POLICY PAPER

A blockchain is only as strong as its weakest link: transparency and artisanal gold.

Author: Antoinette van der Merwe

Summary

To ensure responsible gold sourcing, accredited refiners often obtain gold directly from a few industrial mines, building up trust relationships and visiting these mines frequently. This approach is not feasible for artisanal mines, given their large numbers and the high-risk conditions in which they operate. Can blockchain be a substitute for trust relationships to support responsible sourcing from artisanal miners? The main obstacle for using blockchain is to create a link between the physical world (the traded gold) and the digital (the blockchain). Linking the physical and digital worlds can be done either by uniquely identifying the physical object by its chemical composition or by adding a unique mark or tag to the product. For the case of artisanal gold, both these methods are limited. Geochemical analysis requires large and expensive reference databases and can only be done before smelting and refinement. Tags need to be added by a central authority, which could weaken the power and trust of the blockchain in fragile areas. While blockchain could contribute to a more transparent gold supply chain, it has a limited ability to ensure responsible sourcing from artisanal miners.

We all use gold every day: to show our commitment, to celebrate, to communicate, to show we care, to invest, and much more. The question is; how do we know if the gold in our mobile phones, wedding rings and bank vaults were not mined by children or in ways that caused irreparable harm to the environment?

The gold supply chain can be divided into two parts, the upstream part from miner to refiner and the downstream part from refiner to retailer. While the downstream part of the supply chain is very complex, transforming the gold into its various final forms, the upstream part is the critical part to ensure responsible sourcing (Demierre 2019).

Various due diligence initiatives, such as the OECD (Organisation for Economic Co-operation and Development) guidelines and LBMA (London Bullion Market Association) accreditation, have

Local traders use a handheld scale or “flail scale” with coins and matches as counterweights to determine the weight of the gold.
Photo: Enough Project

aimed to increase the transparency in the gold supply chain. Refiners are a critical point in the supply chain, with only six major gold refineries in the world - four of which are located in Switzerland. Given refineries' position in the supply chain, responsible sourcing initiatives often have had implications for them, specifically refiners accredited by the LBMA and those following the OECD requirements. One way in which refiners handle the cost of due diligence is by shortening the supply chain. Refiners reduce uncertainty by buying primarily from a few industrial mines, allowing them more control over the source and origin of the gold. They build up personal relationships and perform risk-based onsite visits at these mine sites (Demierre 2019).

Although industrial mines extract about 80% of the gold, the other 20% is produced by a myriad of artisanal miners, often working alone or in small groups or cooperatives (IGF 2017). Artisanal mining creates a livelihood for millions of poor individuals, but at a high cost, as these artisanal miners work in extremely dangerous conditions and are often informal or involved in illicit trades. The sector has also been characterised by various human right abuses, such as child or forced labour, mining in protected areas, and mercury pollution. Sourcing gold from artisanal mines is often considered high risk in terms of due diligence requirements (LBMA 2019).

The supply chain for artisanal gold can be very complex and long, especially at the level of individual artisanal miners, each of whom extract only a very small amount of gold that is subsequently accumulated by many local and regional traders and passed on to local gold shops (Johansson 2018). Worldwide, an estimated 50,000 gold shops buy from artisanal miners (Telmer 2020). These local gold shops or traders smelt gold from various sources together to create a form of unrefined gold, called doré, which, depending on the area, consists of a varying percentage of gold, plus secondary minerals such as silver and copper and other impurities.

Given these long and complex supply chains, it is costly for refiners to meet the necessary due diligence requirements when they buy from artisanal miners. Accredited large refiners, therefore, avoid buying artisanal gold on a large scale. This makes it more

What is a blockchain?

Blockchain, also known as distributed ledger technology, is a system that does not need a central regulating body to oversee or build a trust relationship; instead, trust is integrated into the mechanics of the blockchain system design (Nakamoto 2008). When a new transaction is completed, it is broadcasted to all actors in the network, who record the transaction in their database. Each blockchain system defines its own set of rules of how new transactions are accepted or rejected.

A blockchain can be designed to fit its required purpose. This includes stipulating who can participate in the blockchain, for example a select group or the public; and defining the appropriate consensus mechanism, which specifies the requirements for accepting a new transaction. For example, lowering the number of participants required to accept a new transaction could push a large volume of transactions through but could be more error prone, leading to issues such as “forking” (when two versions of the ledger emerge). Alternatively, a high acceptance rate could create a more accurate dataset but be slower in validating new transactions.

Refiners create 99.99% pure gold, removing trace and secondary minerals that could be used to determine provenance in a geochemical analysis. Photo: PAMP SA

difficult for responsible artisanal mines to make a livelihood. Can blockchain cut the due diligence cost of buying from artisanal miners and bring responsible artisanal miners into the formal market?

