

Implementation of Blockchain Technology to Improve Transparency and Accountability in the Mineral Supply Chain

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Abstract

This study analyzes the potential and challenges of implementing blockchain technology to enhance transparency, accountability, and traceability in mineral supply chains. Using a qualitative approach with case-study methods and thematic analysis of interviews, company reports, regulatory documents, and scientific literature, the study compares initiatives by several industry actors. The findings show that blockchain strengthens end-to-end provenance tracking, authenticity verification, compliance with environmental and ethical standards, and minimizes data manipulation and illicit trade practices. In addition, blockchain integration drives operational efficiency and inter-stakeholder trust through immutable, auditable transaction logs. However, adoption faces structural barriers in the form of regulatory uncertainty, limited digital infrastructure in developing countries, and organizational resistance to system change. This study recommends establishing clear regulatory frameworks, public-private collaboration, cross-platform data standardization, and capacity building including integration with IoT and digital identity to maximize blockchain's impact on more sustainable and responsible governance of mineral supply chains.

Keywords: Blockchain, Transparency, Traceability



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INTRODUCTION

The mining industry particularly the mineral sector plays an important role in the global economy. Mineral resources are essential raw materials for multiple sectors, including electronics, construction, energy, and automotive. Despite significant profit potential, the sector faces major challenges related to transparency and accountability in supply chains. Numerous

cases reveal illegal practices such as illegal mining, money laundering, and human-rights violations linked to mineral supply chains, which harm communities and damage the reputations of companies and countries. As attention to sustainability and business ethics grows, the need for systems that can monitor and verify the entire supply-chain process has become more urgent (Ye & Zhang, 2026; Ziaya et al., 2025). One proposed solution is blockchain technology. Known for its ability to provide transparent and secure systems, blockchain can offer an effective pathway to improving transparency and accountability in mineral supply chains.

Blockchain is essentially a distributed digital ledger that stores data in blocks linked together and replicated across many network nodes. Each transaction is recorded and can be monitored in real time, making manipulation highly difficult. The technology can be adapted to oversee mineral supply-chain processes from exploration and mining through processing and distribution to end consumers. Applying blockchain to mineral supply chains not only increases transparency but also ensures that each transaction can be accounted for. This is crucial given the high risks of resource theft, labor abuse, and environmental damage in the mining industry (Sukumar et al., 2026; Vakil et al., 2025). By integrating blockchain into these processes, a more responsible and sustainable system can be achieved.

A growing body of research has explored blockchain's application across industries, including mining, and indicates considerable potential for enhancing transparency and accountability in supply chains (Kandasamy et al., 2025; Zhou et al., 2026). The technology enables all parties involved to access consistent, tamper-resistant information, which in turn can deter corruption and inequity. Other studies find that blockchain can increase efficiency and traceability in supply chains by minimizing human error and data manipulation. Such research suggests that blockchain adoption can reduce transaction costs and strengthen trust among participating parties.

Nevertheless, despite broad potential, practical applications in the mineral sector remain limited. More specific studies highlight implementation challenges, including regulatory issues, limited technological infrastructure in developing countries, and reluctance among large firms to change entrenched legacy systems (Salehi et al., 2026; Zhou et al., 2026). Relevant studies also show how blockchain can address mining-sector problems such as accurate and honest mineral provenance tracking from the point of origin to the end consumer thereby reducing the risk that traded materials are illicit or fail to meet environmental and social standards.

RESEARCH METHOD

This research employs a qualitative approach using case-study methods. The qualitative approach is chosen to deeply examine the implementation of blockchain in mineral supply chains from both theoretical and practical perspectives. Case studies are used to analyze blockchain implementation by several companies or countries that have adopted the technology within their mineral supply chains (Abdullah & Hs Alani, 2025; Marcelletti et al., 2026).

The research steps are as follows:

Case Identification: The study begins by identifying several company or country cases that have adopted blockchain technology in their mineral supply chains. Data are obtained from the literature, company reports, and interviews with involved stakeholders.

