

## Global Impact Venturing

# The future of mining

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> **Cost drives miners and suppliers to open innovation**

> **Oil and gas peer group for venturing techniques**

> **Digitisation opens up potential new challengers**

**It is an irony that as the world moves to cleaner sources of energy it is increasingly reliant on one of the most challenging industries for the commodities.**

As the global economy switches to low-carbon technologies to combat global heating, demand for minerals, such as cobalt, copper, lithium, manganese, nickel and zinc – six essential to the renewable energy industry, could rise by as much as 900% by 2050, according to World Bank estimates.

And in digging out the minerals, miners are increasing their own demand for energy, as well as affecting other natural resources, such as water, and social and environmental conditions for communities.

A report last December by the Columbia Center on Sustainable Investment (CCSI) said the mining sector could account for anything between 1.25% and 11% of total global energy demand, depending on which downstream activities are included. The study estimated mining sector energy consumption could increase by 36% by 2035, as demand for minerals grows and remaining ores become more difficult to extract.

For most of the last century, the industry has responded to the challenges of ageing mines and declining ore grades by digging deeper and crushing more rocks. Now it is turning to open innovation and more exploratory fields to meet demand while controlling costs.

This openness has come not a moment too soon. After a near three-quarters drop in industry valuations between 2011 and 2016 due to falling commodity prices, valuations have improved with demand but it now takes double the amount of water and 15 times the amount of power to produce 40kg of

copper than in 1900, according to mining company Anglo American as it prepares to open Quellaveco as “one of the last, if not the last [open cast] mine of this size and scale,” said Tom McCulley, head of Anglo American in Peru, in an interview with the Financial Times last month.

Anglo is looking for the Quellaveco pit to last into the next century as copper, an efficient electrical conductor, will be increasingly in demand as more solar panels and wind farms are connected to the grid and the use of electric vehicles (EVs) grows.

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Andre Joffily

EVs are expected to contain four times as much copper as combustion-powered vehicles and analysts said the copper market slipped from a surplus into a deficit last year.

The other commodities behind the renewable energy and electrification boom are also in vogue.

Andre Joffily, mining leader at consultancy Deloitte Brazil, in its annual report, Tracking the trends 2018: The top 10 issues shaping mining in the year ahead, said: “Looking back just 20 years, it would have been inconceivable to imagine that nickel, lithium, cobalt, and graphite would be powering batteries. If mining companies want to get ahead of the trends likely to emerge 20 years from now, they truly need to delve deeply into emerging market disruptors.”

This thinking seems in part to be behind Rio Tinto forming Exploration and

Ventures units last year, nearly 150 years after its formation from the eponymous river in Spain in 1873.

At the launch of Rio Tinto Ventures under Kevin Fox in August 2018, the company said: “There is some excellent work being done by the likes of the Massachusetts Institute of Technology that may guide us in this regard, looking at key new technologies that will influence future metal demand.”

In terms of project characteristics, the company added: “Rio Tinto Exploration covers the earlier stages of discovery and evaluation, while the Ventures interest will begin when projects reach feasibility and beyond.

“The majority of our investments are expected to be upstream in mining and the first stages of processing and refining, but we will be open to considering related businesses where there is a clear value proposition and, most likely industrial logic and synergies with our existing businesses [covering Rio Tinto iron ore, aluminium, copper and diamonds, and energy and minerals].”

This move seems to confirm the view of Rajeev Chopra, global leader for energy and resources at consultants Deloitte Touche Tohmatsu, in its annual report that “miners have finally realised that they cannot be islands unto themselves.

“To effect lasting change, they must partner with each other to reduce project risk, collaborate with external vendors to reconceive how they operate, work more closely with governments to help inform policy, and strengthen relationships with local community stakeholders.”

Of the larger miners, however, Anglo has probably moved furthest down this path to develop a broader business model under the marketing division. In its 2018 annual report, Anglo said: “Our Marketing model maximises value from our resources and value chain positions.



We do this by seeking to fully understand and address our customers' specific needs and through optimising our capabilities in the financial and physical markets to drive the right commercial decisions across the value chain – from mine to market."

