own volition to conduct legitimate commercial activities. Certified ASGM is often the aspirational goal for the miners, wherein ASGM operates formally and gets certified against a sustainability standard (Hunter et al. 2017).

Recycled gold

Although primary mining of gold covers most of today's demand, secondary recycled gold also plays a crucial role. Around 33 % of the gold supply in the last 10 years has been covered by recycled gold (World Gold Council 2021h). The recycling of gold from old jewellery, dental gold, and high-grade electronic waste (computers, mobile phones, etc.) is highly specialised and highly professional. Due to its high value, gold is very attractive for recycling, even if specific contents are low. It must be emphasised that the availability of gold for the purpose of recycling is lower overall than for other precious metals such as platinum or palladium. The reason for this difference is the much higher usage rate of these other precious metals for technical purposes such as car exhaust catalytic converters. Gold, on the other hand, is mainly used for investment (bars, coins) or for watches and jewellery. The availability of gold from these applications for recycling is naturally limited.

3.2 GLOBAL SUPPLY SITUATION

On a country level the supply situation of gold is very diverse. Gold was mined in 103 countries in 2019. In comparison, silver was mined in 70 and copper in 56 countries, but for both in much higher volumes. A bulk commodity like bauxite is mined in only around 33 countries. This difference in geographical spread for gold mining is driven by the high gold price, as even exploitation of small gold deposits is lucrative (British Geological Survey 2021).

Figure 3–1 displays the largest production countries. Total mine production of gold in 2019 amounted to 3 300 tonnes. The country with the largest production was China with 380 tonnes of gold, followed by Australia with 325 tonnes and Russia with 305 tonnes (United States Geological Survey 2021). Since more than 100 countries produce gold, the supply situation is quite diverse (O'Neill and Telmer 2017).

Largest gold production countries 2019 in tonnes of gold (USGS 2021)

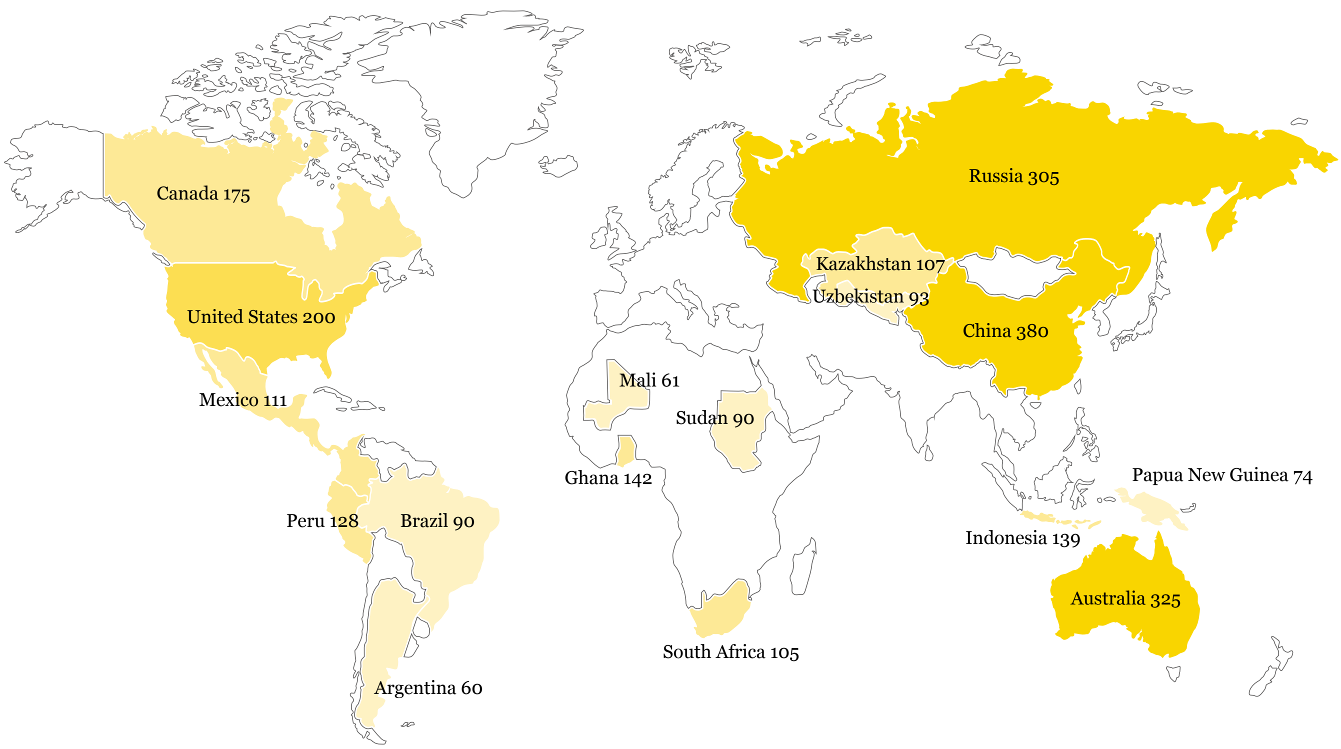


Figure 3–1: Global world gold production in 2019 in tonnes (United States Geological Survey 2021).

Global gold supply sources in 2019

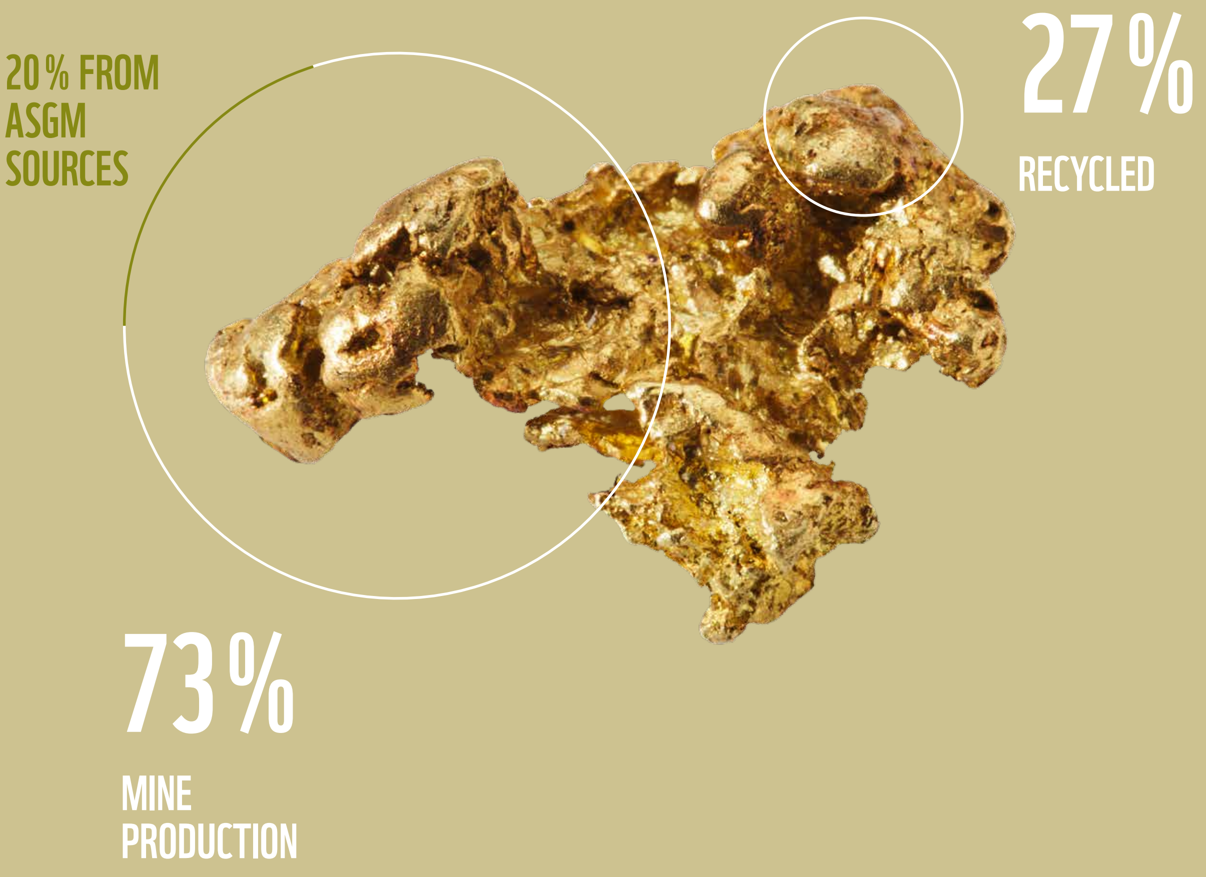


Figure 3–2

(World Gold Council 2021d)
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In 2019, a total of 4 809.5 t of gold were sourced globally[6], including recycled gold. Recycled gold only made up 27 % of the global gold supply and primary production, 73 % (Figure 3–2). Subsequently, the global gold supply strongly depends on mining for primary resources, which is estimated to be sourced at around 20 % from ASGM and 80 % from LSGM. Unfortunately, the ASGM supply situation is quite uncertain, and no official figures are available. Therefore, the global figures for gold are subject to uncertainties. Most of ASGM is performed in Sub-Saharan Africa and South America (World Gold Council 2021g; Intergovernmental Forum on Mining, Minerals and Sustainable Development 2017; O'Neill and Telmer 2017).

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3.3 RELEVANCE OF SWITZERLAND AS A GOLD HUB

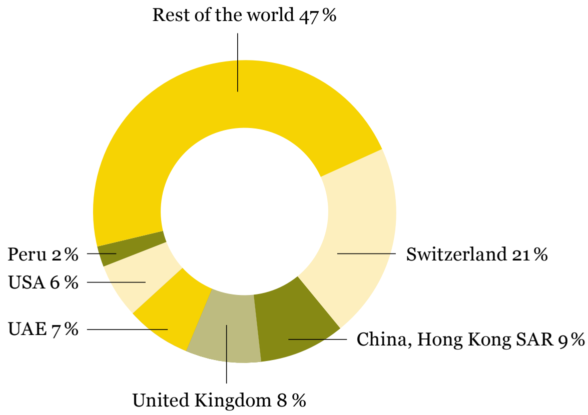
While gold is mined in over 100 countries around the world, gold exports occur in a small number of countries, most of which do not mine gold themselves but rather refine and process gold and sell it on. Of the largest seven refineries worldwide, four are headquartered in Switzerland: Argor-Heraeus SA, Metalor Technologies SA, PAMP SA and Valcambi. The large refineries play a central role because they are the keystone in the gold supply chain. Switzerland plays a unique and dominant role in the international gold trade. In terms of trade volume, Switzerland is second only to the United Kingdom (UK) in gold imports. In London, large quantities of gold refined to a very high degree of purity are stored in vaults for investment purposes.

Switzerland is not only the second largest importer of gold; it is also the single largest exporter of gold. It was responsible for 21 % of the global export trade value in 2019, as can be seen in Figure 3–3 (United Nations 2021). Characteristically, gold is sold multiple times nationally and internationally, between its source and final purpose, often already in a refined state. Until recently, 70 % of the world's gold was imported from Switzerland (Pieth 2019). Subsequently, Switzerland acts as the hub through which most of the world's physical gold passes, and in the process, it is branded as "Swiss gold" (BBC 2021; Bullion Star 2021a; Marc Ummel 2020).

The position of Switzerland as a gold hub has developed historically and is based on several factors. At its core, it is based on advanced technical and industrial know-how in the gold refining process. Furthermore, Switzerland has an exceptionally strong economic position in the three largest demand sectors for gold – watches, jewellery, and investment. This unique situation is linked to Switzerland's extraordinary level of security and logistics and to its financial system paired with its political stability and pledge to neutrality. The exceptional political position of Switzerland inside Europe has also served as the foundation to dominate the historical gold trade with South Africa and, to a lesser degree, with the Soviet Union. Unlike the UNO and the rest of Europe, which boycotted the apartheid regime in the 1980s and 1990s, Switzerland continued buying gold from South Africa, which at the time was one of the biggest gold producers globally. To obscure this, the gold trade was exempt from official statistics from 1981 until 2013. This secretive trade partnership allowed Swiss refineries to gain direct and exclusive access to gold and helped them solidify their leading role in the gold trade (Bullion Star 2021b; Burri 2015).

[6] Discrepancies between these figures and the USGS data can be explained not least by the fact that gold from ASGM activities cannot be adequately included in official mining statistics.

Trade Value Export, 2019



Trade Value Import, 2019

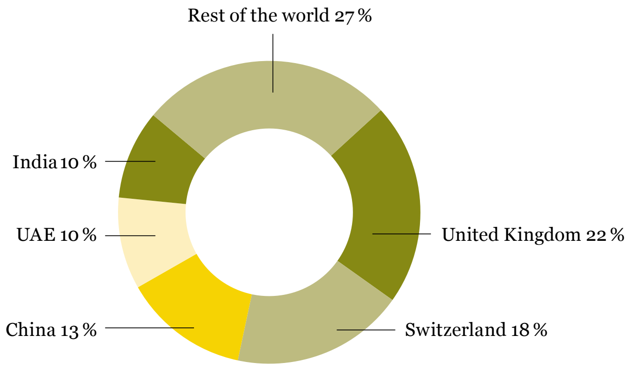


Figure 3–3: Global gold trade statistics for 2019, commodity code 7108 (United Nations 2021).

In 2019, Switzerland imported 2092 t of gold with a trade value of USD 60 605 million, which translates to an average of USD 29 million per tonne of gold. In the same year, Switzerland exported 1402 t of gold, accumulating to a trade value of USD 61 896 million or USD 44.2 million per tonne of gold. This means that Switzerland exported less gold than it imported in 2019 but managed to generate a higher trade value (United Nations 2021). Not included in these statistics is the amount of gold that is recycled nationally in Switzerland. Gold that is sold on a national level to a manufacturer in Switzerland and then exported as a product, like a watch or jewellery, is not declared as a gold export in the official statistics (Mariani 2012; Sunshine Profits 2021; Bullion Star 2021b).

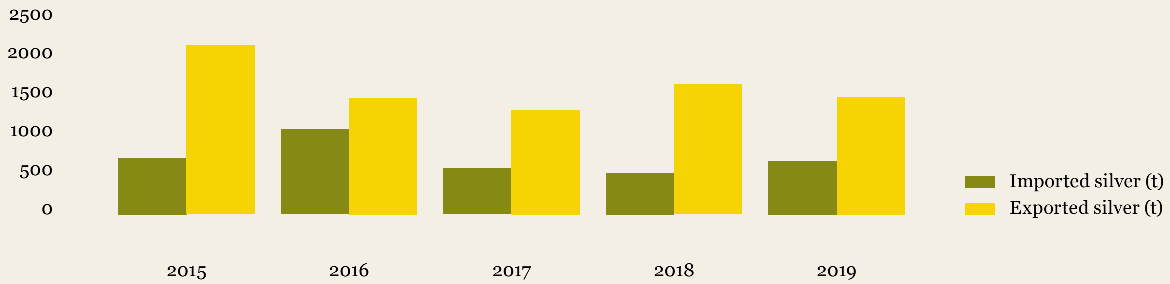
There are multiple reasons for these Swiss import, export, and pricing differences. Prominently, the value of gold is increased through the refining process. Regardless, only around one third of the gold bought by large Swiss refineries is mined gold in an unrefined and raw state (London Bullion Market Association 2020). Looking at sourcing, in total Switzerland imported gold from 67 different countries. The ten countries with the highest trade value are listed in Table 8–2 (see appendix 8.4). Curiously, four of the top five countries (UAE, UK, Italy, Germany) do not source gold themselves but rather act as intermediaries. They possess advanced refining capabilities themselves, both in terms of quantity and quality, of the gold they can process. Subsequently, much of the gold from these destinations arrives in Switzerland in an already well-refined state. It is nevertheless still processed in a Swiss refinery and sold afterwards with high guarantees towards its purity and quality as certified Swiss gold. Hence, much of the gold is transformed rather than refined in Switzerland before being exported again (Marc Ummel 2020). The non-transparency of this multi-layered trading system can be exploited to obscure the real origin of the gold. The gold arriving in Switzerland may be declared as refined gold with no link to its original mining origin and circumstances (Marc Ummel 2020).

