WHITE & CASE

Digitalising the mining & metals global supply chain: Rise of blockchain and the smart contract

Blockchain and smart contracts could deliver a much-needed productivity boost to the mining and metals global supply chain

Digitalising the mining & metals global supply chain: Rise of blockchain and the smart contract

Blockchain technology—and the smart contracts blockchain enables—is the natural next stepping stone in the evolution of the mining and metals global supply chain. On the path to smart contracting, the sector has a number of important choices to make, as **Rebecca Campbell**, partner, and **Andrzej Omietański**, associate, of global law firm White & Case, and **Kate Southwell**, Vice President-Senior Legal Counsel, of Pala Investments, explain.

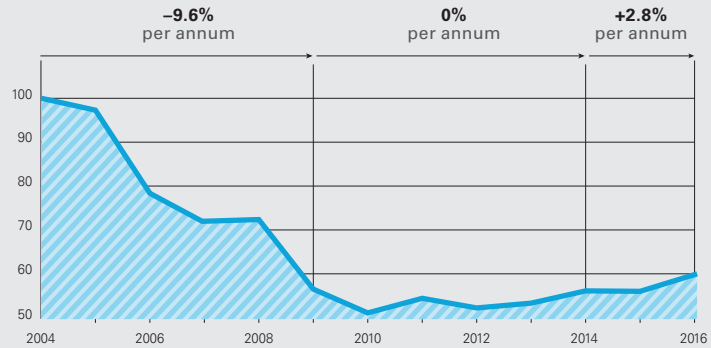
With today's pressured margins, inflationary costs and murmurs that the hard-won productivity gains of recent times may be eroding, mining companies are looking for ways to improve efficiencies. They are also seeking to demonstrate to customers and regulators that their products consistently meet technical, environmental, social and regulatory performance requirements. Blockchain technology, together with 'smart contracts' that run on blockchain, can transform many aspects of the mining and metals global supply chain. There is much to gain by adopting these evolving technologies, but a number of significant—and sometimes unexpected—hurdles stand in the way of the efficiencies and process improvements blockchain promises.

Blockchain—the basics

Distributed ledger technology (DLT) is an umbrella term to describe technologies that distribute information or records among all those using it, privately or publicly.

The recent modest recovery in mining productivity has been threatened again as demand improves and prices recover

MineLens Productivity Index (MPI) index (2004 = 100)



Source: Company reports and websites: MineLens by McKinsey; McKinsey analysis

46%

of blockchain survey respondents say they would be comfortable using a smart contract instead of a paper-based contract

Source: Deloitte

A blockchain is just one type of DLT, a sub-category of a broader definition, much like how gold falls under the umbrella term of precious metals. Blockchains are the first fully functional DLT, and the only one people have known about for close to a decade.

A blockchain is a structure for storing data in which groups of valid transactions, called blocks, form a chronological chain, with each block linked to the previous one through a cryptographic fingerprint unique to each block.

Blockchains are permanent, in that it's nearly impossible for bad actors to alter the data encoded in a blockchain if it's properly set up. They are append-only, in that old transactions cannot be changed in a properly functioning blockchain; only new transactions can be added. And they are distributed, meaning no single entity owns or controls the chain—this is particularly true for public blockchains. A network of computers maintains and secures the database, and each participant, or 'node', in the chain stores a copy. In short, certain blockchains can remove the need for an intermediary completely.

Public (permissionless) and private (permissioned) blockchains are the two most common types. Public blockchains, such as those underlying Bitcoin and Ethereum (open-source,

Examples of public vs private blockchains

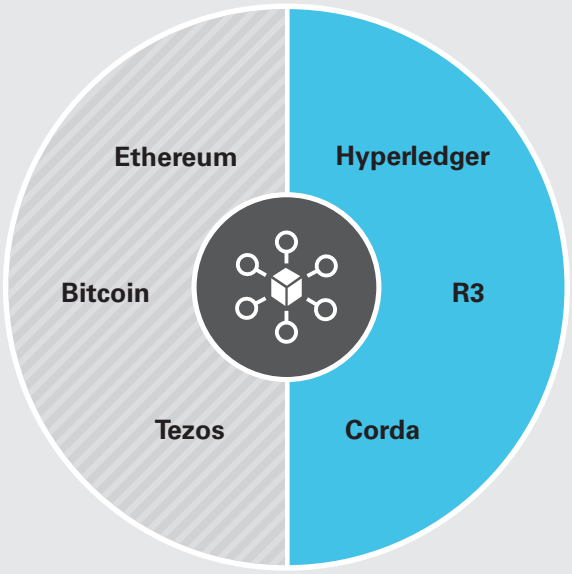
Commercial blockchains are more likely to use private, permissioned architecture

Public (Permissionless)

- Transactions are viewable by anyone
- Anyone can join, read, write and commit

Private (Permissioned)

- Only authorised participants can join, read and write



Source: White & Case

public, blockchain-based distributed computing platforms), are accessible to anyone, meaning the database and the code are public information. A public blockchain network is completely open, and anyone, without any permission, is free to join and participate in the core activities of the blockchain network. Anyone can join or leave, read, write and audit the ongoing activities on a public, permissionless, blockchain network.