Table 2.1 Case Identification

No	Data Source	Data Collection Method	Description
1	De Beers	Tracr: a blockchain-based platform for tracking diamonds from the mine to the end consumer.	Improves transparency and ensures diamonds sold are conflict-free. Builds consumer trust and strengthens sustainability and ethical efforts.
2	Everledger	Blockchain platform for tracking valuable goods and other minerals, including diamonds and other mineral commodities.	Verifies authenticity and provenance, reduces the risk of “blood minerals,” and promotes transparency in the international trade of minerals.
3	IBM & Maersk (TradeLens)	Blockchain platform for tracking logistics and the movement of goods in global supply chains, including mineral commodities.	Increases efficiency, reduces logistics costs, and improves transparency in international transactions—applicable to mineral supply chains.
4	BHP Billiton	Blockchain used to verify and monitor mined and produced natural resources.	Enhances internal reporting and audit systems and ensures sustainability and ethics in mining and trading of minerals.
5	Zinc8 Energy Solutions	Blockchain to track and ensure sustainability within the zinc supply chain used for energy storage.	Ensures minerals used in renewable-energy systems originate from lawful and environmentally responsible operations, while improving transparency and efficiency.

Data were collected through interviews with stakeholders in the mining sector such as mining companies, regulators, and international organizations involved in mineral trade as well as literature studies and document analysis to obtain secondary data (Patel et al., 2025; Soe et al., 2025).

Table 2.2 Data Collection Method

No	Data Source	Data Collection Method	Description	Data Type	Purpose of Collection
1	Mining Companies	In-Depth Interviews	Interviews with managers or officials directly involved in mineral supply chains to understand	Primary (Qualitative)	Identify challenges and benefits of blockchain adoption in mining operations.

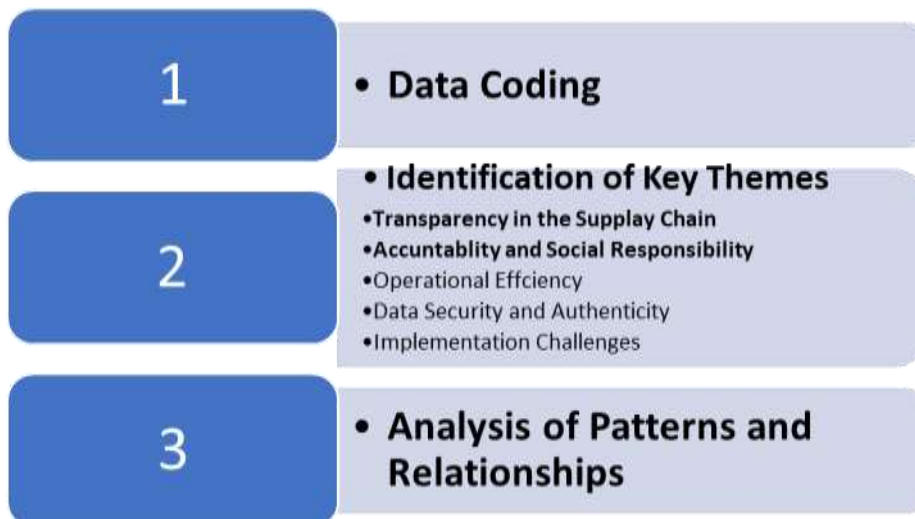
			blockchain implementation.		
2	Government Regulators	In-Depth Interviews	Interviews with regulators overseeing the mining industry to understand their views on blockchain implementation.	Primary (Qualitative)	Assess existing regulations and potential policies related to blockchain in mineral supply chains.
3	International Organizations	In-Depth Interviews	Interviews with representatives of international organizations involved in global mineral trade.	Primary (Qualitative)	Understand the role of international organizations in supporting transparency and sustainability in the mineral sector.
4	Company Reports	Literature Study	Analysis of annual and sustainability reports from mining companies that have adopted blockchain.	Secondary (Quantitative & Qualitative)	Develop an overview of blockchain implementation in the industry and its impact on transparency and accountability.
5	Journals and Scientific Articles	Literature Study	Analysis of academic articles and journals related to blockchain implementation in mineral supply chains.	Secondary (Quantitative & Qualitative)	Provide theoretical references on blockchain technology in the mining sector.
6	Government Reports Regulations	Document Analysis /	Review of regulatory documents governing the mining sector and the use of new	Secondary (Documentation)	Evaluate the legal framework governing the use of blockchain in mineral supply chains and

			technologies.		regulatory challenges.
7	Blockchain Technology Platforms	Literature Study	Review of white papers, technical reports, and case studies published by blockchain platforms for the mining sector.	Secondary (Quantitative & Qualitative)	Provide technical insights on how blockchain is applied in the mineral sector.
8	Non-Governmental Organizations (NGOs)	In-Depth Interviews	Interviews with NGOs involved in sustainability or human rights related to mineral supply chains.	Primary (Qualitative)	Assess the social and environmental impacts of mineral supply chains and how blockchain can mitigate risks.