☞ Taxation on import

The US, the EU and Switzerland all exempt investment gold and certain defined gold coins from VAT on import (Bullion or Plates of high purity). In addition, Switzerland excludes gold in raw form or in the form of semi-finished products intended for refining or re-refining and gold in the form of waste and scrap from the VAT. This regulation includes alloys (e.g. with silver) containing two or more per cent by weight of gold or, if platinum is included, more gold than platinum. On the one hand, this legislation means a competitive advantage for Switzerland in the gold trade, on the other hand it causes losses in Switzerland's tax revenues.

Switzerland exports more silver than it officially imports while not being a primary producer of silver themselves (United Nations 2021; British Geological Survey 2021). Figure 3–4 summarises the Swiss silver imports and exports from 2015 to 2019. In 2019, more than double the amount of silver was exported (1497 t) than officially imported (681 t). While these statistics do not account for silver recycled internally in Switzerland, they also do not contain silver sold to manufacturers like watchmakers and jewellers. Therefore, it can be assumed that most of the silver imported into Switzerland is declared as gold based on the VAT regulations described above. It gives Swiss refineries a competitive advantage on an international level but also reduces the Swiss tax income.

Swiss Silver Imports and Exports



In total, Switzerland exports gold to 61 different countries. In contrast to the gold imports into Switzerland, the three largest destination countries for gold exports from Switzerland (United Kingdom, China, India) dominate by generating nearly three quarters (73.2 %) of the total trade value. While the United Kingdom and China primarily use gold for investment purposes, more than half of the gold exported to India is used for jewellery. A more detailed list of the countries importing gold to Switzerland and the main destination of its gold exports can be found in Appendix 8.4 in Table 8–2 and Table 8–3 respectively (United Nations 2021).

Jewellery, watches, and gold made up 31 % of the total Swiss trade value in 2019 (USD 315 billion), highlighting the importance of gold-related industries to the Swiss economy, as can be seen in Figure 3–5. Unmanufactured gold generated USD 62 billion (United Nations 2021).

Switzerland exports 2019

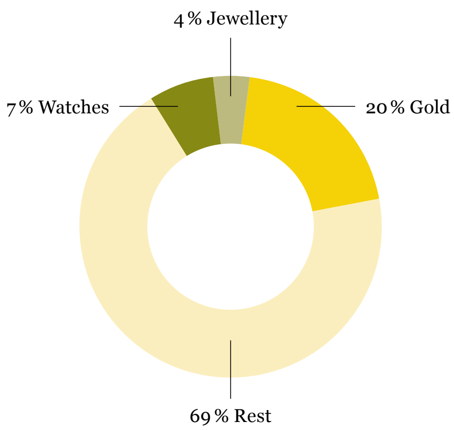


Figure 3–5: Shares of gold, watches and jewellery out of the total trade value of gold exports from Switzerland in 2019 (United Nations 2021).

4. ENVIRONMENTAL & SOCIAL CHALLENGES OF GOLD PRODUCTION

With more and more pressure from civil society, sustainability issues have been increasingly addressed by companies in a wide variety of sectors, including agricultural products, the automotive industry, and textile brands, in particular luxury textile brands (Aybaly et al. 2017). The extraction of gold is linked to important environmental and social problems. Gold mining can severely affect waterbodies and have a direct influence on biodiversity loss through heavy metal contamination or deforestation. Moreover, deforestation negatively impacts climate change. Production of gold is very energy intensive since typical gold ore grades are among the lowest when compared to other mined metals. Since huge amounts of ore material have to be extracted from the ground, milled as well as mechanically and chemically separated for one tonne of gold, followed by complex refining, the specific energy requirement for gold extraction is very high. Manifold impacts on water, air, soil, wildlife, and social issues are reported in the gold value chain.

To understand environmental impacts in the production process of gold, first the different deposit types are introduced followed by an overview of the main production methods. This chapter aims to summarise the typical impacts of gold production. Nonetheless, every operation has different impacts depending on the processes used, management practices applied, the geographic location, the deposit type, or governance in the production country; therefore, the examples presented here should be taken as such.

4.1 DEPOSIT TYPES

Generally, two main kinds of gold deposits can be differentiated: primary and secondary deposits (Hruschka et al. 2016). A primary gold deposit is described as earth with gold deposits. Secondary gold deposits are formed by weathering of primary gold deposits (erosions or weathering), where the gold is washed out of the rock and accumulates to so-called “nuggets” in streams and rivers (Hruschka et al. 2016; Gold.info 2013).

Many of the issues related to gold extraction are caused by the ore grades of deposits, which, in comparison to other raw materials, are very low. Typical iron-ore deposits contain ore grades of ca. 35%–65% of iron content. Translating this into valuable metal compared to waste rock, a typical 50% graded iron-ore mine produces 1 tonne of waste material for each tonne of metal. Typical gold ore grades range between 5 and 30 grams of gold per tonne of ore. The typical gold ore grades of 10 grams per tonne translate to 0.001% gold in the ore. Accordingly, to extract 1 tonne of gold, 100 000 tonnes of waste rock are produced (Priester et al. 2019). This is therefore about 100 000 times more waste rock than for similar amounts of iron ore.

As a rule of thumb, LSGM operations often mine large deposits, ensuring that the total value of the deposit pays off the investment to develop the mine. They therefore are also able to mine lower grade deposits at greater depths. For instance, South African underground gold mines can operate cost-effectively at a cut-off grade of 0.35 grams of gold per tonne of rock. ASGM, on the other hand, do not consider deposit size as the crucial parameter but rather depth and grade. Therefore, ASGM often mines smaller high-grade deposits while deposits below 10 grams per tonne are less suitable for ASGM but for LSGM (Hruschka et al. 2016).

4.2 PRODUCTION PROCESS OVERVIEW

The extraction and processing of gold from a deposit differs significantly between large-scale gold mining (LSGM) and artisanal and small-scale gold mining (ASGM). The following chapter focuses on the most important production routes for both mining categories.

In LSGM, gold is mined both in open-pit and underground mines at depths of up to 4 km, depending on the grade, size, and shape of the deposit. In large-scale industrial mining, heavy machinery are used, such as trucks with a loading capacity of up to 250 tonnes of ore. The ore can be transported by rail or conveyor belts. The gold ore is then transported to the processing plants, which are usually located on site. At the plants, the ore is processed in two steps with the aim of separating and concentrating the gold contained in the ore from other minerals. First, mechanical steps and physical methods are used. This is followed by chemical processes, which can be used to extract up to 99 % of the gold. The most common chemical process used in LSGM mines on an industrial scale is cyanide leaching followed by precipitation. Usually, low-grade doré ingots are produced on site. These bars are transported to refining plants to produce high-purity gold bars (European Commission 2021; Stähr and Schütte 2016; Gökelma et al. 2016).

In contrast, ASGM mines are generally smaller in size, although large land areas can be affected. ASGM takes place both in open pit and underground mines, but in significantly smaller depths of up to 100 m when compared to LSGM. The equipment used can include tools used in manual labour such as picks or shovels; more mechanized sites might use excavators, loaders, jack hammers, and potentially dynamite. The ore of softer deposits usually found in riverbeds or deposits of old riverine sediments can be extracted using shovels, buckets, excavators, loaders, or hydraulic mining processes where water is used to excavate or remove sediment. After extraction, the ore is processed either on-site or transported to a processing location. Here the ore is crushed and milled, either manually or with mechanized tools, to reduce the particle size.

The ore is sieved to obtain the correct grain size. The gold ore grains are then concentrated by gravimetric methods using ladles, sluices, jigs, shaking tables, or centrifuges. Depending on the ore, it is necessary to further improve the concentration by amalgamation. For this purpose, mercury is usually added to the ore, which combines with the gold and separates it from other minerals. The resulting product is called amalgam, which is then heated to vaporise the mercury it contains. The mercury evaporates at temperatures of 257°C, leaving behind a gold sponge that can still contain up to 10 % mercury. The resulting gold sponge can be further refined into gold doré bars by melting it down. At this stage, the gold is usually sold to international markets, where it is treated in a refinery using the same processes as LSGM gold (O'Neill and Telmer 2017; Hruschka et al. 2016). Figure 4–1 gives a simplified overview of the most important processing steps along both the LSGM and ASGM production chain.

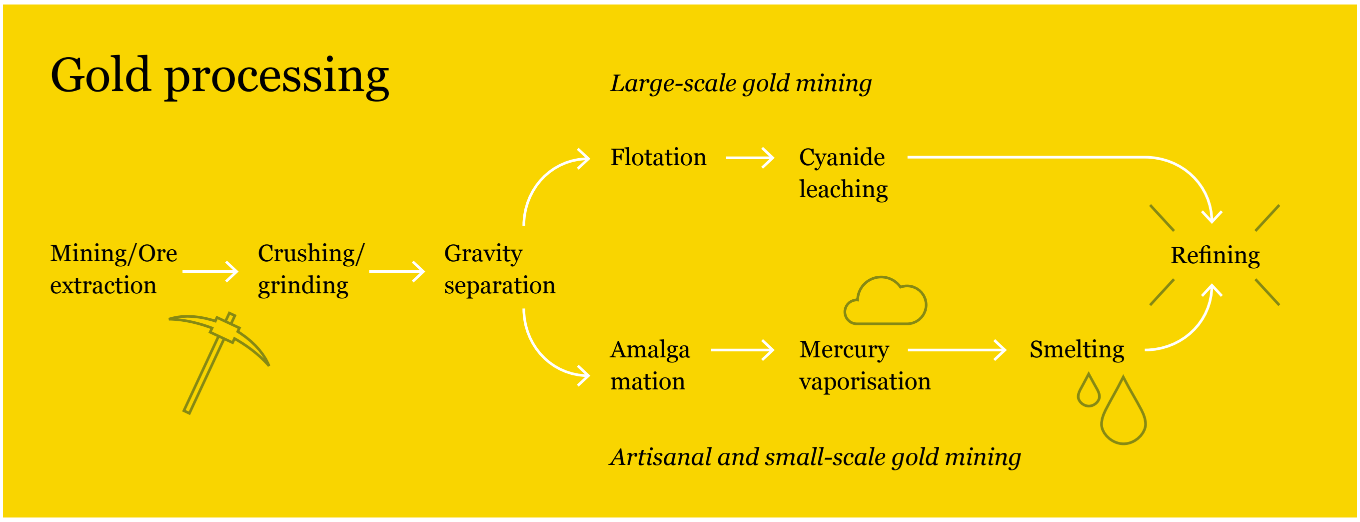


Figure 4–1: Simplified overview of gold processing in LSGM (top) and ASGM (bottom) (Gökelma et al. 2016)

4.3 ENVIRONMENTAL & SOCIAL IMPACTS OF GOLD MINING

The impacts and challenges for the environment and the social sphere that results from large-scale gold mining (LSGM) are different from those for artisinal and small-scale gold mining (ASGM). LSGM has the advantage of being a legal operation that must comply with legislation and regulations and must therefore apply certain standards depending on the country where it is operating. As well, most gold production output stems from LSGM operations and therefore environmental effects can also reflect these standards. This chapter addresses the most important LSGM and ASGM mining impacts.

The informality of ASGM plays a major role in the associated environmental problems. The biggest differences to LSGM arise from the type of deposits exploited in ASGM projects and the fact that the informality in which many ASGM miners work makes it difficult to enforce regulations.While some LSGM projects operate for more than 100 years before the ore body is fully exploited, ASGM takes much less time to shift operations to a new deposit. Therefore, since ASGM miners usually mine smaller deposits, larger areas of land are usually affected. Nevertheless, ASGM's environmental problems, such as acid mine drainage (AMD) or erosion, are very similar compared to LSGM. It should be highlighted that many of the issues with gold mining are interconnected and the separation of these problems into different topic areas – water, air, soil, wildlife, and social issues – aims at helping to provide an overview.

4.3.1 Impacts on water

One of the most significant impacts of a large-scale gold mining (LSGM) project is the impact on the quality and availability of water resources in the area where the mine is operating. Surface and groundwater supplies can be affected and could be unsuitable for consumption as well as the quality of surface waters can be negatively affected, impacting aquatic and terrestrial wildlife (Environmental Law Alliance Worldwide 2010).

Artisanal and small-scale mining (ASGM) processing often requires a lot of water that is rarely managed properly. The water demand can impact communities in the vicinity of ASGM operations, as the same waterbodies are often used for drinking water, cooking, and irrigation in agriculture. Therefore, water contamination (e.g. by mercury) plays a crucial role in assessing the environmental and social impacts of ASGM. As ASGM operations often venture into remote areas, rivers and other waters are often used for movement and transportation of heavy goods. Especially in heavily wooded areas, such transport practices are common; as a consequence, ASGM operations are often performed in close proximity to the water with direct impacts on waterbodies (O'Neill and Telmer 2017).

Mercury

Mercury is widely used in ASGM operations due to its properties for the amalgamation process, its cheap price and ease of use. However, mercury is a chemical of global concern because it can travel large distances in the atmosphere, it bioaccumulates, and then it stays in the environment for long periods of time. There are many ways linked to gold mining processes that mercury is released to the environment. To understand how mercury can be released, it is important to note that there are two forms of mercury useful for ASGM: firstly, elemental mercury, which is used for the amalgamation process; and secondly, organic mercury (methylmercury).

Organic mercury can form in the environment under certain conditions where elemental mercury is transformed to an organic compound called methylmercury. The organic form (methylmercury) bioaccumulates when, for example, fish eat smaller fish that are already contaminated with mercury, increasing the methylmercury contamination further as it moves up the food chain. More than 90% of methylmercury can be absorbed into the bloodstream via the gastrointestinal tract due to its greater lipid solubility.

It can cross the blood-brain barrier and lead to an accumulation in the nervous system, with neurologic diseases, including blindness, hearing impairment, muscle tremors, and paralysis. One of the biggest issues with methylmercury is its ability to cross the placenta, where umbilical cord blood concentrations are higher than concentrations in maternal blood. Methylmercury then can interfere with the neurodevelopment of the unborn child. Consequently, newborns can have profound psychometric impairment, personality impairment and other serious diseases (World Health Organization 2016).

☞ Minamata Convention

The Minamata Convention is named after the city of Minamata, Japan. After 1950, industrial wastewater from chemical plants was discharged into Minamata Bay, the city experienced serious mercury poisoning incidents for decades. Wastewater contained methylmercury, which bioaccumulated in fish in the bay. The locals who ate the seafood in Minamata Bay were very sick and many died or were severely disabled. The issue of mercury pollution has been globally accepted and requires joint action. Therefore, in 2013, the Minamata Convention on Mercury was signed, with the aim of reducing and, where possible, eliminating the use of mercury. It aims at different sectors and addresses ASGM.