A private blockchain can be set up by anyone who would like to permit entry only to select, verified participants. Private blockchains run on a shared database with a blockchain structure that requires participants to obtain permission before reading or writing to the chain.

Large organisations that would prefer to be in control of who can access their blockchain are likely to gravitate towards a private blockchain. In a private blockchain network, the organisation has the authority to initiate and change transactions, modify balances and add new blocks.

Because private blockchains afford tighter control over the ledger, larger organisations, such as large listed mining companies, will likely prefer the use of private rather than public blockchains. The choice of private over public will determine the potential applications of blockchain in the mining and metals global supply chain.

> **With everything we see that is possible with productivity … we have a very good shot at matching that inflation and more, to continue to drive our costs down**
>
> **Andrew Mackenzie, BHP CEO, August 2018**

82%

of executives in the mining industry, surveyed by Accenture in 2016, expect to increase investments in digital technology over the next three years

Source: Accenture

Smart contracts

A key selling point of blockchains and the potential they may have for the mining and metals global supply chain is the ability to run 'smart contracts' on them. A smart contract is a computer program stored in a blockchain that automatically moves digital assets between accounts when conditions encoded in the program are met. Smart contracts serve as a way to create a mathematically guaranteed promise between two parties if certain specific conditions are met; for example, if US$100 is transferred to Party A, then Party B is guaranteed to receive X if the conditional requirements add up.

There is no legal definition or meaning to the term 'smart contract', but if the code and the intentions of the parties satisfy the legal requirements, the smart contract itself may create legally binding and enforceable obligations. One of the major advantages of blockchains is the potential for simplicity and trust in transactions; smart contracts present a way to realise this potential.

So far, smart contracts have seen their popularity explode given they

are one of the underlying tools used for raising capital through initial coin offerings (ICOs). In 2017, more than US$5 billion was raised by ICOs. ICOs are a fundraising mechanism by which projects sell crypto-based tokens in exchange for fiat (i.e., government-issued) money and/or cryptocurrencies, typically Bitcoin or Ethereum.

ICOs could be used to raise significant amounts of capital for junior, mid-cap and large miners. The difficulty is that unlike the regulated equity markets where the valuation of a company should be linked to the economics of a mining deposit, these tokens are typically illiquid and often not linked to something of intrinsic value (such as the issuer's ownership of metal) to protect the investor. In some examples, such as the recent ICO 'gold token' issuances, the tokens did not provide any ownership link to the underlying gold in the ground or enable the holder to convert the token into physical metal. ICOs have not been formally defined as securities offerings and are not yet regulated, but they have already attracted attention from the SEC and various other regulators. Smart contracts can be used for far more than just raising capital.

Smart contracts, with their self-executing automatism and ease of replication, can create significant efficiencies for global procurement and marketing teams and help ensure regulatory compliance in real time through the use of clear business rules and an automated structure. At present their use is fragmented across compliance (such as KYC verification), trading platforms and risk management, but some procurement and marketing teams of major mining companies are using smart contracts already.

Moving contracts onto a blockchain will not in itself prevent disputes, but it may help arrive at a mathematically certain set of facts, which could be used to prove a chain of events with a high degree of certainty in the event of a later dispute. If certain conditions—such as the assay of material—can be proven objectively, the obligation to make payment and the payment itself would be automatic. More difficulty will come when any set of circumstances requires a subjective or external view (such as 'acting reasonably') or the intervention of additional 'off-blockchain' facts (such as force majeure events).

Blockchain benefits for the mining and metals global supply chain

Blockchain's role in sustainable and transparent supply chains could be a game-changer, thanks to its ability to promote trackability, transparency and security through open, peer-to-peer and incorruptible data sharing. Blockchains might be the gateway to a new era offering the tools to monitor and confirm compliance with sustainability and environmental and ethical standards.

By recording information flows throughout both the mining and commercial functions on a blockchain platform, mining and metals sector participants, from producer to end-user, will be able to track title, as well as technical, environmental, social and regulatory attributes, through their global supply chains, from first shovel to final refined product. This will enable identification of the drivers to value creation (including quality and efficiency of production) and recoding all transactions in a consolidated and accessible form. For example, digitising individual mined parcels of ore as assets that can be traded on a blockchain platform could open new investing and trading opportunities by enabling individuals to participate in previously closed negotiations, and tailor their purchases to the precise product grades that are currently available in the market.