Using blockchain in the gold supply chain

Two advantages of using blockchain include (a) lower vulnerability to data tampering, as blockchain lists are decentralised and not kept on one verifying list, making the entire network less susceptible to hacking or tampering; and (b) the ability of users to share information more effectively. In order to use a blockchain system, users have to standardise the way they represent data. This prerequisite, in itself, is often a valuable contribution to increasing transparency in the supply chain, one that could allow companies to more easily manage vast amount of data and avoid data overload.

The Development Economics Group at ETH Zurich conducted interviews with experts in blockchain, tagging and geochemical analysis who are working in gold extraction, trading and logistics, refinery, and retail, to investigate the feasibility of using blockchain as a low-cost mechanism to verify due diligence requirements on artisanal gold.

However, the main issue with applying a digital system such as blockchain to a physical system like gold is the need for a link between the two systems. This means that every gram of gold that is traced needs to be uniquely identifiable in the digital system; the blockchain needs to be able to follow every gram of gold from a responsible source, and be able to differentiate it from other gold. Linking the physical world to the digital one can be done in two ways: (1) as with DNA in humans, by developing a way to analyse the physical product in a way that would allow us to uniquely identify it anywhere in the supply chain; or (2) similarly to a passport issued to an individual, we can add a unique, tamperproof mark or tag to the product. Although using blockchain could marginally contribute to more transparent gold supply chains, evidence suggests that using geochemical analysis and tagging to link artisanal gold to the digital system are restricted.

What is geochemical provenance analysis?

Mineral ores have unique morphological, mineralogical and chemical properties that are linked to the specific geological processes through which they were formed. Geochemical provenance analysis can describe ore mined from a specific deposit by analysing these unique properties, similar to how DNA analysis can identify specific individuals. Refiners, who usually do the geochemical analysis, can then estimate where the gold is from by matching its composition to a reference database of the geochemical composition of gold deposits around the world.

I. Unique link: geochemical provenance analysis

Although geochemical provenance analysis or "fingerprinting" of primary gold is scientifically possible, its application is limited due to gold's physical and chemical properties, only the composition and presence of trace and secondary minerals in the ore can be used to create a unique geochemical signature (Melcher et al. 2008, Hruschka et al. 2016).

Children wave to peacekeepers in Katanga, DRC. The conflict minerals tin, tantalum, tungsten and especially gold have financed armed groups in the DRC in one of the deadliest conflicts since the Second World War. Photo: United Nations

Secondary and trace minerals are only present in ore concentrates before refining and smelting. While gold shops remove many of the secondary and trace minerals, high-end refiners can remove any remaining impurities to create up to 99.99% pure gold. Geochemical provenance analysis can therefore only be applied before refinement (Epstein & Yuthas 2011). This implies that the feasibility of using geochemical analysis depends on whether or not refiners consistently analyse the isotopes in impurities of the gold they buy (Chang 2019).

In addition, this method is not feasible when gold ore from different sources is smelted together, as is invariably the case with artisanal mining. For refiners it will be extremely costly to create a reference database, which would involve taking samples of all known gold deposits. This is especially problematic when there are many artisanal miners who continuously move to new gold deposits (Demierre 2019). Moreover, even if geochemical analysis could give a unique signature for gold from a specific ore, this might not be detailed enough if one wants to differentiate between multiple miners who mine from the same deposit.

Other advantages of using geochemical analysis

Despite these difficulties with using geochemical provenance analysis as a link between the blockchain system and the real world, this method could mitigate some other issues in the gold supply chain.

Firstly, Roberts and colleagues (2016) have shown that the processes used by many artisanal operations, such as mercury amalgamation and low-temperature smelting processes, create unique characteristics in the gold, such as traces of mercury, tin and lead. These metals are not found in gold extracted and processed by industrial mines. The origin of artisanal gold is often incorrectly specified and then declared as scrap gold. The presence of these metals could indicate that at least one of the sources was from an artisanal mine, although the absence of any of these metals is not necessarily proof that gold has been sourced responsibly.

Secondly, geochemical analysis could also be used as a verification tool by confirming that the gold is indeed from the area that the traders claim. In this case a refiner only needs a sample of the ore from where the gold allegedly originates from, instead of a reference database showing the chemical composition of all gold ore deposits in the world.

What is tagging?

Tagging involves fixing a physical tag to a given quantity of a mineral, much like an individual uses a passport to verify their identity. Tags, or automatic identification devices, include a wide range of technologies used to identify a specific item and track it through the supply chain. Gold is highly recyclable and any tag or marking could easily be removed by smelting the gold, without diminishing its value. However, tags are usually fixed not to the actually mineral but to a tamperproof bag containing the gold.