According to the Convention, mercury in ASGM should be eliminated, where feasible, or at least reduced. Overall, air emissions at industrial plants need to be controlled and mercury-containing products should be phased out. Moreover, manufacturing processes using mercury should be reduced and phased out, and trade and supply need to be monitored. The Con-vention also provides technical assistance and information material, addresses public awareness, and calls for research and monitoring. Moreover, signatory parties need to report on measures taken to implement certain provisions (UN Environment 2017; US EPA 2014).

The Carnegie Amazon Mercury Project reports that rivers and lakes in the Amazon region are contaminated with ca. 30 tonnes of mercury each year. Therefore, levels of mercury are 34 times higher than safe limits. The volumes of mercury released are not surprising when considering that 1.8 - 2 kg of mercury are needed to extract 1 kg of gold through amalgamation (Global Initiative against Transnational Organized Crime 2017). After amalgamation, mercury is often disposed of into the environment or burnt – usually without adequate protection – putting workers' health at risk from the toxic fumes (Alex Létourneau 2014).

There are extensive reports of mercury entering the food chain, e.g. through fish passing it through the Amazon (Ronaldo B. Barthem et al. 2017). Amphibians, which are in close contact with the aquatic environment and thus also with methylmercury, are known to be sensitive to the effects of mercury poisoning. Mercury accumulation has been found to impair reproduction, survival, endocrine function, immune function, behaviour, and metamorphosis. As a result, they are a major victim of biodiversity loss due to mining (Christine M. Bergeron et al. 2010; Jason M. Unrine et al. 2004).

In 2015, ASGM emissions to air amounted to ca. 838 tonnes, the single largest source of anthropogenic mercury emissions, at almost 38 % of the worldwide total. The second largest source was the stationary combustion of coal, with ca. 21 % (compare Figure 4–2). LSGM, on the other hand, plays a less significant role in mercury emissions, with 84.5 tonnes or just under 4 % of global emissions (UNEP – UN Environment Programme 2019), as cyanide is mostly used for processing. Looking at the regional distribution of emissions by sector, it becomes clear that certain mercury-emitting regions are dominated almost completely by ASGM: South America and sub-Saharan Africa.

☞ Regulations on Mercury

Mercury regulations are linked to gold, as ASGM operations are the biggest source of mercury released to the environment (UNEP – UN Environment Programme 2021). Based on the Minamata conventions stricter rules on the export of mercury have been put in place in the member states including the EU, USA, and Switzerland. Since 2009, the USA have a complete ban on the export of mercury, while the EU put a complete ban on the export of metallic mercury and selected mercury compounds in 2011. Since 2018, mercury from Switzerland can only be exported for analysis and research purposes. In addition, until 2027 the export of mercury for dental amalgam capsules is still allowed. These measures have drastically reduced the export of mercury from the EU, USA, and Switzerland. Nevertheless, up until 2017 Switzerland was one of the biggest exporters of mercury. While the Minamata convention has eventually led to changes in some countries, still large amounts of mercury are exported by countries who have not signed the convention like China and India (Daniel Bütler 2017; Umweltbundesamt 2016; UFAM, Bundesamt für Umwelt BAFU 2021; planetGOLD 2021).

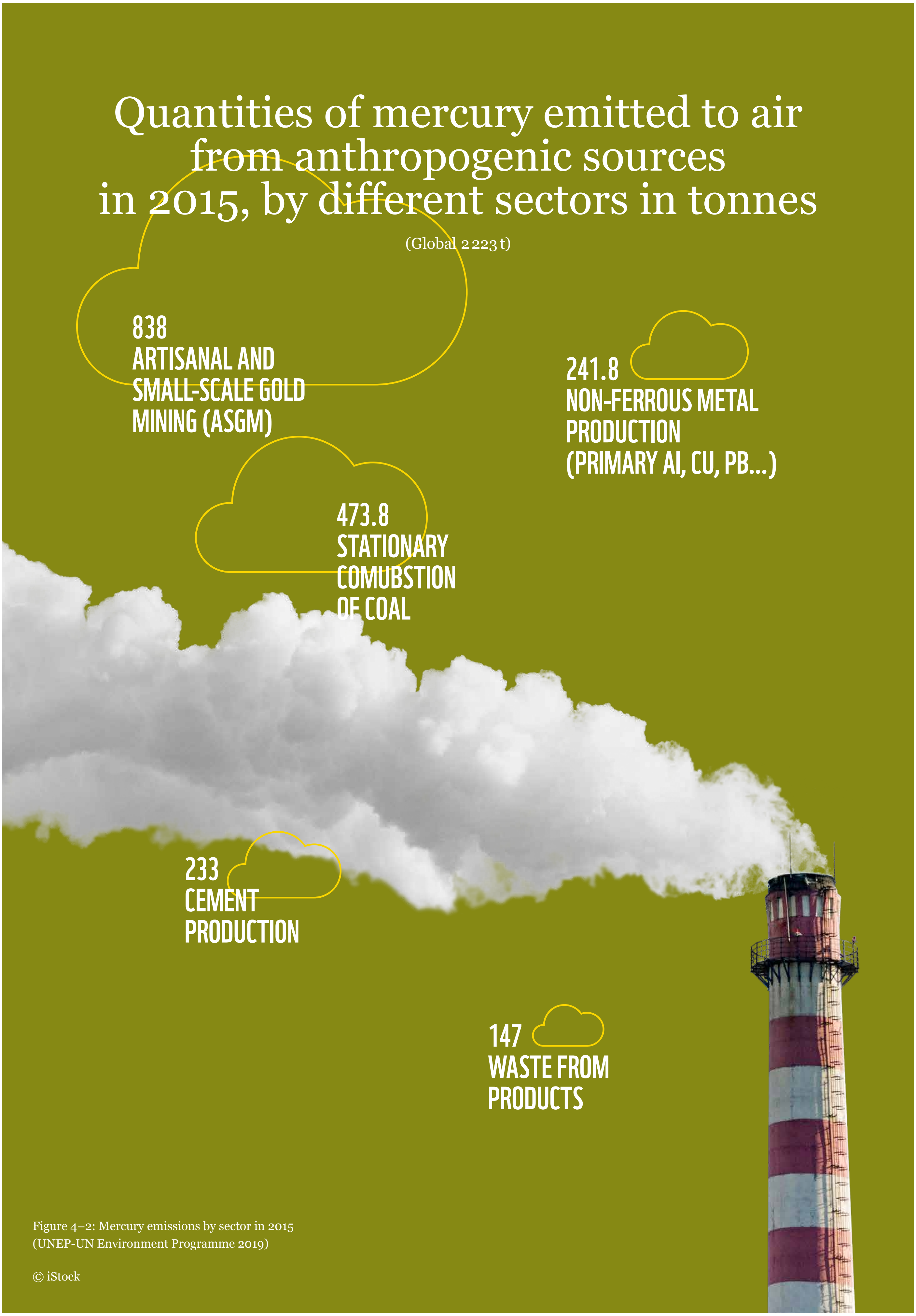


Figure 4–2: Mercury emissions by sector in 2015 (UNEP-UN Environment Programme 2019)

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Looking at the development of mercury emissions between 2010 and the last assessment in 2015, the use of mercury in ASGM has increased significantly. Of all the world's regions, only sub-Saharan Africa and South America experienced significant increases in mercury emissions: by almost 20 % in sub-Saharan Africa and by 163 % in South America (UNEP – UN Environment Programme 2019). This goes hand in hand with an increase in ASGM in the Amazon. In 2016, the Peruvian government declared a state of emergency in the Madre de Dios region due to the extremely high mercury concentrations accumulating from illegal gold mining. Although the issues have been tackled by the Minamata Convention, problems are still present, e.g. in Bolivia, Ghana, Mali and Sierra Leone (Hilson et al. 2018; Dolega et al. 2016).

☞ Alternative processing routes

Although mercury has a very negative impact on human health and the environment, it is a part of the standard process for ASGM. Alternative processes for gold mining exist that are equally simple and applicable. Mukono et al. (2018) propose alternative processing methods in their research paper, where they argue that the processes need to be easily accessible, not very complex and inexpensive, and they should use locally available materials. The authors propose a direct smelting method suitable for alluvial and hardrock deposits. The process up to gold amalgamation remains unchanged, meaning that ore is concentrated through a variety of gravimetric steps. Afterwards, gold containing black sand, borax and soda ash are mixed and melted in a charcoal or gas-fired smelter. The borax and soda lower the melting temperature and allow for a better material flow when melted. This very new method allows a recovery of 99.8 % of gold compared to 97 % in the case of amalgamation (Mukono et al. 2018).

Acid mine drainage

One of the most important general issues for mining and freshwater is the generation of acid mine drainage (AMD) (United Nations Environental Program 2010). AMD happens when sulphide minerals, which are part of the ore or waste rocks of mining tailings[7], are exposed to oxygen and water, leading to a chemical reaction in which sulfuric acid forms. The acid then may dissolve heavy metals, such as arsenic, cadmium, mercury or lead, also contained in the rocks and can contaminate groundwater and soil if no restraining systems are installed (Dolega et al. 2016). Acidic water can have devastating effects for the longterm health of river systems, streams, and aquatic life. Arsenic, lead, or cadmium can cause cancer and contribute to metabolic disorders and other diseases such as damage to brain, liver and kidney tissue, nerve damage, and blood and bone damage (Abdul-Wahab and Marikar 2011; Environmental Law Alliance Worldwide 2010).

AMD is not caused by chemicals or other reagents added during processing but is a result of grinding and milling the ore. These processes enormously enlarge the surface area of the sulphide-containing minerals and enable them to react with water and oxygen to form acid (Mineral Resources Tasmania 2019).

Gold is often extracted from sulphide ores in hard-rock open-cast mining, although smaller quantities are also extracted from gold-quartz veins in underground mining or gold placers in loose-rock open-cast mining (compare chapter 4.1). Dehoust et al. (2020) argue that, due to the fact that gold is often connected to sulphide deposits, the risk for AMD is high. AMD causes long-lasting pollution that can last up to thousands of years (Dolega et al. 2016).

Gold mining waste residues (Putsch 2012) © Philip Mostert

A particularly serious case of AMD is associated with abandoned mine waste dumps near residential areas in Johannesburg, South Africa. In the 1950s, gold mining residues were dumped in sparsely populated areas outside Johannesburg. Rapid population growth led to rapid urbanisation, which now extends to the boundaries of former waste dumps that are close to newer residential areas. AMD has a very negative impact on living conditions in these areas (Dolega et al. 2016). Many of the waste dumps contain large amounts of uranium, as gold from underground mining in South Africa is often associated with high concentrations of the radioactive element (about 0.02 % uranium in ores) (Dehoust et al. 2020).

The Global Acid Rock Drainage (GARD) Guide published by the International Network for Acid Prevention (INAP) has developed a safe handling of acid mine drainage (AMD) and for acid rock drainage (ARD) and the prevention of heavy metal contamination. The guide focusses on the prediction, prevention and management of drainage produced from sulphide mineral oxidation (INAP 2021)[7].To prevent or reduce any adverse effects on the environment due to the management of mining waste, the EU has developed the EU Mining Waste BREF outlines responsible management practice of mine residues (European Commission 2021).

☞ Cadia Valley Operations, Newcrest Mining Ltd

Australia's largest gold-mining operation is a good example of how good practices can both benefit the environment and be economically attractive. The Environmental Impact Assessment (EIA) for the mine from 1992 to 1995 classified the wastes as potentially acid-forming. Consequently, with the start of mining, the properties of the waste were monitored through further tests and regular inspections. Over ten years, the waste management was refined and optimised so that separation between potentially acid-forming waste and non-acid-forming waste became possible. The AMD waste classification scheme helped to reduce the amount of AMD-forming waste to be treated, the benefits of which far outweigh the cost of the characterisation programme (Australian Government 2016).

Erosion

Soil and sediment erosion in mining projects can be a huge problem leading to surface degradation. Open-pit operations disturb large areas of land, leaving earthen materials exposed to weathering, particularly during storms and high snowmelt events. When it rains, surface areas without sufficient vegetation cover are vulnerable to erosion. Surface runoff can form rills, channels, or gullies that transport sediment, which is deposited in either surface waters or floodplains of a stream valley. The deposition of sediments from eroding mining sites can be dangerous due to their composition, e.g. if containing heavy metals, and can build up thick layers of fine minerals and sediment in flood plains, leading to the alteration of aquatic habitat and potentially a loss of storage capacity within surface waters (Dolega et al. 2016; Environmental Law Alliance Worldwide 2010).

Mines in arid regions are potentially less affected by erosion in comparison to the ones located in tropical rainforest areas with regular heavy rainfall. However, healthy watersheds compared to streams affected by ASGM show drastic differences in neotropical fish communities in South America in part as a result of erosion. According to a study by Mol and Ouboter (2004), the gold-affected streams had high turbidity rates and elevated concentrations of potassium, aluminium, and iron; moreover, mercury was detected in low-water season. More than 95 % of the increased sediment load was caused by eroding goldfields. The streambed was covered by a 23 cm thick layer of sediment from the gold mine. As a consequence, the variety of fish entering the stream was diminished. In total a low-fish diversity was observed, missing species that are visually oriented and cannot therefore find their way in turbid waters (Mol and Ouboter 2004).

[7] Tailings are residues from wet processing used to separate the valuable fraction from the uneconomic fraction of an ore. The slurry of waste material is referred to as tailings and consists of fine particles of waste rock and chemical reagents. Sometimes, it can have high concentrations of toxic substances.
[8] International Network for Acid Prevention 2021, available online at http://www.gardguide.com/index.php?title=Main_Page, updated on 09/10/2021, checked on 09/10/2021
European Commission 2021, available online at https://ec.europa.eu/environment/topics/waste-and-recycling/mining-waste_en#ecl-inpage-497, updated on 09/10/2021, checked on 09/10/2021

Tailings

Environmental impacts from tailings are a problem for both LSGM and ASGM. However, especially in LSGM, there is a risk of major environmental catastrophes caused by tailings dam failures. As described in chapter 4.2, mined ore is concentrated through a variety of processes. In each processing step, waste material is produced that needs to be stored. Dry waste material can often be stored on heaps while wet residues are pumped as a slurry into tailings storage facilities (TSF) or tailings impoundments. These structures consist of dams that are often built from earth fill, rockfill, or even the tailings themselves when properties are suitable. The bottom of the structure is usually sealed with a lining to prevent leakage into the ground. Processing residues are then stored in the structure. Depending on the processes used, the stored tailings can have different properties, such as containing cyanide or heavy metals, being radioactive or containing other harmful and toxic substances (Dolega et al. 2016; European Commission 2018; Environmental Law Alliance Worldwide 2010). Tailing Dam Safety has been addressed by two institutions with guidelines: The International Commission on Large Dams (ICOLD) with its bulletin 139: Improving Tailings Dam Safety – Critical Aspects of Management, Design, Operation and Closure and by the Mining Association of Canada with its "Towards Sustainable Mining" (TSM) Tailings Management Protocol (International Commission on Large Dams 2021, The Mining Association of Canada 2021)[9].