Inevitably some regulators and tax authorities see the blockchain evolution as an opportunity to monitor activity to ensure regulatory compliance and generate revenues from taxation. But in an environment where end-users too (for example, Apple and OEMs for their battery minerals procurement) are increasingly demanding that their suppliers demonstrate compliance with robust technical and regulatory performance standards, blockchain applications can enable miners to efficiently demonstrate this to regulators and customers in real time.

US$190bn

Digital technology has the potential to help the mining industry generate additional US$190 billion over the next decade

Source: WEF, 'Digital Transformation Initiative: Mining and Metals Industry'

Empowering miners to trade more directly with customers has potentially profound implications for trading houses, although so far the various digital platforms do not seem to have had major impacts on the role of the trading houses in the global supply chain. Online trading platforms such as Trade Cloud already exist, but these are largely limited to spot trades and, at present, a producer would likely not risk tying up substantial long-term offtake on an unproven platform or with an unknown counterpart.

Mining and metals companies are already following the lead of manufacturing and industrial giants such as Unilever, Nestlé and Dole in tracking products. BHP Billiton is already using blockchain with its vendors, including recording movements of wellbore rock and fluid samples and securing real-time data generated during production, De Beers is using this technology to track diamonds, and Barrick has committed to invest US$75 million in 2018 in digital systems that aim to reduce operating costs and increase productivity.

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The rub: challenges to adoption

Amidst the blockchain hype, a number of significant hurdles come into view between how the mining and metals global supply chain operates today and the promise of a blockchain-empowered future.

Will smart contracts be drafted by lawyers or coders? Will computer programmers need to learn the law, or will lawyers need to learn how to code (or both?). The development of an industry standard 'language' and form of smart contracts (and specification of exactly who will draft them) will be key to ensuring a smooth and progressive adoption of this new technology in mining and metals, where the legal languages and standard-form legal contracts are well established.

Can computer code that enshrines a smart contract create binding and enforceable obligations as a matter of law? While some academic research has been conducted on this question, there are scant actual examples of the determination of the legal status of these contracts, because their use is not yet widespread in documenting legally binding contractual obligations. Smart contracts are not a tried and tested technology, but in theory, if the conditions to create a legally binding contract are met, a smart contract can substitute for a written one.

How will judges resolve disputes? Will they have to understand the programming code of the smart contract, and know how a blockchain platform on which the disputed smart contract works? Which judge will resolve the dispute if no legal forum is chosen by the parties? Will disputes be determined by the platform's or smart contract's developers instead of judges, in particular if the ledger platform fails or there are bugs in the code underpinning the contract? Is it the law of code versus the law of the contract? Building in governing law and jurisdiction provisions through code into the smart contracts, and creating mechanisms for developers to resolve bug/ledger failure disputes, would be key in ensuring smart contracts benefit from established legal oversight and the technical expertise of the relevant developers to resolve code-specific (but not contract-specific) disputes.

Tokenising mining and metals assets on a blockchain generates distinct legal ownership issues. For example, when one purchases, through an ICO, a gold token giving one a right to 1 percent of the total gold reserves of a specific mine area, how can one be certain that one owns these rights through the token? Nearly all jurisdictions have different mining and metals ownership/rights laws, and an entitlement to ownership may necessitate a direct relationship with the relevant mining authority to be granted any mining right. Will a token be registered with the relevant mining authority? The mining authorities would need to realign their systems to cater to the digitisation of physical assets on blockchains. Anything that is tethered to legal reality on the blockchain requires a system of legal realignment.

A public blockchain would enable all participants on the ledger to see each transaction. In theory there can be no interference with a blockchain, or indeed with the terms of an agreed smart contract. However, there are security risks related to hacking and '51 percent' attacks of blockchains or to individual keys to allow users to decrypt their assets, even if the blockchain protocol itself remains secure.

ICOs are already subject to regulatory uncertainty. The wider investment community may be slower to embrace this new digitised method of raising capital until regulations (in particular whether certain tokens are treated as securities or not) have been clearly defined—and mining and metals companies already have a high burden in terms of regulatory compliance and investor scrutiny.

90%

More than 90% of respondents of *Mining Journal*'s 2018 Transformation survey said preparing for transformation was either 'Very Important' or 'Becoming Increasingly Important'.