In July last year, Anglo's corporate venturing unit, Platinum Group Metals (PGMs) Investment Program, was spun out to independent management with the formation of the AP Ventures fund. Anglo said: "Having enjoyed success and a strong track record while being managed by Marketing, we separated the fund in order to attract additional outside investment and allow AP Ventures to increase the scale of its activities to support the growth of PGM technologies and PGM demand," in particular, the work to support the commercialisation of fuel cell electric vehicles and related hydrogen technology.

In copper, Anglo sold only own-produced metal until 2015. More recently, third-party and traded metal represented about 30% of Marketing's copper

sales volumes in 2018, with bespoke logistics and price-risk management for customers using the derivatives market. "This results in higher margins for Anglo American's products, supporting both EBITDA [earnings before interest, tax, depreciation and amortisation] growth and better risk management."

Also from its 2018 annual report, Anglo said it wanted \$3bn to \$4bn in annual group EBITDA run-rate improvement by 2022, relative to 2017. This would come through its Marketing initiatives and its data analytics and innovation programme to forecast machine failures and mine ores.

### Smart shovels

Corporate venturers in the mining industry pointed to the success between Canada-based Teck Resources and MineSense's for so-called smart shovels where sensors are mounted on the shovel bucket and use x-rays to tell the difference between waste rock and valuable ore, one shovel load at a time.

Teck partnered Canada-based MineSense for the first full-scale trial

of the bucket-mounted ShovelSense technology in 2017 and Bryan Rairdan, technical services manager at Teck's Highland Valley Copper Operations where it is being used, said: "This technology helps us to use less energy, create fewer emissions and improve productivity. In fact, smart shovels have the potential to create hundreds of millions of dollars in value."

Equipment maker Caterpillar is an investor in MineSense, alongside specialist venture capital firms, including Chrysalix, which has a number of mining companies as limited partners in its latest fund.

Vendors and service providers, such as Caterpillar, Mitsubishi (which also owns stakes in about 30 mines), ABB, Siemens and Komatsu, have traditionally taken the lead in working with startups through their corporate venturing units and buying them.

Caterpillar and Komatsu, for example, have bought dispatch systems by buying startups Modular Mining and Venco.

Mike Mahan, managing director of Stanley Ventures, the corporate venturing unit of equipment maker Stanley Black & Decker, said: "While industries like mining, infrastructure

### How mining can learn from other industries: capitalise on the venture capital model

*Charlie Haythornthwaite, managing director at Chrysalix Venture Capital, said experiences from industries with deeper innovation history, point to a successful formula that leverages technology startups.*

As mining seeks to build its innovation muscle and find a path to best practice, it is worth observing other resource-intensive industries, such as oil and gas, electric utilities and chemicals that have been evolving their innovation programs for longer. How have they identified and accessed startup innovation?

For instance, virtually every oil and gas major possesses its own corporate VC fund or has invested in independent VC funds to achieve similar results. Acting through self-interest, the intent is to nurture a healthy ecosystem of risk capital and entrepreneurs tackling the problems that matter to them. Capital is heavily leveraged by other financial and corporate investors. Most importantly, the venture model attracts the best ideas to them,

enabling them to scan for best-in-class solutions.

It is notable that sophisticated industrial players use venturing to create competitive advantage quite differently from the traditional closed model of internal R&D. The strategy typically comprises:

- Prioritising and openly publicising pain points and opportunity areas
- Positioning their company as startup-friendly and a partner of choice to attract the best ideas to them
- Leveraging others' expertise and capital to support early-stage startups
- Building core competency in evaluating and piloting the most attractive solutions while managing risk
- Rolling out the successes across their operation

The new mantra is: "Think big, test small, scale fast!" It is about defining big wins while managing uncertainty along the way. Mining is already very familiar with this portfolio approach to creating optionality and staged risk reduction – it is the mirror image of exploration.

and construction would like to have fully-autonomous machinery onsite, the reality is that kind of transition will likely take place in phases. That is why Stanley Ventures invested in Fort Robotics – a startup that sells remote control kits for heavy machinery. As opposed to letting a computer entirely take over your site and vehicles, Fort Robotics enables a step change in process by taking the worker out of the cab and allowing them to drive machines with an easy to use remote control system. This provides the benefits of autonomy, like efficiencies and less headcount required for jobs, without introducing safety issues and costly unknown accidents attributed to fully autonomous solutions.”