One major issue is leakage from tailings storage facilities (TSF). When the floor lining of a TSF or the dam structures are not properly sealed, stored content that potentially contains toxic reagents and heavy metals can enter the groundwater. In the case of gold, cyanide is often contained in the tailing's slurry. Groundwater that has been contaminated affects the clean drinking-water supply. Moreover, it can enter the food chain if contaminated water is used for irrigation in agriculture (Dolega et al. 2016). Cyanide is highly poisonous; small amounts, such as only 2 tablespoons of a 2 % cyanide solution, can be lethal to an adult. Although cyanide is toxic, it is biodegradable and decomposes over time when exposed to sunlight and oxygen (Pieth 2019). The fact that huge amounts of ore need to be treated with large volumes of the reagent in LSGM operations make it crucial to handle cyanide with great care. Due to its advantages over mercury, cyanide is used in almost all LSGM operations.

☞ The Cyanide Code

Due to the dangers related to handling cyanide in gold and silver mining, the Cyanide Code has been developed under the United Nations Environment Programme in a multi-stakeholder approach. It is a voluntary certification programme that ensures the application of best practices in mining with cyanide, the manufacturing of cyanide and transporters of the chemical. Companies seeking certification are audited by a third party (The Cyanide Code 2020).

One of the reasons for the development of The Cyanide Code was one of the worst mining accidents in Europe that happened in Baia Mare, Romania in 2000, where a TSF dam broke and released 300 000 m³ of highly concentrated cyanide wastewater, polluting rivers, vegetation and wildlife. Plankton in connected rivers became either completely extinct or partly destroyed, affecting the ecosystem and human health (Wachter 2003) .

Lack of waste management in alluvial gold mining in Kalimantan, Indonesia
© REY Pictures / Alamy Stock Photo

In another example, in Kalimantan, Indonesia, the lack of waste management for ASGM has led to the dumping of tailings in the gold mine pits. Excessive land use takes place, resulting in low productivity of these mines. Habitats are lost as vegetation cover is removed and water bodies are polluted with tailings, often contaminated with mercury (O'Neill and Telmer 2017).

[9] International Commission on Large Dams 2021, available online at https://www.icold-cigb.org/GB/dams/dams_safety.asp, updated on 09/10/2021, checked on 09/10/2021
The Mining Association of Canada 2021, available online at https://mining.ca/towards-sustainable-mining/protocols-frameworks/tailings-management-protocol/, updated on 09/10/2021, checked on 09/10/2021

Mine dewatering

Open-pit gold mines can reach depths below the water table, leading to groundwater inflow into the pit; similarly, underground mines mostly reach below the water table. To continue mining, the water must be continually pumped out of the pit and discharged at another location. Alternatively, wells surrounding the mine might be used to drain the groundwater to levels where the pits and mine stay dry. This intervention in the natural hydrology can lead to a reduction or elimination of surface water flows and cause the degradation of water quality depending on the ore composition. This can also affect wetlands and the species living there, since lowering the groundwater table can leave the surface without sufficient water for plant roots to reach and thereby destroys plant habitats. Water from wells or the pits after treatment can be used for irrigation to mitigate negative impacts (Environmental Law Alliance Worldwide 2010).

Issues associated with mine dewatering in ASGM are similar to those in LSGM; however, for ASGM, the problems can be even more severe, as water is usually not treated prior to release into other areas. Macdonald et al. 2015 investigated impacts on water quality at ASGM sites. Among 11 sample sites, one site in Ghana received dewatering from an ASGM underground mine. Large volumes of untreated water were pumped out of the mine into the stream. Additionally, ASGM activity in the area led to an increase in sedimentation, altered the river morphology, and led to elevated manganese concentrations. Water quality in the river at many sites did not meet the standards set for the environment by the Ghanaian EPA or Ghanaian drinking water standards (Macdonald et al. 2015). In general, dewatering discharges connected to ASGM stand out as exceptionally harmful.

Water use

LSGM can have negative impacts on water quality as well as consuming significant volumes for production. The largest water volumes are used for processing when gold ore is ground and goes through a flotation process. Also, watering of roads or waste heaps to reduce dust emission can have an impact on water usage. The amount of water needed for mining processes can vary depending on many different factors, such as mining and processing steps applied, ore grade etc. The global average of water usage in gold mining is estimated to be ca. 0.350 m³ of water per tonne of ore-grade rock (Richardson 2019). Of course, gold yield out of the ore strongly depends on the deposit, mining, and processing. Regardless, on average this means that, for a watch containing 75 g of gold (see Appendix 8.3), 2 625 l of water is used in the gold mining alone.

4.3.2 Impacts on air & climate

LSGM can have significant effects on airborne emissions during all stages of operation, covering gas emissions as well as particulate matter dispersed by wind. While there are comprehensive figures for LSGM with regards to air emissions, as shown in the below chapters, there are no figures available for ASGM. Although CO_2 emissions certainly play a role in ASGM, the dominant environmental factor in ASGM are mercury emissions.

Mobile & stationary sources

LSGM operation make use of heavy machinery such as hauling trucks or excavators. Such machines are usually powered by large diesel engines. Depending on the age and quality of the equipment, substantial differences in the emissions can result. The burned fuel also leads to CO_2 emissions. Stationary sources that directly emit gas emissions include diesel-fuelled power generators and installations for drying, roasting and smelting operations (Environmental Law Alliance Worldwide 2010).

☞ Electric machinery

With innovations in lithium-ion batteries, rapid electrification of mobility in many sectors is taking place. Larger vehicles and machines are already becoming electrified. Heavy machinery, such as trucks and excavators, can be powered by batteries, effectively reducing direct gaseous emissions on site to zero. This has many advantages, as noise is reduced, no combustion emissions are present and ventilation systems in underground mines need less energy. Although electric equipment has a higher price, ca. 25 %–30 % above combustion engine equipment prices, about USD 9 million are expected to be saved on fuel and the cost for ventilating underground tunnels could be halved. Moreover, electric machinery compared to diesel engines has significantly fewer parts, lowering maintenance costs (Taylor and Lewis 2018).

Energy consumption and emissions

The production of 1 kg of gold results in 208 000 MJ of required energy and leads to the emission of 12 500 kg of CO_2-eq (Nuss and Eckelman 2014). This translates to ca. 41.25 million tonnes of CO_2-eq for all gold produced in 2019, almost three times higher than all transport-related emissions in Switzerland in 2019 (Bundesamt für Statistik Schweiz 2021). Although gold mining only amounts to ca. 3 300 tonnes of gold per year, gold ranks among the metals with the highest cumulated energy demand. To illustrate this, both zinc and gold need roughly about 700 000 TJ of energy per year to be produced. However, zinc production generates about 12 700 000 tonnes of zinc, meaning that almost 4 000 times more material is produced that carries the same burden in terms of energy demand (United States Geological Survey 2021; Dehoust et al. 2020).

Looking at the complete process of LSGM and attributing shares to the greenhouse gas emissions from gold, gold smelting with ca. 40.6 % of emissions is most relevant, followed by mining with 31.1 % and milling with 28.3 %; refining only accounts for 0.01 % of GHG (Statista 2021). As the weight of mined gold is relatively low in comparison to other metals, the emissions from transportation, for example by plane or ship, are rather low [10].

While in LSGM large machinery is used, ASGM uses small machinery and, depending on the operation, more manual labour is required. Nonetheless most of the machinery in ASGM is fuelled by petrol or diesel engines, which emit greenhouse gases and can lead to poisoning of workers when used in confined spaces. If no adequate ventilation is present, carbon monoxide can accumulate, potentially leading to lethal dosages. Moreover, methane, oxides of nitrogen, and other gases that occur in underground mines may reduce available oxygen and cause health issues for workers (World Health Organization 2016).

Fugitive emissions

CO_2 emissions are a major concern, but all phases of mining can affect air quality. Mining, crushing, and grinding operations often produce fine particles and dust that are blown by the wind, with the resulting environmental pollution and negative health impacts. One strategy to avoid and reduce dust emissions is generally water spraying. Waste dumps or dried spoil heaps can be sprayed to prevent the wind from carrying the dust further. Waste can be covered temporarily or permanently with tarpaulins. Trucks or conveyors transporting ores or wastes can also be covered during transport to prevent wastes from flying away. Speed limits for trucks are an effective way to prevent fugitive emissions, as are general restrictions on handling waste in high winds. The corresponding measures are more difficult to implement in ASGM (European Commission 2018).

Fugitive emissions in LSGM as well as ASGM can contain silica dust, which is distributed to the air during drilling, extraction, crushing or blasting and can be inhaled without adequate protection. In ASGM, such protective measures are rarely applied. Silica dust can lead to lung tissue damage, where scarring can take place, leading to respiratory diseases. Other minerals present in the ore, such as iron, arsenic sulphide, or lead sulphide, can lead to significant health issues due to their hazardousness (World Health Organization 2016).

4.3.3 Impacts on soil

LSGM projects can contaminate large areas and negatively affect the fertility and health of soils. Generally, gold mining leads to the exposure of previously undisturbed rocks and minerals. From processing, those rocks are significantly reduced in size through grinding, milling, etc., increasing mineral surface areas and therefore exposing heavy metals and enabling aeolian (wind) transport. To get access to the ore body, topsoil needs to be removed and is therefore lost as a habitat or for other use. Soil degradation is connected to impacts on other areas such as water (Environmental Law Alliance Worldwide 2010).

The deposition of heavy metals on soils poses a significant threat to the health of both wildlife and humans since these metals are toxic, accumulate in food chains and have a long persistence time in soil and sediments (Abdul-Wahab and Marikar 2011). Soils affected by gold mining contain significantly higher concentrations of heavy metals and fewer soil nutrients in comparison to relatively undisturbed areas (Eludoyin et al. 2017).

In most ASGM operations, enormous amounts of soil are moved and processed to extract gold. This leads to changes in the environment and especially the soil. Regardless of differ-ences in the environment and mining techniques, studies have demonstrated the impacts of gold mining on the soil.

When using aquatic methods, the composition of the soil is changed. Large portions of topsoil are removed, and the remaining soil is composed of larger particles, becoming sandier. In addition, the amount of organic matter in the soil is strongly reduced, making the soil less nutritious. The cloudy and muddy colour of the water in gold mining pits and flowing out of the mining areas indicates that it is loaded with suspended matter, flushing out smaller particles and organic matter. Therefore, it has been found that forest recovery in areas exposed to ASGM is drastically slowed (Román-Dañobeytia et al. 2015; Kalamandeen et al. 2020; E.J.M.M. Arets et al. 2006; Eludoyin et al. 2017).

Deforestation due to gold mining in Peru © Peter Jordan / Alamy Stock Photo

[10] For gold, the aircraft is the preferred means of transport, as gold has a high specific weight (and thus low volume) and a high specific value. As a result, flight costs are of secondary im-portance here.

4.3.4 Impacts on wildlife and forests

LSGM also affects flora and fauna in the habitats surrounding gold mining projects. Impacts can be very direct when habitats are destroyed and deforested to gain access to a deposit. Also, building of infrastructure that fragments habitats into smaller pieces negatively affects migratory species. Moreover, indirect effects, through contamination of soil, air and water can lead to diseases and loss of biodiversity. ASGM activities impact wildlife directly and indirectly in multiple ways, often interlinked with some of the other forms of impact described. The more direct forms of impact are described below.

Habitat loss and fragmentation – deforestation

Different wildlife species live in interconnected habitats that influence each other, e.g. through food chains. ASGM as well as LSGM has very direct impacts on habitats, resulting from the disturbance, removal, and redistribution of land areas. Access to deposits is often associated with deforestation. Impacts can be localised or widespread, as well as short-term or very long-lasting.

The excavation of surface areas directly destroys and displaces wildlife. Mobile animals leave affected areas; birds, game animals or predators are less likely to live near mines, which in turn destroys the sensitive balance of wildlife in those areas. Animals that are more sedentary, like invertebrates, small mammals or reptiles are more severely affected. Waterways that are polluted can have severe impacts on aquatic wildlife or amphibians. Also, loss of vegetation plays a major role, since nesting areas and essential provision of food as well as protective cover from predators are severely limited (Environmental Law Alliance Worldwide 2010).

In southwest Ghana, for example, LSGM activities are l eading to significant changes in land use and deforestation. Extensive, large-scale gold mining causes deforestation of huge areas of vegetation. This loss of vegetation leads to soil erosion, the formation of runoff and rivulets, and reduced groundwater recharge. At the same time, the loss of vegetation results in a direct loss of habitat for animals. Local communities report that previously common species are no longer present, including rabbits, rodents, antelopes, snails, and monkeys (Usman Kaku et al. 2021). Noise and vibration from LSGM activities are also relevant. The loss of vegetation cover and the resulting erosion processes also lead to significant losses of agricultural land and arable land. Studies by the Food and Agriculture Organisation show that between 1990 and 2005 26 % of forests and 15 % to 20 % of agricultural land in southern Ghana were lost to gold mining (Usman Kaku et al. 2021).

Compared to other minerals, gold is by far the commodity that is mined most often in forest areas (Bradley 2020). Out of 1 010 gold mines, 47 % are in forest areas. The majority of the mines in forest areas are located in biome sub formations, which are particularly valuable ecologically, greatly increasing the potential forest impact of gold mining (World Bank 2019; Bradley 2020).

While habitat loss is a significant problem, habitat fragmentation can also have significant negative effects on wildlife that are often underestimated as ASGM operations are more spatially dispersed contrary to e.g. a single, large mining complex. LSGM operations often are in secluded areas, for example in tropical rainforests. While building the pits and processing plants on site has a large impact locally, the mine needs to be connected to broader infrastructure. Accordingly, roads and other infrastructure need to be constructed to be able to transport e.g. chemical reagents or equipment to the mine and to move the product to its destination. Access roads not only fragment habitat, but can facilitate access into previously inaccessible areas, increasing poaching / illegal harvesting (Sonter et al. 2017).

Mining in the Amazon rainforest causes loss of forests within a radius of up to 70 km around mining concessions. Deforestation outside these mining areas was 12 times higher than inside these areas between 2005 and 2015. Deforestation is triggered by mining infrastructure, construction of residential areas for the growing workforce and supply chain infrastructure. Sonter et al. (2017) suggest that the impact of mining in environmental impact assessments should not be limited to the mining lease area but should also include surrounding areas and infrastructure. Although the study did not focus specifically on gold mining, gold mines were included in the selection of mining sites studied (Sonter et al. 2017).

In both, ASGM and LSGM, habitat fragmentation affects migratory species, which avoid the highest disturbance zones and therefore travel further distances or expend more energy for navigating through highly disturbed areas. Due to fitness consequences, this can result in decreased survival rates and lessened productivity of migratory populations (Blum et al. 2015). Additionally, the fragmentation of habitat can cause population fragmentation, threatening genetic diversity and changing predator-prey relationships, leading to ecosystem decay (Fahrig 2003; Michelle Marvier et al. 2004; O'Neill and Telmer 2017).

The Amazon rainforest is of crucial importance to the entire world since it is home to many endemic species and because the diversity of flora and fauna is among the highest of all habitats worldwide. Although globally deforestation is declining, Caballero Espejo et al. (2018) conclude that it is on the rise in the Western Amazon. ASGM is the root of the problem. As in many parts of the Amazon, ASGM is the primary source of deforestation, for example in Suriname (Peterson and Heemskerk 2001).