II. Unique link: tagging

Similar to issuing passports, tags need to be assigned by a central authority. This weakens the blockchain's trust mechanism, which can reduce the power of using blockchain (Brugger 2019). A blockchain is a system that does not need a central authority's input; meaning, if a central authority administers tags, the system could resemble a normal ledger instead of a distributed ledger or blockchain.

During bagging-and-tagging projects done in the DRC by the iTSCi (ITRI Tin Supply Chain Initiative), conflict-free tin and tantalum mines received bar codes which were added to the bagged ore, updating information on the bar code manually through the supply chain, and cross-checking with logbooks. Many technical problems hindered the capabilities of these projects. The iTSCi reported instances of untagged bags being smuggled or corruption compromising the operation (Gerritsen 2013). Many reported that government fieldworkers solicited miners for bribes, a situation which, in the end, closely resembled the one that the project aimed to curb (Vogel et al. 2018). Other issues included a lack of electricity and internet connection impacting information uploads, and logbooks being lost or damaged by bad weather (Bray 2012; Evans-Pughe 2010). In addition, the cost of running such a large operation could make it unsustainable (Evans-Pughe 2010).

A pilot project in the DRC by the German Federal Institute for Geosciences and Natural Resources (BGR) assessing the feasibility of bagging-and-tagging to track gold from conflict-free artisanal mines showed that an automated system could address some of these issues. Four conflict-free artisanal mines were identified and supplied with tamperproof plastic bags with near field communication (NFC) tags. Government fieldworkers were responsible for bagging and tagging the gold at the mines. Various checkpoints in the supply chain were identified and supplied with biometric cards, which automatically updated information when connected to the NFC tag in the bagged gold. All information was stored in the chip and did not have to be recorded manually. The automated nature of the system significantly reduced the cost of tracing the gold (BGR 2017, Nindel 2018, Mugisho 2019).

"If a central authority administers tags, the system could resemble a normal ledger instead of a distributed ledger or blockchain."

Using tags to link the real world and the blockchain is feasible, but its success still depends on the security and trust in the point of human intervention needed to tag the gold (Brugger 2019). For such a system to be successful, the country of extraction needs to have certain systems in place. In the BGR pilot study, existing governmental fieldworkers were responsible for bagging the gold, which reduced the cost but could still include a risk of exploitation during tagging. Other important prerequisites include legislation for legal procedures about artisanal mining rights and duties, royalty schemes and governmental structures to enforce the law (Mugisho 2019).

Conclusion

Given the numerous difficulties with creating a unique link between the blockchain and the physical gold, it is not feasible to use blockchain to trace the small quantities of gold mined by millions of artisanal miners for the time being. There are two possible links between the blockchain and physical gold. One is to identify gold by its chemical composition, which, like DNA in humans, is inherent to the gold. However, given the many limitations of using geochemical provenance analysis, this is not feasible. Another possible link is tagging, especially since a more automated bagging-and-tagging gold pilot project by the BGR addressed some of the technical issues usually associated with bagging-and-tagging projects. However, the fact that tags need to be added manually reduces trust in the blockchain system.

Although blockchain, and therefore geochemical analysis and tagging, is not the panacea for the problems surrounding artisanal gold mining that many have hoped for, it could be a progressive improvement towards a slightly more transparent supply chain as long as its limitations are kept in mind. For example, geochemical analysis could detect traces of mercury, which could serve as an indication that at least one sources of the gold is an artisanal mine. Alternatively, geochemical analysis could be used to confirm that the stated provenance of the gold is correct. While tagging, especially an automated tagging system, could allow downstream actors to buy from responsible miners within conflict areas, there is a risk that the tagging procedure could create new opportunities for rent seeking and solicitation from those responsible for administering tags. Therefore, while blockchain could contribute to a more transparent gold supply chain, its ability to include responsible artisanal miners in the formal supply chain on large scale is limited.

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Photos

p.1: Gold mine in Burkina Faso. Photo: Ollivier Girard/CIFOR
p.2: Gold trading. Photo: Enough Project
p.3: Gold refinery in Switzerland. Photo: PAMP SA
p. 4: Children wave to UN Peacekeepers in the DRC. Photo: UN/Abel Kavanagh

Author

Antoinette van der Merwe is a doctoral student under the supervision of Prof. Dr. Isabel Günther, at the Institute of Science, Technology and Policy (ISTP) and the Development Economics Group at ETH Zurich. Her doctorate focuses on various ways to create cleaner and safer gold supply chains.

ETH Zürich NADEL
Clausiusstrasse 37, CLD
8092 Zürich
Schweiz
Tel. +41 44 632 42 40
info@nadel.ethz.ch
www.nadel.ethz.ch