Michael Young, head of Caterpillar Ventures, said: “Mining is leading the world in autonomy. We have hundreds of trucks at level 5 autonomy and have been adding additional equipment to the system.

*“Mining is all about calculated risk, but my experience was a slow implementation of new technology”*

**Ben Wright**

“On the mining side, efficiency is the name of the game now (versus more production at any cost). This is driving the investment into the sector.

“Service providers have been active in developing pilots but we will see more adoption if majors, such as BHP Group, Rio Tinto and Anglo American, are more aggressive but the industry takes a much longer time than oil and gas majors, which is not lightning fast.

“Still, credit that majors are interested and running pilots, such as our investment in Guardhat, which also has

3M as investors. Caterpillar has been investing almost five years and want financial returns but do this for strategic reasons to help our business units.”

Ben Wright, head of 3M New Ventures, said: “We have invested in mining companies in the past, but it is no longer a focus. We do have a large personal safety business that does sell into the mining industry.

“We invest in companies strategically aligned to 3M, so mining aligns to several of our internal businesses. The companies we invested in the past were aligned to specific divisions’ strategies.

“Key learnings include long development cycle and difficulty securing pilots. Mining is all about calculated risk, but my experience was a slow implementation of new technology. I do not know if that was specific to the investments we had, or if it is an industry norm.”

However, while the pace is still relatively slow there are potential tectonic shifts in the industry, including following Anglo’s progress around what is effectively mining-as-a-service (MaaS).

Ippei Akiyoshi, manager of corporate venture capital in the mineral resources group at Mitsubishi, a Japan-based manufacturing and trading conglomerate and minority partner in the Quellaveco mine, said: “I am intensively working on MaaS project internally and externally.

“The idea came from the question: Why engineering companies in the mining industry are with low margin, not in charge of innovation and so different from the ones in oil and gas?

“I am working on how we can make a difference on this with corporate venturing regarding the increasing partnership between mining corporates and VCs looking for innovation.

“We, as a corporate, expect VCs to give us more access to novel technologies



owned by startups and help us find the ideal way of collaboration.

“Tier 1 mining corporates used to be sceptical on the importance of open innovation. However, I do see the changes in their attitude.”

George Gogolev, head of Severstal Ventures, the corporate venturing unit of the Russia-based conglomerate with steel foundries at its core and in its first direct deal backed alloys company Arcanum Alloys, said: “We are seeing moves to mining-as-a-service as an innovative business model. Can you hold a licence and let others extract with competing technology? Oil and gas service companies have such huge margins because they have unique technology. Mining has not had that.”

Deloitte in its annual report confirmed this. It said: “With slowing global mine supply growth and a shortage of world-class deposits in key commodities like copper and gold, innovative exploration strategies are needed. One option is undersea or deep-sea mining, prospecting for minerals on the ocean floor. According to the World Economic Forum, the world’s undersea reserves include 10 billion tonnes of polymetallic nodules. Despite the resource potential, deep-sea extraction is very challenging. Yet, technical advances are making it more commercially viable. Deep-sea robots, used extensively by the offshore oil and gas industry, are being used in undersea mining. Innovations in surveying technology may also allow miners to better locate and identify undersea ore bodies.”

There remain, however, issues around capital and exits. The industry dipped its toe into corporate venturing a decade ago just around the start of the global financial crisis with integrated metals and mining company ArcelorMittal setting up a €100m carbon fund and a separate Clean Technology Venture Capital Fund that invested in Miasolé in its first deal.

But with few notable successes and the cratering of valuations, few others followed.

Peter Bryant, managing partner at Clareo, said: “Mining remains the only significant industry to not lean into corporate venturing in a significant way, which is a gap given the dearth of VC [venture capital] money available to startups focused on the mining industry. This just amplifies the persistent under investment in innovation.



“The result is that a lot of great innovation is either stranded in research organisations or within perpetually small companies that can never raise funds to fund growth and further development of a scale required.

“There are now glimmers of hope in AP Ventures and Chrysalix’s fourth fund, RoboValley, which targets strategics as LPs [limited partners].