Caballero Espejo et al. (2018) studied the development of the southern Peruvian Amazon for a period of 34 years, from 1984 to 2017, trying to quantify ASGM-caused deforestation. In that time frame, 1 000 km^2 of rainforest were lost due to ASGM, which exceeded previous estimates by 21%. Moreover, the rate of deforestation in the Amazon is increasing; 10 % of the deforestation took place in 2017 alone. More than half of the deforestation can be dated to the years after 2011 (Caballero Espejo et al. 2018).

Problems with deforestation are amplified by the fact that, as most ASGM mining operations are informal, there are no plans or efforts for renaturation or restoration of the impacted areas. In addition, mining equipment and other waste is often left behind. Studies that analysed the biomass recovery of deforested areas have found that recovery rates on abandoned mining pits and tailing ponds are among the lowest ever recorded for tropical forests. As the mining depletes soil nutrients, especially nitrogen, forest recovery is slowed down, with close to no woody biomass recovery apparent after three to four years. Therefore, areas abandoned after mining operations are not only uninhabitable for wildlife, but also take extraordinarily long to recover (Kalamandeen et al. 2020; Peterson and Heemskerk 2001). This problem is an epidemic across the Amazonian rainforest (RAISG 2020). However, the impacts are not limited to South America; there are studies on issues connected to AGSM in Madagascar, Indonesia and other countries (Puluhulawa and Harun 2020; Cabeza et al. 2019).

The World Bank developed two comprehensive reports to give guidance and support on Forest Smart Mining for both Large-Scale Mining and Artisanal and Small-Scale Mining. The two reports recommend an integrated approach and shall support countries to combine sustainable development and poverty reduction with a respectful treatment of the environment and the needs of the local population (Worldbank 2019, World Bank 2019b)[11].

Noise & vibration

LSGM can have large noise emissions and generate vibration due to the size of the operation, in the case of open pits, and the use of heavy machinery, trucks, and blasting. Diesel engines used in truck and excavators produce both noise and vibration. Noise and vibration also pose issues at ASGM sites. The cumulative effects of different noise sources can have negative impacts on wildlife and lead to them abandoning or avoiding the habitats (Environmental Law Alliance Worldwide 2010).

4.3.5 Social impacts

LSGM as well as ASGM can have severe effects on local populations, indigenous peoples, and workers. Social issues can extend from resettlement when a mining operation starts to human rights issues because of mining or can include problems with occupational health & safety.

Resettlement & Migration

Resettlement or displacement in LSGM poses a significant threat to social stability. Mining projects are often developed in areas that are inhabited. Inhabitants who must be resettled due to LSGM projects lose their productive resources (e.g. forests, pastures, fishing areas, agricultural land) and sources of income. Resettlement areas may not suit their skills and occupations. Social networks and group identity may be weakened by the loss of culturally relevant places (Starke 2002; Environmental Law Alliance Worldwide 2010). For instance, the development of the Grasberg mine, the largest gold mine in the world, on Papua province in Indonesia led to a displacement of 15 000 residents who were mostly indigenous people. No compensation was paid to ca. 4 000 Amungme indigenous people. Many of the displaced had to relocate to lowlands where malaria was prevalent and killed several hundred people (Terminski 2014). While many were displaced, others migrated to the area in large numbers, finding work directly or indirectly through mining. The local population increased from ca. 1 000 in 1973 to ca. 100 000 in 1999 (Starke 2002).

Health & safety

As described in the previous chapters, mining projects have manifold negative impacts on water, air, and soil, potentially releasing hazardous substances such as heavy metals to the environment. Accordingly, the social well-being of affected communities can be negatively altered. Substances released can cause and contribute to increased mortality rates or illnesses. Mining workers often suffer from a higher risk of certain illnesses due to the circum-stances of their occupation. Although health and safety at LSGM usually is monitored to some extent, issues may still exist. The occupational risk at jobs in the mining industry generally tends to be high. Reports about accidents, e.g. due to landslides in open pit mines, are not rare (Environmental Law Alliance Worldwide 2010).

[11] World Bank 2019b: Forest-Smart Mining: Forest-Smart Mining: Identify-ing Good and Bad Practices and Policy Responses for Artisanal and Small-Scale Mining in Forest Landscapes, 2019, available at https://elibrary.worldbank.org/doi/abs/10.1596/32026

ASGM miners and dealers involved in the burning of amalgam are exposed to extremely high concentrations of mercury. The most damaging release of mercury therefore occurs when miners inhale the vapours during the burning process to rid the gold of mercury and form a gold sponge. Ingestion of mercury through inhalation, contaminated food, etc. leads to the following pathologies:

— irritation of the respiratory tract, pneumonia, pulmonary oedema and breathing difficulties,
— gastrointestinal irritation,
— nausea, vomiting, headache, fever, chills, cramps, and diarrhoea,
— neuropsychiatric symptoms such as fatigue, insomnia, depression, nervousness, irritability, and memory problems, and
— nerve and kidney damage.

Likewise, the intake of methylmercury through fish consumption can decrease cognitive and kidney function. Moreover, methylmercury can cross the placental barrier to affect foetuses, leading to impaired neurodevelopment, cognitive function, and motor skills. This leads to severe dangers for the people working in ASGM, their families, and residents. In addition, through bioaccumulation and fish migration, many more communities may be impacted through their food supply by relying heavily on what turns out to be contaminated fish (Sarah E. Diringer et al. 2015; Gibb and O'Leary 2014). This finding is also confirmed by the results of the platform "Mercury Observatory – Mapping gold mining impacts in the Amazon" (Mercury Observatory 2021).

As ASGM is often informal or even illegal, working conditions in mines are not regulated or controlled, with no labour rights or social protection for workers. Adequate safety equipment or precautions are not common, even though working conditions and surroundings are often remote and extreme. This poses enormous risks for the workers' physical well-being, when, for example, rudimentary hand-dug shafts collapse, transport boats capsize or rocks and other debris fall, resulting in injury and even death (Marc Guéniat 2015; Paula Dupraz-Dobias 2020; Pieth 2019). Noise emissions and vibration can also affect workers' health and safety. Hearing loss is a common problem (Usman Kaku et al. 2021). Effects of noise exposure can be hearing impairment, hypertension, heart disease and stress, as well as sleep disturbance and cognitive impairment are reported (World Health Organization 2016; Usman Kaku et al. 2021).

Governance issues

Governance issues, such as corruption, tax evasion, weak regulation, and weak enforcement of regulations, are a crucial issue in LSGM. Gold is mined in several countries that have governance problems (Starke 2002).

ASGM can have serious consequences for the structure and stability of entire regions. Many features of gold mining and trading attract organised criminal groups. Gold has a high and predictable value, and a buyer can always be found. Gold is also relatively easy to smuggle by land and air; it is not uncommon for gold to be smuggled in hand luggage on commercial airlines. Gold can be traded almost anonymously, either by using it directly as a means of payment or by exchanging it for other gold or cash. It is also often used for money laundering. For both illegal mining and smuggling and trading to work, corruption, fraud and weak law enforcement are beneficial to organised crime gangs. In many regions, these groups involve local elites, e.g. political, military or economic actors, all working together to profit from the illegal gold mining and trade. For the affected regions and states, this leads to tax evasion and capital flight. Furthermore, it strengthens ruthless illegal structures that form in parallel with the government and are geared towards profit without regard for human lives or environmental concerns (Pieth 2019; Interpol 2021).

Criminal organisations that trade illicit gold can facilitate the general insecurity induced by non-state armed groups to lower on-site prices, often working together or even merging. In some cases, like in Sudan, Liberia and the Congo, the armed groups themselves operate all along the gold supply chain to finance their activities. This can mount to political and societal insecurity as well as outright civil war (Interpol 2021; Marc Ummel 2020; Society for Threatened Peoples 2018; Pieth 2019).

☞ Development & certification initiatives

Since gold jewellery remains directly with the end consumer, certified products play an important role. Initiatives like Fairmined, Fairtrade, IRMA (Initiative for Responsible Mining Assurance), the World Gold Council's conflict-free gold standard (World Gold Council 2021h), the Better Gold Initiative (BGI) or the Responsible Jewellery Council are known and established initiatives and standards (World Gold Council 2021c). Certifications and standards can deliver relevant contributions to the ongoing search for adequate ASGM strategies (Bodle et al. 2020). However, they are only part of the solution, as not all risks and relevant environmental and social issues might be addressed and so far, only little quantities can be produced under these standards. To ensure that certification works, its credibility is of crucial importance, and transparency and accountability are fundamental. Moreover, the enforcement of functioning sanction mechanisms in cases of non-compliance, as well as the publication of decision-making processes and increasing interoperability, are of utmost relevance (Rechlin et al. 2017).

To date, ASGM certification does not cover large market shares. For example, in 2019, Fair-mined reported that 412 kg of certified gold had been sold to the market, covering 0.00012 % of global annual primary gold production. Initially, Fairmined and Fairtrade were developed together as a standard in a partnership between the Alliance for Responsible Mining (ARM) and Fairtrade International. ASGM that complies with the standard was receiving 95 % of the international gold price plus a premium between 10 % and 15 % that needed to be invested in local communities. The price of 95 % is significantly higher than the typical 70 %.

After 2013, Fairmined by ARM and Fairtrade by Fairtrade International now work separately from each other. While ARM believed higher volumes and lower prices were the best responses, Fairtrade believed that such initiatives went in the direction of greenwashing. Nonetheless, the two standards remain the most important examples of ASGM certifications. Both offer possibilities for a basic and ecological or premium certification, which offer higher premiums for ASGM miners but simultaneously require more environmentally friendly practices, such as mercury-free extraction (Sippl 2019).

Another initiative aiming to improve conditions in ASGM mining is the Better Gold Initiative (BGI) launched by the Swiss Better Gold Association (SBGA), a non-profit organisation, was founded in Switzerland by key players in the Swiss industry, in cooperation with the Swiss State Secretariat for Economic Affairs (SECO). The BGI targets the ASGM sector with the aim of improving technical, organisational, social, and environmental practices. Furthermore, a dialogue with gold-producing countries is being promoted in order to formalise the ASGM sector. BGI provides ASGM actors with technical support and training, direct investment to raise safety and productivity standards, fair business terms, and an additional incentive for community development projects. It should be emphasised that many important Swiss companies from various sectors – gold trading and gold refining, jewellery and watchmaking, banking and investment – are now members of the SBGA. Against the background of the considerable problems with ASGM documented in this study, the initiative of the SBGA must be classified as an important step forward, however, the initiative only covers small quantities of the globally mined ASGM gold (8 tons since its foundation in 2013 (Swiss Better Gold Asssociation 2021).

Such developments provide grounds for some optimism that certification in ASGM can contribute to an improvement at ASGM sites, although certification is by no means the solution to all problems, as only small quantities are produced and regulatory changes are necessary.

In contrast to these activities dealing with ASGM, the Initiative for Responsible Mining Assurance (IRMA) focuses on industrial mining (large-scale mining) for all commodities except energy commodities. The IRMA standard is considered to be very comprehensive and strong (Birke, Malea 2019). The IRMA certification system verifies mine sites (not companies). Mines can undertake the comprehensive assessment against numerous IRMA criteria themselves and, after verification by an independent third party, achieve the levels IRMA 50, IRMA 75 to IRMA 100 "Certified" according to their respective progress (IRMA 2021).

In 2019, the World Gold Council launched Responsible Gold Mining Principles (RGMPs). The Responsible Gold Mining Principles are intended to recognise and consolidate existing standards and instruments, including the United Nations Guiding Principles on Business and Human Rights, the OECD Due Diligence Guidance for Responsible Business Conduct and the Extractive Industries Transparency Initiative Guidelines for Multinational Enterprises and the International Council on Mining and Metals' (ICMM) Performance Expectations under a single framework. The Responsible Gold Mining Principles comprise ten main principles in the areas of Governance, Social and Environment, which are addressed through a total of 51 criteria. Companies implementing the Responsible Gold Mining Principles will be required to obtain external assurance from a third party, independent assurance provider (World Gold Council 2021h).

Lastly, the Responsible Jewellery Council (RJC) is a standard aiming for responsible jewellery throughout the entire supply chain. The non-governmental organisation is an industry association of companies working in the supply chain of precious stones and metals, including gold. Many of the renowned Swiss watch and jewellery manufacturers are members of the RJC. The RJC has developed production and chain-of-custody rules for certification. Certification can be obtained under the RJC Code of Practices (CoP) and the RJC Chain-of-Custody Standard (CoC). Both standards are management systems instead of product standards. As a result, the risk management of a company is evaluated, not the traceability of the product itself. Members must achieve certification of the RJC Code of Practices within two years after joining RJC. The Chain-of-Custody Standard is voluntary; the RJC standard focuses on industrial mining. Artisanal and small-scale mining cannot be certified by either standard; however, this is addressed in conflict management. Third parties emphasise the clear definition of responsibilities as well as the fact that NGOs are represented in the standard-setting committee. However, it is criticised that NGOs cannot be members in the RJC and can therefore only have an advisory function without voting rights (Birke, Malea 2019).

Gold miner showing his newly washed gold in a settlement in Madres de Dios, Peru (© André Bärtschi / WWF)

Human rights

Communities in mining areas that feel that they are treated unfairly or inadequately compensated might have disputes with LSGM operators, leading to social tension and potentially violent conflict. In a report published by the Harvard Law School, many relevant human rights obligations in the South African mining sector have failed to be met. Environmentally induced human rights issues play a major role in here. Contamination due to acid mine drainage (AMD) and heavy metals poses significant health risks. Moreover, adequate community engagement has not been managed properly (Harvard Law School International Human Rights Clinic 2016).

LSGM are often contested by local communities, especially indigenous peoples, since land rights issues are not resolved. For example, the huge opposition by the local Peruvian population in the Cajamarca region against the Conga mine of Yanacocha in Peru showed heavy human rights problems that appear through the collusion between the company and security forces that use deliberated violence against protests of the local population (Gesellschaft für bedrohte Völker GfbV 2013).

Criminal groups involved in illegal gold mining and trading seek to maximise profit with little regard for human life, using coercive and violent techniques. Women and children are particularly vulnerable to exploitation. In extreme cases, this results in children working in ASGM operations. In a report from 2015, 30 % to 50 % of the work force in ASGM mines in Burkina Faso were under 18 years of age. But this is far from an isolated problem, as it is estimated that one million children are working in mines worldwide (Marc Guéniat 2015; Pieth 2019). Many are driven into the gold mines and their horrendous working conditions by poverty and desperation. But others are forced or sold to work in ASGM mines (Pieth 2019).