Sources: *Mining Journal* 2018 Transformation Survey

The mining & metals sector is already characterised by strong adoption of automation in the search for productivity

	Explore/ Acquire	Mine dev.	Mine	Logistics	Sales & mktg.
Robotics + automation (mobile and fixed assets)*	42%	47%	54%	33%	24%
Advanced process control	22%	31%	37%	23%	17%
Drones/UAVs	32%	30%	41%	19%	11%
Remote operating centres	30%	29%	41%	22%	17%
Mobile/tablet use	35%	36%	31%	37%	36%
Wearables	32%	37%	41%	23%	25%
Integrated planning	33%	32%	28%	29%	27%
Digital platforms (cloud, etc.)	28%	25%	27%	36%	39%
Real-time visualisation of data	36%	28%	35%	27%	23%
Real-time analytics	33%	28%	38%	29%	23%
Predictive/machine learning analytics	34%	29%	29%	24%	15%
Video analytics	39%	29%	33%	17%	17%
Image analytics	32%	34%	37%	21%	16%
Virtual simulation of physical environment	37%	40%	39%	19%	15%
Artificial intellegence and cognitive computing	32%	32%	27%	25%	20%
Social media	23%	24%	22%	29%	47%
Cybersecurity	34%	32%	26%	38%	33%
3d printing	38%	27%	26%	26%	16%

10-19% 20-29% 30-39% 40-49% 50-59%

* Robotics + automation (mobile and fixed assets): Refer to those instances where respondents have/plan to employ Robotics and/or automation in each respective mining activity.

Source: Accenture

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Mining companies and trading houses are not willing to give up control of their contracting or procurement process lightly, because it means a loss of control, and in some cases, disclosure of sensitive commercial terms. The benefits of the smart contracts can only be realised if one of the market leaders adopts the technology and forces others to react, and the R&D spend on deploying such technology is significant.

The initial applications for blockchain-based platforms are likely to be focused on precious metals and global trading exchanges. Complex commodities (i.e., base metal concentrates) with specialist (human) traders and market makers may be less motivated to digitise their process.

The potential that blockchain offers in terms of traceability means the incorporation in supply chains is almost inevitable. But the technology will not eradicate scarcity and sustainability issues around the sourcing of metal, for example, from the Democratic Republic of the Congo.

Finally, transactions can take a long time to be validated and added to the blockchain, and a blockchain's energy usage is enormous when 'proof-of-work' as a consensus mechanism is used. From a sustainability perspective, at the moment, mining and metals companies will need to justify these energy costs.

It's a question of when, not if

The potential for blockchain and smart contracts in the mining and metals global supply chain is immense and in our view, adoption is inevitable. Other sectors (such as real estate) may view the arrival of blockchain and smart contracts as revolutionary. For our sector, which by its nature is already truly global, characterised by global trading hubs, relatively homogenous global trading norms and a strong ethos of adoption of automation in the search for productivity (e.g., driverless trucks and trains), we see the change as largely evolutionary.

Ten years from now, will OEMs buy their cobalt via blockchain and smart contracts? Given the advantages of digitalising contracts and the rise of DLT in multiple industries, the answer seems to be a resounding 'Yes'. It's a case of when and how, rather than if.

> **The potential for blockchain and smart contracts in the mining & metals global supply chain is immense and adoption is inevitable**

But will the OEM buy the cobalt through a private blockchain controlled by a large metals trading house using a negotiated smart contract, or will it buy directly from the miner through a public blockchain rather than a conventional trader? This is one of many questions that cannot be answered until blockchains begin to see significant penetration into the mining and metals global supply chain.

Look out for our next article in our series on blockchain applications for the minerals supply chain **Digitalising the mining & metals global supply chain: bringing sustainability to the forefront?**

Sample ‘simple interest’ smart contract

The code is based on Solidity (a contract-oriented programming language for writing smart contracts. It is used for implementing smart contracts on various blockchain platforms, including on Ethereum). Is this how legal contracts will look in the future?

```
pragma solidity 0.4.18;
import "./SimpleInterestTermsContract.sol";
import "../ERC721Collateralizer.sol";
contract ERC721CollateralizedSimpleInterestTermsContract is SimpleInterestTermsContract {
    ERC721Collateralizer public erc721Collateralizer;
    function ERC721CollateralizedSimpleInterestTermsContract(
        address _contractRegistry,
        address _erc721Collateralizer
    ) public SimpleInterestTermsContract(_contractRegistry) {
        erc721Collateralizer = ERC721Collateralizer(_erc721Collateralizer);
    }

    function registerTermStart(
        bytes32 agreementId,
        address debtor
    )
        public
        onlyDebtKernel
        returns (bool _success)
    {
        bool registered = super.registerTermStart(agreementId, debtor);
        bool collateralized = erc721Collateralizer.collateralize(agreementId, debtor);
        return registered && collateralized;
    }

    function getTermEndTimestamp(
        bytes32 _agreementId
    )
        public
        view
        returns (uint)
    {
    SimpleInterestParams memory params = unpackParamsForAgreementID(_agreementId);

        return params.termEndUnixTimestamp;
    }
}
```

Source: White & Case, DharmaLabsInc

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