

Traceability & Blockchain for Gemstones – an Overview

概述寶石的可追溯性和區塊鏈

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作者討論寶石的可追溯性和區塊鏈在寶石業應用的原因、運作、優點和近年的歷程，並替主要術語提供定義。作者認為區塊鏈在鑽石和寶石供應鏈的可追溯性或改進並非靈丹妙藥。然而，最終，多種方法、舉措和技術將能提高行業透明度，並提供較持續的成果。

Recent developments have brought “due diligence”, along with tracking and traceability, to the forefront of discussions and requirements in the diamond, coloured stone and pearl industries (Hänni and Cartier, 2013; Archuleta, 2016; Cartier et al., 2018). To address this trend, certification mechanisms and technologies (such as blockchain, technology that can record the history of a gem from its origin through fabrication and sales - see *full definition in Glossary below*) are being developed to solve inherent traceability challenges. As applied to gems, such standards and associated technology could benefit from the support of existing gemmological approaches (e.g. geographical origin determination) to enhance traceability and transparency measures. This article seeks to provide the reader with an overview of current developments, terms used in this context and further research that may be needed.

Diamond – in the form of conflict diamonds and the Kimberley Process Certification Scheme (KPCS) – is not the only mineral or metal used in jewellery supply chains that has been scrutinised in recent years: for example, there has been a focus on gold (Dirty Gold campaign in 2004 and Conflict Gold in 2012), rubies and jade from Myanmar, lapis lazuli from Afghanistan or precious corals listed under CITES to name a few notable cases. In response to these developments, jewellery industry associations (e.g. CIBJO, WDC, ICA, AGTA) have begun to address these issues and companies have gone on to form a range of initiatives to strengthen responsible practices in the industry, such as CIBJO’s responsible sourcing blue book or the Responsible Jewellery Council (RJC).

Why traceability? Why now?

As in other sectors (e.g. food, fashion, shipping), there is now greater demand for specific information on how the raw materials leading to finished pieces of jewellery are extracted and processed. Traceability is one way to provide more transparency and specific information, and it is frequently argued that by increasing transparency, supply chain issues can be better mapped and understood (Mol, 2015). Blockchain, and other traceability tools, are being heralded by some as solutions to transform the jewellery industry.

At present, there are a number of factors shaping the development of responsible practices and the move for increased traceability and transparency in the jewellery industry, and more specifically for diamonds and coloured gemstones:

- Consumers are increasingly interested in knowing where and how the gemstones and jewellery they purchase are mined and manufactured.
- Media and NGOs are placing the gem and jewellery industry under increased scrutiny regarding the origin and sustainability footprint of various gemstones and human rights issues in the artisanal mining sector.
- Some companies want to be proactive so as to mitigate risks and better understand their own supply chains and contribute to positive outcomes.
- Governments want to improve the management and revenue collected from gem resources.
- Global governing bodies have highlighted issues such as smuggling and money laundering.
- Some governments (e.g. USA, EU) have instituted ‘conflict mineral’ legislation, requiring publicly traded companies to know and trace their supply chains and comply with their laws.

Traceability is often understood to mean that an object is fully traceable (i.e. an individual gem is uniquely documented and identifiable at each step of the supply chain from mine to market),

but there are other models of product traceability (Solomon and Nicholls, 2010; Norton et al., 2014). Traceability information could be used:

- as a tool for supply chain management (managing and locating stock)
- to demonstrate compliance (against given standards or legal requirements) and support due diligence
- to provide evidence of provenance and/or sustainability claims



Fig. 1 Rough stones on offer at a gem market in Mogok (Myanmar), probably from a great number of different mines. The complex and fragmented nature of the gem industry makes 'traceability' a challenging undertaking.

Photo: Laurent E. Cartier

在緬甸摩谷的寶石市場上出售的寶石原石，可能來自多個不同的礦源。寶石行業複雜而分散的特性使“可追溯性”成為一項具挑戰性的任務。

As best practices and standards within mining, processing and sale of gemstones are increasingly defined worldwide - the development of techniques to track and trace gemstones may support the accountability of such schemes and it may even become necessary, for example, for publicly listed companies to demonstrate compliance to specific government regulations. Importantly, the Organisation for Economic Cooperation and Development (OECD) have developed due diligence guidelines for responsible mineral supply chains for companies seeking to respect human rights and avoid contributing to conflict through their mineral sourcing decisions and practices; these guidelines now apply to all minerals, including diamonds and coloured gemstones (OECD, 2016).