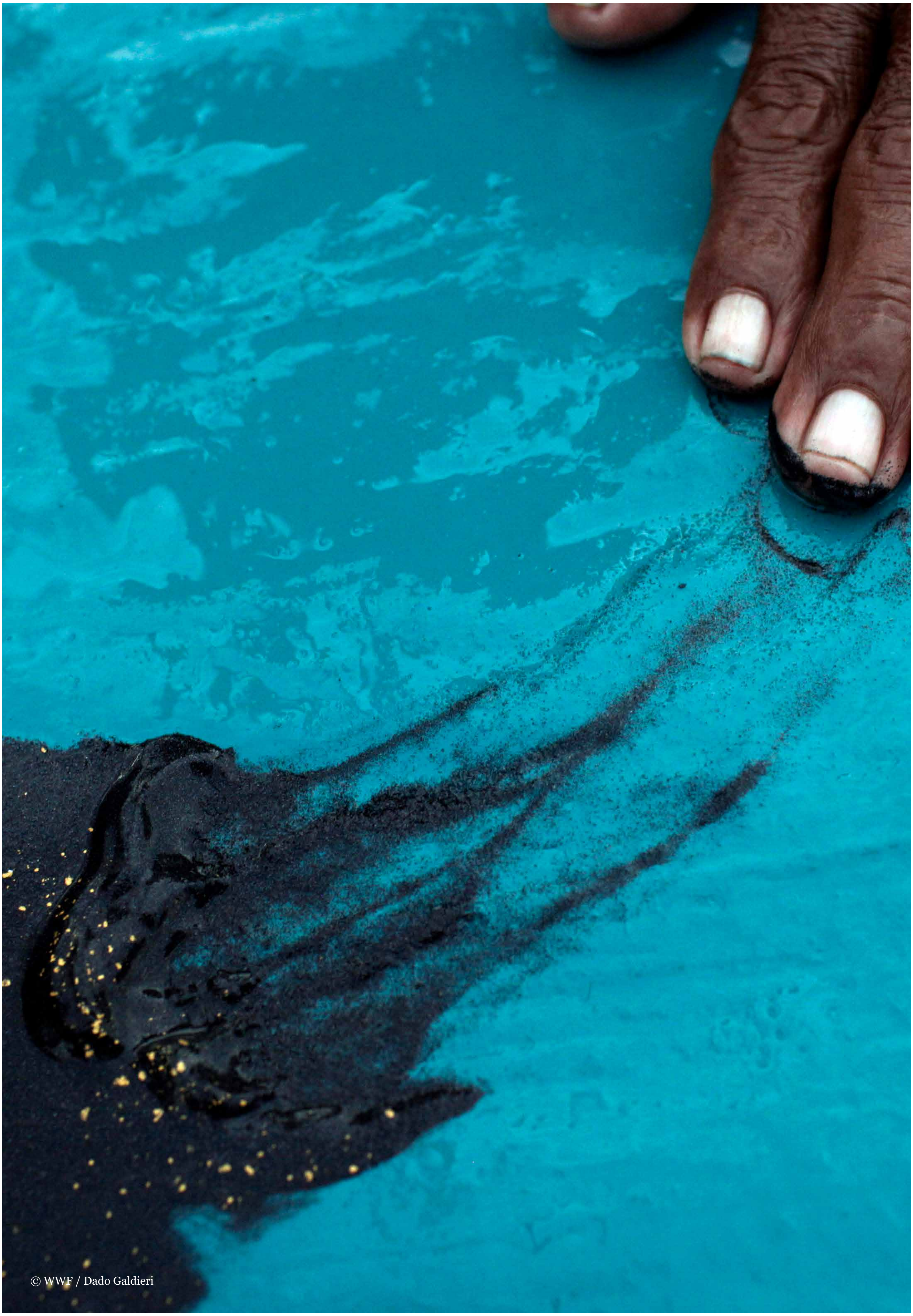
Moreover, the surrounding conditions of ASGM operations are often accompanied by human trafficking, sexual exploitation, and violence. It has been reported from Peru that women and girls as young as 12 years old from poorer areas across the country are recruited with fake job offers and trafficked to mining towns in the Madre de Dios or Puno province to work in brothels. Estimations assume that the illegal gold mining town of Delta 1 alone employs approximately 2 000 sex workers, 60 % of whom are minors. In La Rinconada, more than 4 500 girls from Peru and Bolivia are estimated to be trafficked for sex work or working in bars largely visited by miners (Global Initiative against Transnational Organized Crime 2017).

4.4 GOLD RECYCLING

Generally, gold recycling has a significantly lower social and environmental impact when compared to primary gold mining, as no direct intervention to landscapes is necessary. The impact rather relates to greenhouse gases and waste material such as slags from gold processing. Gold in products is already highly concentrated. In the case of jewellery or watches, high-grade gold alloys are used that are very easily recycled to a high degree, while recycling from electronics is more challenging.

Recycling of high-quality gold scrap results in a cumulative energy demand of 820 MJ and a global warming potential of 53 kg CO_2-eq. per kg gold (Fritz et al. 2020). In comparison, primary gold mining results in in 208 000 MJ of required energy and leads to the emission of 12 500 kg of CO_2-eq (Nuss and Eckelman 2014). Very similar numbers to those from Fritz et al. (2020) are derived by other studies using even lower values for recycled gold, amounting to only 29 kg CO_2-eq. per kg of recycled gold. Resulting in carbon footprints of recycled gold lower by a factor of 400 to 2 000 (Reisert 2019). Therefore, recycling is significantly less burdensome than primary mining in terms of greenhouse gas emissions. However, to be environmentally beneficial, recycling needs to replace mining. Recycling of old jewellery or waste electronics after their use-phase is an example that might lead to reduced primary demand.

Nevertheless, not all recycled gold comes from trustworthy sources. In part, gold that is recycled comes from sources such as organized crime looking to launder their profits. Scrap jewellery or origin of gold bars are easy to obscure. Moreover, there are reports of gold that was just mined being declared as scrap and then directly recycled. Likewise, some of the recycled gold sold by refiners is in fact newly mined gold. There are also concerns that recycled gold leads to lower demand of certified primary gold, since both options claim to be sustainable, while recycling is significantly less pricey compared to paying a premium to ASGM miners and tracking the supply chain (Bates 2021; Schein 2019).



5. GOLD PATH FROM PERU TO SWITZERLAND

This chapter portrays an example of the complete gold supply-chain, from production in Peru to the finished product in Switzerland, in an effort to showcase the complexity and non-transparency of the gold trade.

5.1 PERU AND GOLD

Peru is the largest gold producer in Latin America, producing ca. 4 % of the total amount of gold mined annually worldwide, resulting in a total of 128.4 tonnes in 2019. Peru's five-year average from 2015 till 2019 was 144.1 tonnes of gold per year (British Geological Survey 2021). It is important to keep in mind that these statistics primarily rely on data from formally mined gold, primarily LSGM. Estimates have been added for the output of ASGM based on availability but may vary depending on the source. Nonetheless, the overall picture remains unchanged (Intergovernmental Forum on Mining, Minerals and Sustainable Development 2017; U.S. Global Investors 2020).

Mining, especially the extraction of copper and gold, is an essential part of Peru's economy, as trade statistics show. In 2019, mining products in their raw or refined state accounted for more than 50 % of the trade value of goods exported from Peru. Gold itself accounted for a large share, 14.5 % of the total trade value (The Observatory of Economic Complexity 2021; United Nations 2021).

There are numerous large-scale industrial gold mines throughout Peru, including the 251 square kilometre Yanacocha open pit mine in the Cajamarca region, one of the largest and most profitable gold mines in the world (Jorge Acosta et al. 2015). The companies behind LSGM operations often use a direct trade route to refineries around the world. In addition to formal industrial LSGM operations, the share and importance of ASGM in Peru is significant. One must rely on rough estimates grasp the extent of informal and illegal mining. Due to rising gold prices, illegal small-scale mining has expanded rapidly and uncontrollably in some regions of Peru for more than two decades. This increase applies to both the lowlands of the Amazon jungle and the mountainous regions of the Andes, where the scale of illegal mining increased fivefold between 2009 and 2014 (Pure Earth - Blacksmith institute 2021).

Throughout the last thousand years or more, the peoples living in Peru have identified with precious metals as a part of their societies. Artisanal gold mining has a long practice in the Andes. In some areas responsible ASGM is successfully carried out and forms a traditional livelihood that provides an important source of income for local communities (Stähr and Schütte 2016; Pure Earth - Blacksmith institute 2021). Illegal mining is a way for many to earn money quickly, and the scale is often directly or indirectly related to external factors such as the price of gold, government deregulation of deforestation, or reduced protection of indigenous lands and protected areas. Estimates attempt to capture the extent of illegal mining and its impact at different levels in Peru in 2014, 2015 and 2016. According to these estimates, 15 % to 22 % of Peru's gold was extracted illegally, equivalent to about 25-35 tonnes of gold per year (Alex Létourneau 2014; Society for Threatened Peoples 2018; Stähr and Schütte 2016). Cases of illegal ASGM gold mining have been reported in at least 24 of Peru's 26 states. In some regions, it contributes either directly or indirectly to up to 50 % of economic output. Overall, the number of illegal artisanal gold miners in Peru is estimated to be between 70 000 and 150 000. In addition to this direct involvement, another 500 000 people[12] are indirectly employed in connection with illegal gold mining, for example as gold traders or suppliers of mining equipment (Stähr and Schütte 2016; Society for Threatened Peoples 2018; Alex Létourneau 2014; Pure Earth - Blacksmith institute 2021; Global Initiative against Transnational Organized Crime 2017).

[12] This would correspond to about 1.5 % of Peru's current population (estimated for 2021): https://www.worldometers.info/world-population/peru-population/

Gold path

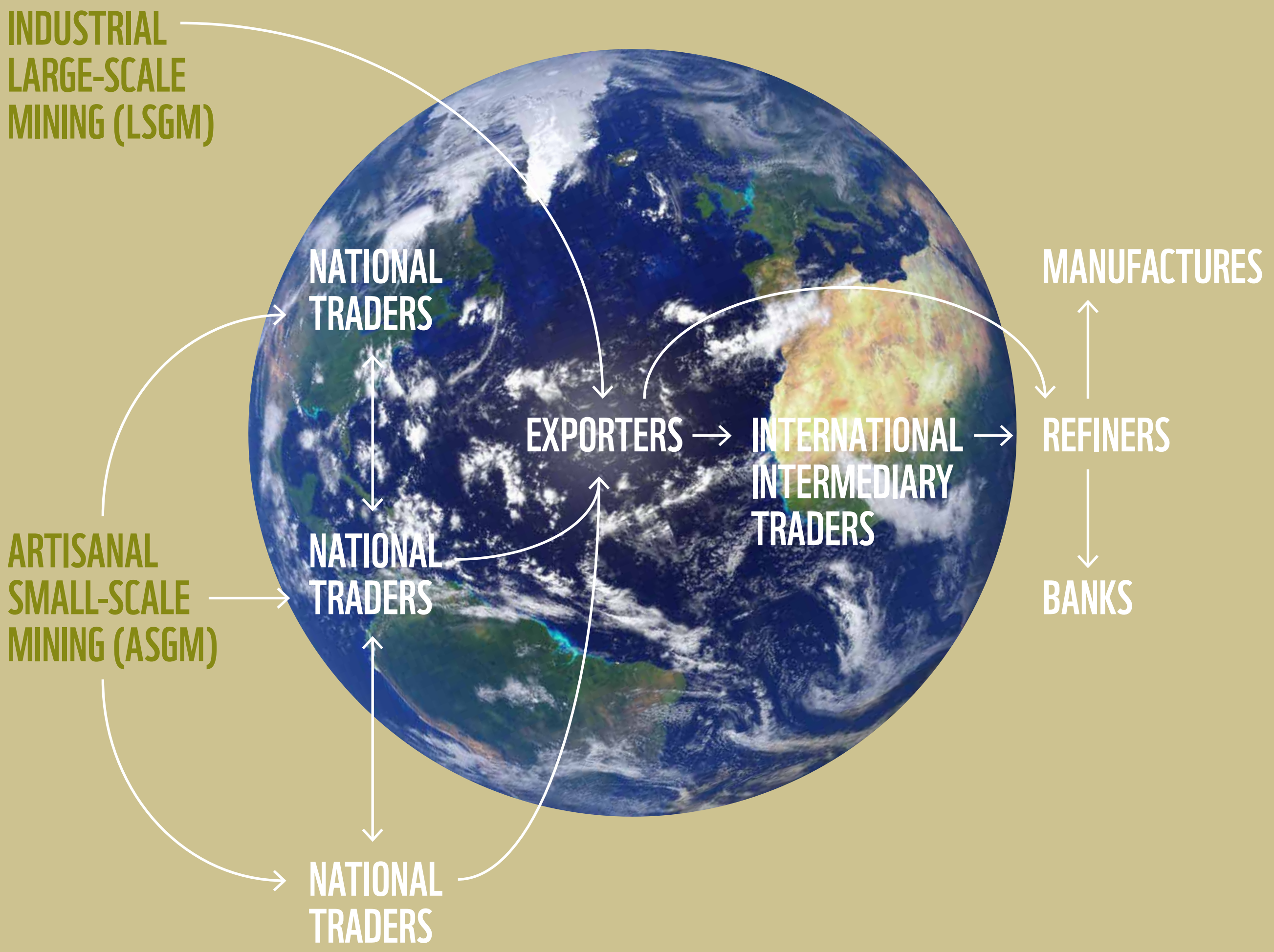


Figure 5–1: schematic gold path

5.2 INFORMAL MINING IN LA RINCONADA (PUNO) AND MADRE DE DIOS

While ASGM in Peru is widespread and has historical roots, two regional developments involving two informal ASGM operations stand out that have generated international attention and caused significant environmental and humanitarian destruction. One hotspot is around La Rinconada, which is a populated centre within the jurisdiction of Ananea District in San Antonio de Putina province, located in the department of Puno and bordering Bolivia. It is located around 5 100 m above sea level in the Andean mountains, where the climate is cold and dry. Such elevated regions make up 70 % of the region's territory; the rest is covered by the Amazon rainforest. Its capital is the city of Puno located on Lake Titicaca. The mining in the mountains around La Rinconada is informal and chaotic, with widespread violence, but it is not deemed illegal (Society for Threatened Peoples 2018; Pieth 2019).

The other hotspot is in the district Huepetuhe, which is part of the province of Manu located in the south of the region Madre de Dios. Madre de Dios itself is in the southeast of Peru and borders Bolivia and Brazil. It is a flat region in the lower planes of the Amazonian basin and covered with rainforest. Its capital is the city of Puerto Maldonado. It is crossed by the newly built interoceanic highway that has established a much quicker connection between Puerto Maldonado and Cusco. Madre de Dios is among the most biodiverse regions in the Amazon. Its rainforest includes some of the less affected and eroded areas of the Peruvian Amazon and is home to some of the last groups of uncontacted indigenous people (The Center for Amazonian Scientific Innovation 2021; Society for Threatened Peoples 2018).

5.3 FOLLOWING A GOLD PATH FROM PERU TO SWITZERLAND

It is extremely difficult to accurately trace the path of gold from its source in Peru to a watch-maker in Switzerland or to the vault of a bank in London. The gold sector is extremely opaque compared to other sectors. Due to the lack of transparency, gold that has been extracted illegally and with major environmental and social impacts in an area not intended for mining cannot later be traced back to its source. Figure 5–1 shows a simplified representation of the path that gold takes. Gold mining operations often trade their gold directly to an international refinery, often bypassing intermediaries. The path of ASGM gold is often more complex and less transparent, and it is therefore difficult to trace.

Mining in Peru

The gold we follow starts in Huepetuhe, in the region of Madre de Dios in southern Peru. While a legal mining corridor exists, as well as a buffer zone to protect existing nature reserves, multiple illegal mining locations can be found operating in non-designated areas. Hotspots include particularly La Pampa, along the Malinowski River, or the Pariamanu River (Finer M 2020, 2021; Society for Threatened Peoples 2018).