Data Analysis

Data analysis in this study uses thematic analysis to identify patterns and themes emerging from interviews, literature, and documents. The goal is to gain deeper insights into how blockchain implementation can affect mineral supply chains and to identify the challenges and benefits arising from adoption of the technology (Bhuvaneshwari et al., 2025; Yousef et al., 2025).

Stages of Data Analysis



Data Collection Techniques

In-Depth Interviews: Conducted with stakeholders who possess deep understanding of mineral supply chains and blockchain implementation. Interviews are semi-structured, with open-ended questions to elicit in-depth perspectives. **Literature Study:** Secondary data are also drawn from scientific articles, industry reports, and documents related to blockchain in mineral supply chains (Farooq et al., 2025; Zhang et al., 2025).

RESULTS AND DISCUSSION

The results show that implementing blockchain technology in mineral supply chains has the potential to enhance transparency and accountability. Companies that have implemented blockchain report that the technology helps track mineral provenance, verify product authenticity, and ensure compliance with ethical and environmental standards throughout the supply chain (Bruzzese et al., 2025; Pongnumkul et al., 2025). For example, mining companies collaborating with blockchain platforms can verify that the minerals they procure do not originate from areas controlled by illegal armed groups or from mining practices that damage the environment.



Raw Material:

In the mining industry, raw materials are the minerals extracted from the mine. The process involves exploration and extraction of various minerals such as gold, copper, nickel, or coal (Bang et al., 2026; Ebrahimi et al., 2026).

Supplier:

After extraction, suppliers act as intermediaries between miners and processing plants, delivering raw minerals to facilities for further processing.

Factory (Processing Plant):

At the plant, raw minerals are processed and transformed into semi-finished or finished products depending on the mineral type for example, gold refining or nickel ore processing.

Distribution Center:

After processing, semi-finished or finished products are stored in distribution centers, prepared for shipment to various outlets or for export. These facilities manage inventory to ensure supply availability.

Import and Export:

Imports may occur when raw materials or components for mining processes are sourced from other countries. Exports occur when processed mineral products are shipped to international markets.

Outlet:

Outlets are the points at which end products from mining are distributed to end users for example, metal or mineral products used by the automotive, electronics, or construction industries (Abid et al., 2026; Liu et al., 2026).

Major challenges include limited technological infrastructure in some countries and the absence of clear regulations governing blockchain use in the mining sector. Many jurisdictions lack adequate regulatory frameworks for this new technology, creating legal uncertainty for companies seeking to adopt it (Irwan et al., 2025; Kumar et al., 2025).

Blockchain implementation in mineral supply chains can have significant impacts, particularly in reducing corruption and illicit trade. However, effective implementation requires strong collaboration among governments, companies, and international organizations to develop supportive regulatory frameworks (Pavithra et al., 2025; Petrillo et al., 2025).

CONCLUSION

This study concludes that implementing blockchain technology holds considerable potential to improve transparency and accountability in mineral supply chains. The technology allows every transaction within the supply chain to be recorded and monitored in real time, reducing the likelihood of data manipulation or resource theft. Blockchain can therefore play an important role in improving a sector long considered vulnerable to corruption and injustice. The main challenges are limited infrastructure in many developing countries and the lack of clear regulations concerning the technology's use in the mining sector.

The study recommends that governments and relevant stakeholders design regulations that support blockchain use in mineral supply chains. Mining companies should also be more proactive in adopting the technology to meet rising demands for transparency and sustainability. With appropriate implementation, blockchain can not only increase accountability and transparency but also contribute to building a more sustainable and responsible mining industry.

AUTHOR CONTRIBUTIONS

Look this example below:

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.

CONFLICTS OF INTEREST

The authors declare no conflict of interest

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