Glossary

As recent conferences and events suggest, there is some confusion around the terms used surrounding traceability and responsible sourcing. As such, in a recent article, we sought (Cartier et al., 2018 and references therein) to define and contextualise these terms to provide clarity to members of the trade. These terms include:

Blockchain: A system for storing data in which groups of valid transactions, called blocks, form a chronological chain, with each block securely linked to the previous one. Originally invented for the digital currency bitcoin, a blockchain is a permanent, unalterable digital file of encrypted transactions that can be distributed in multiple copies across a network of devices linked to the blockchain. Given that every storage device has an exact and updated copy of the ledger, data can be verified and is considered immutable – an important property when transactions occur among users that do not know or trust each other.

Chain of custody: The document trail recording the sequence of companies and individuals that have custody of minerals as they move through a supply chain.

Due diligence: The act of proactively ensuring that the products sourced and traded by companies within a supply chain conform to national and international regulations. (See OECD Guidelines)

Disclosure: The release of information by companies required by regulators or requested by business partners in the supply chain.

Provenance: A (documented) claim made on the origin (e.g. country or mine), source (e.g. recycled, mined, artisanally mined, natural, synthetic), previous ownership (e.g. a historic gemstone or a piece of jewellery formerly in a royal collection) or extraction and processing practices (e.g. conflict free, untreated, responsibly sourced).

Traceability: The ability to identify and trace the history, distribution, location, and application of products, parts, and materials (ISO).

Tracing: The use of traceability records or an object's properties to identify the origin, attributes or history of a product within the supply chain (i.e. from market to mine). This could include origin determination using gemmological science.

Tracking: The use of traceability records to track an item from its origin to the end consumer through the supply chain (i.e. from mine to market). This is often complemented by the use of tracking technology such as radio-frequency identification (or RFID) chips, near-field communication, synthetic DNA implantation, barcodes or other forms of tagging.

Blockchain – a silver bullet for the industry?

There has been considerable hype around blockchain in recent times with radical promises made as to how it could disrupt and transform entire industries. Blockchain is a decentralised and immutable ledger, which is the basis for

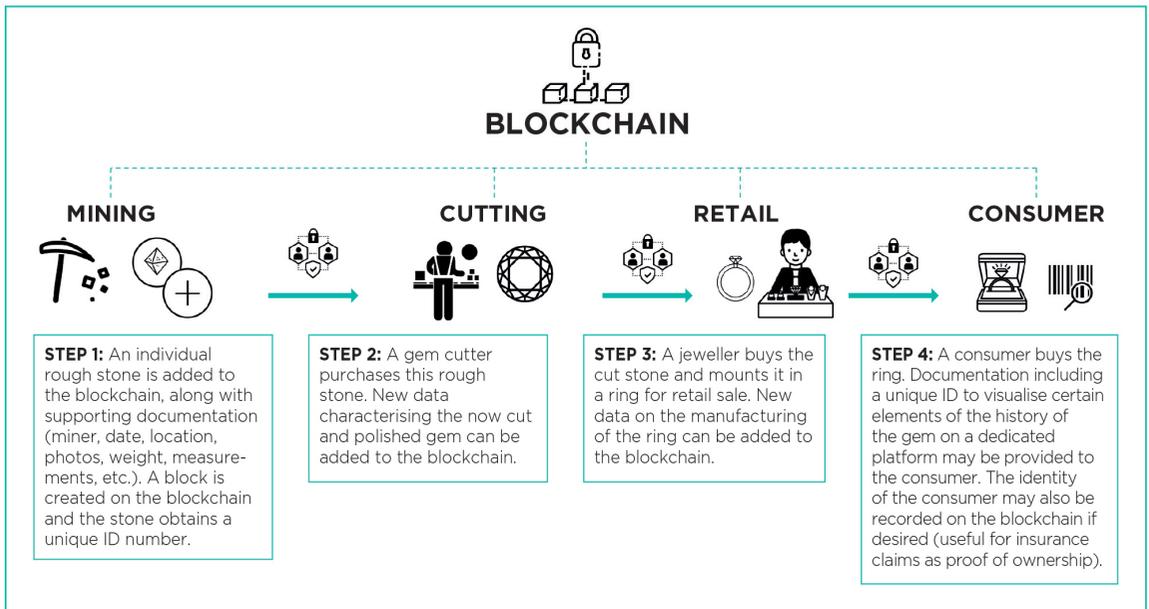


Fig. 2 This generalised example of a blockchain serves to illustrate how information can be documented on a single gem's journey from mining to cutting and onward to retail and eventually the end consumer. After the stone is mined, the trade and transfer of ownership are validated at each step by both parties involved and recorded immutably to the blockchain.

Illustration by L. E. Cartier (Courtesy of Journal of Gemmology).