In these areas, miners turn the jungle into dusty sand, often working along rivers to easily use them as a means of transport. Deforestation can be tracked using satellite imagery, as shown in Figure 5–3 (Finer M 2020, 2021; Caballero Espejo et al. 2018; Moher and Blades 2021; Tollefson 2020). Over a three-year period, deforestation and erosion were clearly visible at ASGM sites in the Alto Malinowski River. In addition, the impacts of mercury in the region are well documented (Gerardo Martinez et al. 2018; Caballero Espejo et al. 2018). Water quality in the area is negatively affected and the landscape is destroyed. Precarious health and education services, increases in disease and malnutrition, and conflicts arising from land use struggles and the forced displacement of indigenous people are noted (Cowie 2021; Matti Salo et al. 2016; Tony Corbett et al. 2017).

Figure 5–3: Satellite images showing in white the increasing deforestation along the Alto Malinowski River from (Finer M 2020).

Lured by economic promises of the new highway and the gold business, Madre de Dios is estimated to be the fastest growing region in Peru. The enormous explosion of its population creates massive challenges for the towns and villages as people live in makeshift shanty-towns; the quality of life in the areas is deteriorating (connectas 2015). It is estimated that the possibility for wealth attracted between 50 000 to 70 000 illegal miners into the region, as well as many more who are employed indirectly. Especially, the population of the capital city of Madre de Dios, Puerto Maldonado, has increased rapidly. Another accompanying problem and an acute health risk is the burning of mercury in makeshift furnaces in residential areas. This has led to measurements of mercury levels in the air being 1 000 times higher than the Peruvian limit and 10 000 higher than US government minimum risk levels (Paula Dupraz-Dobias 2020).

In February 2019, the Peruvian government declared martial law to curb the problem of illegal mining. They expelled an estimated 5 000 miners and occupied large swaths of land. This crackdown was labelled ‘Operation Mercury’, and the military used force to battle the negative impacts of illegal mining operations and defend protected nature reserves. These activities led to mining camps being destroyed and heavy military presence in the region. It is reported that the deforestation rate in the Madre de Dios region decreased by 90 % because of this effort (Finer M 2020, 2021).

While deforestation has been slowed in certain regions, success is often only temporary; driven by poverty and desperation, the miners are highly elusive and, in some instances, have started operating at night. So far, the incentives for legalization are not high enough and the process of formalization is too complicated and therefore too slow. Pressure and direct involvement from national and international actors in the gold market is necessary to establish responsible ASGM mining and form a basis of economic security (Paula Dupraz-Dobias 2020; Tollefson 2020).

Trading inside of Peru

For the gold we are tracking to get to Puerto Maldonado or another city that functions as a gold trading centre it has probably already changed hands at least once. The quantities and qualities mined are more reliable in LSGM and the mines are usually operated by large companies that export the gold themselves or have firm export partners. However, this is not the case for gold from ASGM, which often passes through one or more traders on its way from mine to exporter (Intergovernmental Forum on Mining, Minerals and Sustainable Development 2017). Among the many mineral trading companies, A&M Metal Trading and Veta de Oro have been identified as the main local buyers in the Madre de Dios region of Peru (Paula Dupraz-Dobias 2020).

Small, informal, and easily accessible trading shops are widespread in the region (Pure Earth - Blacksmith institute 2021). ASGM is often practiced in rural areas that are logistically not well connected and difficult to reach. Therefore, a trader collects the gold from several ASGM prospectors in remote areas, buys their gold and sells it collectively to an exporter or another trader at a trading hub. Often the gold is already processed at this point, since, for example, refining steps are carried out to reduce the mercury content of the gold. In these processes, the gold from different sources is mixed, which disguises its origin. Officially, traders are only allowed to buy and sell gold from a certain region, but this is difficult to control and gold from other regions can easily be mixed in (Paula Dupraz-Dobias 2020).

Thus, gold from legally operated sources can be mixed with gold from illegal or informal mines. Officially, newly mined minerals are marketed through a legally authorised institution. However, these institutions have no way of determining exactly where the gold comes from. Usually, the gold is sold in ingots that have been rudimentarily produced by traders or miners using improvised furnaces and equipment. At this point, it is impossible to determine whether the gold was acquired legally or not and whether it really came from the place indicated. It is assumed that the gold acquired is legal; therefore, little, or no due diligence is done. Furthermore, the gold might be labelled as recycled to disguise its true origin (Melina Risso, Julia Sekula, Lycia Brasil, Peter Schmidt and Maria Eduarda Pessoa de Assis 2021; Paula Dupraz-Dobias 2020; Society for Threatened Peoples 2018).

Gold from unlicensed sources can easily be attributed to an officially operated ASGM mine. In the case of ASGM, gold is usually mined in very small quantities in many different locations, making it difficult to track and monitor. Moreover, the sale of even small quantities is profitable because of the high price of gold. These traders usually operate on a national level, but in some cases, they also cross borders and smuggle the gold illegally. It is thus almost impossible to trace the path of the gold back to its source. The nature of the gold trade, its irregular structure and its high-profit opportunities attract criminal organisations to prospect, trade and smuggle gold. They can often leverage their infrastructures and networks already established through other operations and use the profits to fund illegal mining activities (Marc Ummel 2020; Marc Guéniat 2015; Human Rights Watch 2018; Intergovernmental Forum on Mining, Minerals and Sustainable Development 2017; Paula Dupraz-Dobias 2020; Neumann 2019; Melina Risso, Julia Sekula, Lycia Brasil, Peter Schmidt and Maria Eduarda Pessoa de Assis 2021).

Due to the opaque structure and informal workings of the gold trade, the actors and companies involved often cannot be precisely identified, making the path of the gold we are following increasingly difficult to track.

Export from Peru

Gold is usually exported by large international trading companies that focus on minerals and precious metals. These companies are often characterised by non-transparent operating and ownership structures. They are often represented by licensed traders, agents or representatives on the ground. At this level, the mixing of legal and illegal gold as well as fraudulent invoicing is regularly reported. This system leads to massive monetary losses for producing countries through tax evasion and capital flight that are facilitated and enabled by corruption. For example, it is not uncommon for gold to be marked with a lower fineness, e.g. 14 carats instead of 24 carats, as fineness is difficult to judge with the naked eye; this underestimation leads to mispricing and capital flight (Melina Risso, Julia Sekula, Lycia Brasil, Peter Schmidt and Maria Eduarda Pessoa de Assis 2021; Paula Dupraz-Dobias 2020; Society for Threatened Peoples 2018).

It is possible that the gold we are tracking was mined illegally and ended up with exporters. In fact, the exporting companies AS Perú & CÍA and E&M Company have been accused of money laundering and illegal gold trading in the Madre de Dios region in the past. These companies are always being renamed or reopened, but often the numbers and infrastructure behind the businesses remain the same (Society for Threatened Peoples 2018).

Despite working in secret, these now defunct exporters were important players in the gold market. The largest player, Minerales del Sur, operated under a state licence and had local branches and agents in various locations to accumulate gold from Puno and probably other places like Madre de Dios. Minerales del Sur was the third largest Peruvian gold exporter behind the transnational industrial mining companies Yanacocha and Barrick. The direct gold trade of AS Perú & CÍA and E&M Company to the Swiss refiner Metalor was stopped in 2014 after publications by the Society for Threatened Peoples. Minerales del Sur has also apparently not exported gold for several years. Nevertheless, gold mining continues in Madre de Dios (Society for Threatened Peoples 2018).

Another possible route of the gold we are following could have been via illegal transport out of the country. The smuggling of illegally mined gold from Peru to La Paz in Bolivia is not uncommon. La Paz is near the mining centres of Madre de Dios and especially Puno and is well connected to them. Border controls are lax, as the course of the border and its geographical features make it almost impossible to control. Large quantities of Peruvian gold have been found to be smuggled via this route to Miami in the United States, where it is mixed with gold from other sources and refined (Óscar Castilla C. 2014; Paula Dupraz-Dobias 2020).

One way or the other, the gold we follow left the land of its origin, heading towards an international refinery. North America plays an important role as a destination of Latin American gold, see Figure 5–5, with Canada the prime destination in terms of volume for Peruvian gold. While many of the large traders of precious metals as well as mining operators are in North America, the refining capacities and global recognition are not on par with Switzerland. Nevertheless, the gold will probably go through a refining process, in which gold from different sources is unified and standardized bullions are formed before being sold further. In 2019, the second largest importer of Peruvian gold after Canada was Switzerland with 132.8 t (United Nations 2021).

Export destinations of peruvian gold in tonnes

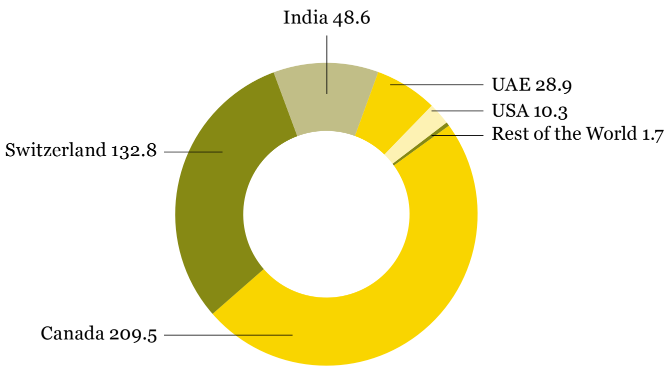


Figure 5–5: Export destination of Peruvian gold in 2019 in tonnes, not including gold that was smuggled out of the country (United Nations 2021).

It should be noted that the total amount of gold exported from Peru, about 432 tonnes, is considerably larger than the144.1 tonnes of gold that resulted from Peru's mine production on average from 2015 to 2019 (British Geological Survey 2021). On the one hand, this can be explained by the fact that silver-gold alloys are shown as gold in the export statistics and, on the other hand, gold from ASGM activities in Peru is also included, which is not recorded in the mine production statistics.

Peruvian gold in Switzerland

Often the gold takes a detour through international intermediary traders. The fact that most of the gold imports into Switzerland originate from countries that do not have primary gold production attests to that. These intermediary traders further obscure the traceability of the gold and allow the mixing of gold from different sources. Problematically, the middle countries often have low standards in terms of customs control and import regulations, fostering illegal gold smuggling. The imported gold is destined for one of the large refineries in Switzerland. Yet, the form of the incoming gold varies greatly depending on the route the gold has taken. It may still be in a relatively raw, unrefined state, declared as mine gold. But it is also common for the gold to have already been refined at least once and declared differently. The refineries are in a key position to control the gold trade.

While traditionally they were closely associated with banks, nowadays gold refineries belong to precious metals traders or producers, technology companies or jewellery producers. All four large Swiss refineries are listed by the London Bullion Market Association (LBMA), as 'Good-Delivery' as well as being three of the five 'Good Delivery Referees'. These licenses solidify their position as the eye of the needle for the gold trade, by turning the raw unrefined gold into a tradable and highly valuable product. The refineries sell their gold to a wide variety of organisations across the globe. The main share goes to manufacturers that produce watches and jewellery; the second biggest share is sold to banks for the purpose of investment (Marc Ummel 2020; Melina Risso, Julia Sekula, Lycia Brasil, Peter Schmidt and Maria Eduarda Pessoa de Assis 2021).

The major Swiss refineries claim that they are not involved in illegal gold mining. Rather, they say that the responsibility lies with the producing countries and that these countries are responsible for making changes to improve mining standards. In response to the accusations, some Swiss refineries have stopped all purchases of ASGM gold. To limit the damage to a company's image, this approach may seem reasonable at first glance. However, it does not automatically lead to a solution that would improve the overall situation. On the ground in the mining regions, nothing has changed; buyers can always be found for gold (Society for Threatened Peoples 2018; Paula Dupraz-Dobias 2020).

A positive example of a Swiss refiner is Metalor, which has been purchasing around 500 kg of gold annually since 2019 via the mining company Minera Yanaquihua S.A.C. in the Arequipa region in the Peruvian highlands. This company has been supported by the Better Gold Initiative for Artisanal and Small-scale Mining, the Peruvian affiliate of the Swiss Better Gold Association, since 2019. The Society for Threatened Peoples (STP) welcomes Metalor's decision and believes that it offers an opportunity to ensure the necessary due diligence and transparency. At the same time, the STP emphasizes that the quantities of ecologically and socially responsibly produced ASGM gold are still very small overall (Society for Threatened Peoples 2018).

6. OVERVIEW OF THE LEGAL FRAMEWORK SITUATION

As shown in the previous chapters, Switzerland has a special position in gold trade, facilitated by its legal situation. In addition to low requirements for transparent information in customs statistics and a lack of due diligence obligations when importing minerals from conflict areas, tax advantages when importing gold (and alloys) also matter. Relative to legislation and regulations in the EU and the USA, Switzerland is far behind.

This section highlights important differences between Switzerland, the EU, and the U.S. regarding the legal framework for gold trading.

Transparency and audit obligations along the supply chains

USA

In 2010, the Dodd-Frank Act was enacted – a law designed to improve transparency in the U.S. financial system. Three of the articles there in are specific to mining and deal with conflict minerals, reporting requirements of safety and health standards in mines (Mine Safety Disclosure), and of payments by companies engaged in the extraction of raw materials. The law applies to all companies listed on the U.S. stock market that source conflict minerals from the DRC and adjoining countries. Minerals from other regions (e.g. South America) are not covered by the regulation. Environmental aspects are not explicitly addressed by the Dodd-Frank Act. Under the legislation, companies must comply with the following steps:

- Determine if its manufactured products contain conflict minerals from the conflict regions
- Conduct due diligence (e.g. OECD Guidance on Responsible Supply Chains) on the source and chain of custody
- If its conflict minerals origin from a conflict region a conflict minerals report has to be filed that has to be audited by an independent third party (Ernst & Young 2012)[13]

There is no other legislation that affects responsible gold trading.

EU

Since 2021, the EU has a law regulating the trade of conflict minerals (tin, tungsten, tantalum and gold (3TG)) from high-risk countries. High-risk areas are countries with mineral deposits that are subject to high demand and affected by conflict, weak governance, or human rights violations. This list is continuously updated by experts.

The law aims to ensure that 3TG is sourced responsibly by following the responsible sourcing standards of the Organisation for Economic Cooperation and Development (OECD). It applies to all companies that import conflict minerals (in a certain quantity) into the EU, not including manufacturers and sellers of finished products as under the Dodd-Frank Act. These companies must conduct a five-step due diligence of their value chain to ensure that the minerals were mined responsibly. The regulation also incorporates environmental issues. The steps include:

- Establish strong company management systems
- Identify and assess risk in the supply chain
- Design and implement a strategy to respond to identified risks
- Carry out an independent third-party audit of supply chain due diligence
- Report annually on supply chain due diligence (OECD 2013)[14]

SWITZERLAND

Since 2012, data on raw gold have been available in Swiss foreign trade statistics. The year, country of origin (for imports), country of destination (for exports), value (CHF) and quantity (kg) are shown. The country of origin only must be stated if it is known[15]. Since 2021, the statistics distinguish between mined and refined gold[16]. This is intended to increase transparency regarding the origin of gold (Schweizerische Eidgenossenschaft 2021). There is no legal regulation on human rights or environmental issues.

Although according to the Precious Metals Control Ordinance (Edelmetallkontrollverordnung EMKV, SR 941.311), cases must be reported in which there are doubts about the legality of the acquisition in the country of origin, i.e. the gold was stolen or acquired illegally, social or environmental aspects of due diligence remain open. Also, according to the Criminal and Civil Code (Straf- und Zivilgesetzbuch), it is allowed to prevent the import of gold produced under conditions that violate human rights. However, this possibility is rather theoretical, as no such case is known to date (Schweizerische Eidgenossenschaft 2015).

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[14] OECD (2013), OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas: Second Edition, OECD Publishing. https://trade.ec.europa.eu/doclib/docs/2018/august/tradoc_157243.pdf, checked on 09/10/2021
[15] Due to the exceptional nature of these goods and exclusively in the absence of clear indica-tions, the country of dispatch may be declared as the country of origin for: Gold, silver and other precious metals according to the general rules for the interpretation of the Harmonised System, in raw or semi-finished form of Chapter 71 of the Customs Tariff. (R-25 Foreign Trade Statistics, Guideline 2.3.4.1, Goods of Chapters 71 and 97)
[16] Mine gold is gold that has been mined or has come from watercourses and has not yet been refined.

7. WWF RECOMMENDATIONS

MINING PRODUCERS

Producers should be aware of the ongoing public debate on sustainable and responsible gold exploitation and supply chains, requesting a social license to operate and an adherence to national laws as well as to international moral or legal standards.

Recommendations

- Seek certification of production.
- Adhere to international standards for responsible mining (IRMA, IFC, ICMM, OECD, etc.).
- Apply appropriate best practice technology for mining and mineral concentration.
- Provide Environmental and Social Impact Assessments (ESIA) for ASGM.
- Establish grievance mechanisms open for local communities and civil society organizations.

GOVERNMENTS IN PRODUCING COUNTRIES

Governments in producing countries play a key role in regulating and supervising mining activities and safeguard local, regional, and national interests.

Recommendations

- Develop and implement mechanisms to stop illegal ASGM. Develop a clear formalisation process and framework for the ASGM sector considering relevant social and environmental standards.
- Provide a fair share of government mining revenues to communities living at and around mining sites to compensate for social and environmental costs.
- Allow local communities to be heard in the mining licensing process and establish grievance mechanisms.
- Establish and implement a cohesive legal framework (especially mining, environmental and labour laws, and regulations) to safeguard national wealth and wellbeing.
- Promote traceability schemes.
- Make mineral governance procedures transparent.
- Become member of the Extractive Industries Transparency Initiative (EITI).

BANKS AND OTHER FINANCIAL INSTITUTIONS

Financial institutions are relevant at all stages of the gold value chain. They provide funding for mining operations and therefore, they can play a key role in establishing responsible risk management in the mining sector and in avoiding new mining projects in environmentally sensitive areas. Moreover, financial institutions offer investment opportunities for institutional and private investors in the form of loans, debt, and equity finance along the various stages of supply chain from mining, transport, smelting, refining and production of gold containing products. Financial institutions also provide investment opportunities into physical gold, gold funds and gold Exchange Trade Funds (ETFs).

With transition, legal and reputational risk becoming more and more relevant, financial institutions should – in their own interest – establish responsible investment strategies and adopt appropriate policies.

Recommendations

- For project finance follow the IFC Performance standards, e.g. Performance Standard 6 on Biodiversity. This will, for example, require Free Prior Informed Consent (FPIC) and Environmental and Social Impact Assessments (ESIA) as a prerequisite and avoidance of critical habitats.
- In case of high environmental, social or political risks or difficult track records of applicant companies conduct risk analyses, and ensure that management plans are validated by independent third parties (e.g. auditors).
- From investee companies, request full compliance with international frameworks, such as OECD Due Diligence and standard and certification schemes e.g. IRMA, LBMA Best Delivery Standard, RJC, Fairtrade, Fairmined.
- Ensure that all gold sold, whether physically or in investment funds, is sourced from traceable, responsible gold supply chains. Guarantee the same minimum standards for all gold investment products including ETFs.

REFINERS

Refiners have a key role in the gold supply chain. They are the central supply chain actor responsible for ensuring traceability and transparency across the upstream supply chain.

Recommendations

– Fully apply LBMA policy requiring a documentation of commitment from producers to respect ESG related standards.
– Train auditors to ensure a competent evaluation of ESG risks in the upstream supply chain.
– Invest in initiatives that promote responsible ASGM to help small-scale miners transform to more responsible mining.
– Further develop and disseminate existing initiatives and technical solutions to promote and improve traceability and responsible supply chains.
– Disclose information about the origin of gold to allow traceability and transparency, when appropriate this can be limited to stakeholders with legitimate interests (i.e. clients, auditors etc.).

INDUSTRIAL USERS (WATCH / JEWELLERY COMPANIES, TECHNOLOGY COMPANIES ETC.) AND RETAILERS

Increasingly, people expect businesses to step up and help tackle social and environmental issues. The growing consumer awareness offers at the same time a great business opportunity: It is a new way of adding value to a brand, engaging consumers, and employees, building trust while avoiding risks, reducing long-term cost, becoming compliant for upcoming regulations, and securing the long-term viability of a company.

To remain relevant and minimise business risks, there is an urgent need for the private sector to act and move towards responsible and transparent gold supply chains. Every company sourcing or working with gold or gold products can contribute significantly towards a more transparent and responsible sector. Be it by fostering innovation, changing business operations or through establishing courageous collaborations.

Recommendations

– Ensure fully traceable supply chains and demand transparency from your suppliers.
– Source critical raw materials responsibly, recycle them or use alternative materials.
– Invest in the transition of small-scale miners towards responsible ASGM through purchasing responsible ASGM gold and/or through supporting initiatives that promote responsible ASGM.
– Invest in initiatives that promote responsible ASGM and purchase responsible ASGM gold to support small-scale miners transform to more responsible mining.
– Analyse your impact, set, and implement scientific sustainability goals.
– Report regularly and publicly on relevant sustainability and human rights topics.
– Collaborate openly with academia, NGOs, or industry peers to achieve your sustainability goals .

CONSUMERS

We encourage consumers to demand disclosure of origin and mining circumstances as well as ethical and ecological commitments from the brands they purchase from. Currently, the gold of many consumer goods is not sourced responsibly and is instead contributing to human misery and environmental destruction in production countries of the global South. By requesting transparency and considering responsibly sourced gold in their purchase decision, consumers can influence value chains towards following more responsible practices about natural resources and the environment.

Recommendations

– Always ask about the origin, working conditions, and responsibility standards and certifications when buying or investing in gold products. Choose products with certified recycled or re-refined metals and recycled or synthetic gemstones. When buying products containing newly mined raw materials, choose items with certified eco-friendly, conflict-free, and responsibly sourced raw materials. It is best to seek out international frameworks e.g. OECD Due Diligence and/or standards and certification schemes e.g. LBMA Best Delivery Standard, RJC, IRMA. Fairtrade, Fairmined.
– Purchase responsibly. Only buy jewellery, watches or gold from companies committed to responsible and transparent sourcing and production. Where possible, rent watches and jewellery, buy second hand, or buy products designed for longevity.
– Repair defective items and recycle old and unused jewellery, watches, and electronic devices.
– Only buy and invest in Exchange Traded Funds (ETF) or physical gold bars and coins from responsible production.
– Support collective action to advocate for responsible products.

GOVERNMENTS IN GOLD BUYING COUNTRIES

Governments of gold buying countries set an important regulatory framework for trade and business and play an important role in extending these internationally via trade treaties. In the long run, international action should pave the way for a level playing field for all actors.

Recommendations

– Develop and implement legally binding policies for all companies to ensure compliance with human rights and environmental standards across global supply chains.
– Judicial instruments like corporate liability should be available and effective as well as complaints procedures for affected individuals and communities.
– Issue/endorse and fully implement regulations for responsible trade and raw materials supply chains.
– Include ESG compliance in international trade treaties.

8. APPENDIX

8.1 DETAILS ON THE SWISS WATCH MARKET

Globally, only 0.3 % of all watches exported were produced partly or completely using precious metals. Of these precious metal watches, the biggest share, around 15 %, was exported from Switzerland. These statistics support the notion that Switzerland's watchmakers are the leading producers of precious metal watches. Consequently, Switzerland generated 47 % of the global trade value from the export of watches containing precious metals. Indeed, no other country accounted for more than 10 % of global trade value (United Nations 2021).

8.2 DETAILS ON LEADING COMPANIES AND BRANDS IN THE WATCH SECTOR

GROUP	BRANDS
Swatch (Switzerland)	Omega, Longines, Tissot, Breguet, Blancpain, Rado, Swatch, Mido, Hamilton, Harry Winston, Certina, CK Watch, Glashutte Original (all from Switzerland)
Rolex (Switzerland)	Rolex, Tudor (both from Switzerland)
Richemont (Switzerland)	Cartier Watches, IWC, Jaeger-LeCoultre, Vacheron Constantin, Officine Panerai (all from Switzerland)
LVMH (France)	TAG Heuer (Switzerland), Hublot (Switzerland), Bulgari (Italy), Zenith (Switzerland)
Fossil (USA)	Fossil (USA), Relic (USA), Michele (USA), Zodiac (Switzerland), Skagen (USA)

Table 8–1: Overview of the largest watch companies and their associated brands

8.3 GOLD AS MATERIAL IN WATCHES

In a forum entry on the 'The Rolex Forums', the weight of the main parts of a gold Rolex 'Day-Date', which costs more than USD 35 000, were listed. It was found that the 18 ct gold parts weigh 99.89 g, which fits well with other sources and estimations of around 100 g of gold in that type of watch. 99.86 g of 18 ct gold are equivalent to 75 g of 24 ct fine gold. At the time of writing (June 2021), 24 ct fine gold is priced at USD 56.51/ g. Subsequently, at the current market price, the gold in such a Rolex would be sold for USD 4 232.32. In relation, the price for alloy elements like copper and silver as well as stainless steel materials are negligible. It is apparent that there is a large difference – around USD 25 000 – between the value of the gold used in a watch, which is around USD 4 000, and the retail price for a comparable watch with and without gold. Generally, even though precious metals only account for a small portion of a watch's components, they constitute for a large share of their value (see Figure 8–1).

8.4 INTERNATIONAL GOLD TRADE: FACTS AND FIGURES

Table 8–2 lists the trade value in million USD and the amount of gold in tonnes (Qty. [t]), the share of both trade value and quantity in percent, and the average gold price for each coun-try. By comparing the share and the average price of each country, large price differences are visible. Peru especially stands out, selling the largest amount of gold in terms of quantity, but for the lowest average price of USD 16.1 million/t. This is also influenced by silver trade declared as gold, as described above. For a comparison, the average price per tonne for gold traded from the United Arab Emirates to Switzerland was USD 45.2 million. Furthermore, no single country took up a dominant position, with the highest share in trade value from the United Arab Emirates at 13.2 % of the total worldwide trade value (United Nations 2021).

Watches by material

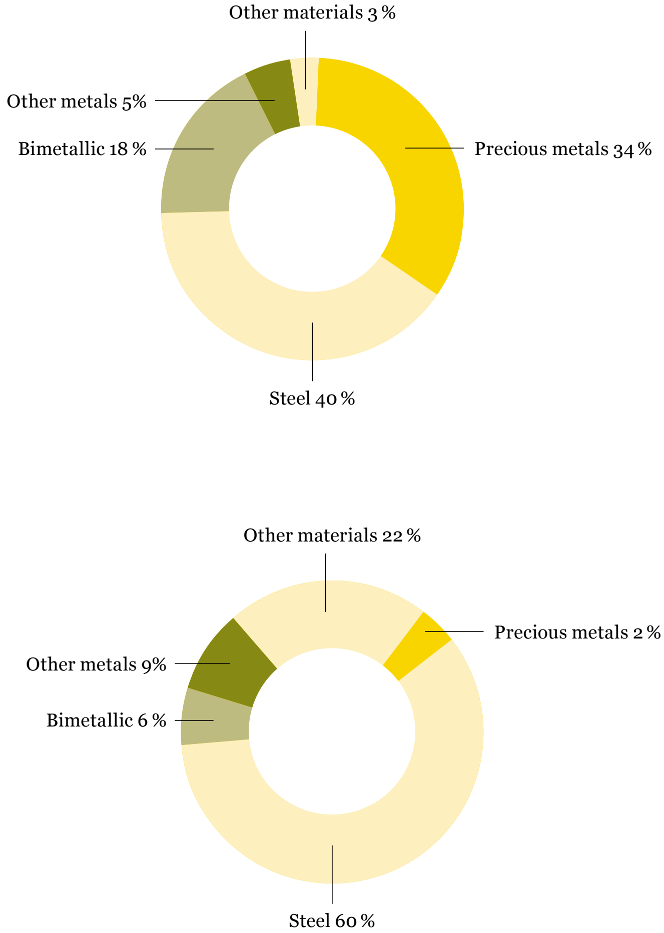

Figure 8–1: Watch sales by value and units based on material (Verband der Schweizerischen Uhrenindustrie FH 2019)

Gold imports into Switzerland 2019 (skewed by silver declared as gold, see text)

EXPORTING COUNTRY	TRADE VALUE (million USD)	QUANTITY (t)	SHARE TRADE VALUE (%)	SHARE QTY (%)	AV. PRICE PER T (mio USD/t)
United Arab Emirates	5 795.5	128.1	13.2	9.2	45.2
United Kingdom	5 759.7	130.9	13.1	9.4	44.0
Thailand	4 123.5	92.3	9.4	6.7	44.7
Italy	2 905.8	68.3	6.6	4.9	42.5
Germany	2 889.4	79.5	6.6	5.7	36.3
USA	2 575.5	n. a.	5.9	n. a.	n. a.
Ghana	2 377.8	62.9	5.4	4.5	37.8
Peru	2 194.2	135.9	5.0	9.8	16.1
China, Hong Kong SAR	1 724.8	39.7	3.9	2.9	43.5
Rest of the world (57)	13 555.4	649.3	30.9	46.8	20.9

Gold exports from Switzerland 2019

IMPORTING COUNTRY	TRADE VALUE (million USD)	QUANTITY (t)	SHARE TRADE VALUE (%)	SHARE QTY (%)	AV. PRICE PER T (mio USD/t)
United Kingdom	18 604.4	389.6	27.8	25.3	47.8
China	15 278.4	364.6	22.8	23.7	41.9
India	15 109.1	354.3	22.6	23.0	42.6
Germany	2 539.1	56.7	3.8	3.7	44.8
Singapore	2 140.5	49.0	3.2	3.2	43.6
Thailand	2 056.8	48.3	3.1	3.1	42.6
Turkey	1 791.9	39.4	2.7	2.6	45.5
China, Hong Kong SAR	1 610.2	37.5	2.4	2.4	43.0
Italy	1 460.0	36.9	2.2	2.4	39.6
Rest of the world (51)	6 391.2	163.6	9.5	10.6	39.1

Table 8–2: Gold imports into Switzerland per country in 2019, commodity code 7108 (United Nations 2021)

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Our Mission

Together, we protect the environment and create a future worth living for generations to come.

WWF Switzerland

Hohlstrasse 110
PO Box
8010 Zürich

Tel.: +41 (0) 44 297 21 21
wwf.ch/contact

Donations: PC 80-470-3