這區塊鏈示例說明如何在單一寶石從開採到切割，再到零售以及最終消費者的歷程中的信息記錄。在開採寶石後，寶石所有權的交易和轉讓在所涉的各方面的每一步驟都得到驗證，並且不可變更地記錄到區塊鏈中。

the potentially huge transparency gain that this technology can offer. At each step, data added to the blockchain are verified, ownership is attributed, and the information is time stamped, encrypted, and stored permanently in a distributed and decentralised manner, providing an immutable record that is formed of a single, yet shared, source of information about a gemstone's journey from source to end consumer.

Blockchain can thus provide transparency and verification to the regulators and other users who require it, while still providing the privacy and the specific views into the ledger that are relevant for each different type of user. This is an important factor for the gem and jewellery industry, which demands verified, but often anonymised, chain-of-custody solutions. Combining blockchain with smart contracts (automatic trades and verification between accounts/users if pre-required conditions are met) could potentially provide a huge gain in efficiency (especially with regards to demonstrating compliance and know-your-customer procedures), and this is one of the main reasons why blockchain is being widely investigated as a game-changing technology.

Diamond miner De Beers launched the Tracr blockchain in 2017 to track diamonds through the full value chain. The Trustchain Initiative (piloted by IBM) is an industry collaboration to pilot

traceability using blockchain in diamond and gold jewellery from mine to retailer. Finally, Gübelin and Everledger are piloting a blockchain for coloured gemstones that is due to be launched in 2019.

Traceability for gems is nothing new: the role of gemmology

As the science of gemmology emerged in the early 20th century, and synthetics and treatments became critical research issues, interest grew in carrying out structured investigations on gem materials from different origins to characterise their properties more effectively. For example, Chesley in 1942 attempted to correlate spectroscopic features of diamonds to their source localities. Geographical origin determination of coloured stones as we know it today appeared in the 1980s, and at the beginning focused on characterisation of typical microscopic inclusions from a deposit (Gübelin and Koivula, 1986). This was subsequently complemented by chemical and spectroscopic work on gem materials from various localities, such as early work on Kashmir sapphires (Hänni, 1990).

Origin determination of gems today is an expert scientific opinion on the origin (country) of a stone, based on characteristic inclusions and chemical and spectroscopic features. Although it is not possible to trace a coloured stone back to a specific mine, origin determination can help validate claims made by companies regarding country of origin.

Importantly, gemmological science can continue to provide much-needed assistance regarding claims of origin (geographical and whether a gem is natural or synthetic) and whether or not a gem has been treated. A gem's inclusions and their location within the stone can be used to help verify its identity, as well as provide gemmological data that can later be compared to existing chain-of-custody information.



Fig. 3 A tiny QR code can be inscribed on a gemstone during chemical analysis with GemTOF instrumentation (Wang and Krzemnicki, 2016). The QR code shown here measures $500 \times 500 \mu\text{m}$ and has been inscribed on the girdle of an emerald weighing 2.5 cts. The material ablated during the inscription of the code is used to measure trace-element concentrations that are evaluated for determining country of origin. The code can be read (after magnification) using a QR reader on a smartphone, and gives the user access to various types of information on the stone. *Composite photo by H. A. O. Wang and V. Lanzafame, SSEF. (Courtesy of Journal of Gemmology).*

使用GemTOF儀器對寶石進行化學分析同時，可以在寶石上刻上微細的QR碼 (Wang和Krzemnicki, 2016)。上圖顯示的QR碼尺寸為 $500 \times 500 \mu\text{m}$ ，並被刻在重2.5克拉的祖母綠石腰上。在代碼登記期間所消融的材料是用於測量和評估用於確定原石產地的微量元素之濃度。商家可使用智能手機上的QR閱讀器讀取代碼，以便得悉寶石的各樣信息。

Technology and traceability – what's next?

As blockchain is a nascent concept in other sectors too, it is unclear whether industry-wide consensus is possible or necessary at this stage. Fundamentally, for a gem and jewellery industry that consists largely of cottage and family-owned companies, further research is needed to understand how all levels of the supply chain can benefit from the traceability opportunities that blockchain technology provides. The current focus on full mine-to-market traceability may not be as realistic as it has been shown to be for other sectors, nor may the market necessarily want or require it.

The fragmented nature of some parts of the gem industry makes traceability a complex and challenging undertaking. Sorting and aggregation steps in supply chains – in which goods may be

sorted in terms of quality rather than origin – may further complicate this endeavour. Regulatory requirements and consumer demands for supply chain integrity and knowledge of provenance will continue to push the industry to find solutions. This may also provide newfound opportunities if, for example, synthetics and treated stones can be separated more clearly from natural/untreated material in the supply chain based on traceability information to verify the ownership and authenticity of gem materials at different stages of the supply chain.

In summary, there is no 'silver bullet' for traceability or improving practices in the diamond and gemstone supply chains. Ultimately, however, multiple approaches, initiatives and technologies are likely to spur greater transparency and provide more sustainable outcomes in the industry.

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