“Autonomy may spur VC investment in mining-focused startups. For example, SafeAI, a Silicon Valley-based company focused on autonomy solutions for mining and construction, is funded by some of the leading autonomy VCs, such as AutoTech Ventures.”

And while some vendors have bought startups and private equity firms eyed up assets the biggest move by a major was Brazil-based major Vale acquiring local startup New Steel last year for \$500m.

New Steel, which owns patents in 56



### Infinity of minerals nearly within reach

Since 2000, more than \$13bn has been invested in space-related businesses that extend far beyond established industries like satellites and launchers. In fact, space may ultimately support a commercial market worth over \$37bn, comprised of opportunities such as manufacturing (the low-gravity environment can deliver significant productivity improvements), space tourism and exploration support, according to consultants Deloitte, which added: "Although asteroid mining still sounds like science fiction, companies like Planetary Resources are looking to mine asteroids.

"The market potential could be huge, one asteroid (16 Psyche) is made up almost entirely of iron, nickel, and rare metals like gold, platinum, copper, cobalt, iridium, and rhenium.

"Planetary Resources is a privately-owned US company financed by

a number of industry-launching visionaries who see the mining of space resources as a potential trillion dollar opportunity. They are particularly focused on near-earth asteroids (NEAs), which are easiest to access and are estimated to contain over 42 trillion tons of resources. NEAs represent a potential mineral resource at least 50 times larger than the earth's entire iron ore reserve. Planetary Resources has successfully launched two spacecraft into, demonstrated its technology in Earthbound mining operations, and is aiming to launch the first commercial Space Resource Exploration Mission by 2020."

Caterpillar is working with NASA to build autonomous machines that could excavate and mine the lunar surface for raw materials to use for its planned lunar outpost, while China has already explored the rocks on the far side of the moon and startups, including Virgin Galactic, Blue Origin and SpaceX, are looking at space as their final frontier.

countries for its dry processing method of iron ore, had received a reported \$70m investment from Hankoe FIP investment fund managed by Leonardo Szczerb, partner at Lorinvest, an asset manager for the Lorentzen Group.

Vale had used New Steel's Fines Dry Magnetic Separation process in its plant but as pilots can take a long time and be capital-intensive, Lorinvest's majority investment between 2012 and 2013 was effective.

Miners have rarely invested to provide this as equity upfront but Vale is among the South America-based miners to explore corporate venturing after hiring Alexandre Augusto Mosquim from cement maker Votorantim Cimentos in February. Before the Corporate Venture in Brasil conference last month, Mosquim said he had joined Vale because of its appetite for innovation.

Similar explorations are being made for other minerals in the region, especially as 70% of the world's known lithium reserves are in Argentina, Bolivia, and Chile, the so-called lithium triangle.

Chile-based copper miner Corporación Nacional del Cobre de Chile (Codelco) under its chief innovation officer, Sebastián Carmona Caldera, has started to explore open innovation to develop its copper reserves, as well as cobalt, an offshoot from copper production.

Carmona said Codelco has joined the mining group organised by Chile-based open innovation and venture network Innova360, while other miners are exploring similar networks for hackathons and to meet entrepreneurs. Komatsu was part of the Transform Mining hackathon in Australia last year, while Chrysalix's global challenge in Canada looked at how to break up or tear apart ore rather than crush or mill it and 2017, Barrick held the Unearthed Toronto hackathon and then partnered with the winner, Koan Analytics.

At the time of the Komatsu Transform Mining hackathon, Ryoichi Togashi, general manager at Komatsu, said: "Innovation is created by a sense of crisis as a driving force. Mining sites are in a very harsh environment and both people and machinery have to keep fighting against the severe environment 24-7. Through hackathons with outside members who are familiar with mining sites, customers and advanced technologies, we greatly expect results that cannot be achieved by in-house development."



OCP, a Morocco state-owned mining company digging out phosphate for fertiliser, said it had set up a strategy team in Brazil and the US in the past year with an aim to understand less about mining efficiency than exploring consumer demand as Africa has one-twentieth of fertiliser use than Brazil. The company has also set up the MAD200m OCP Innovation Fund For Agriculture as a private equity fund managed by Upline Group Generalist Fund.

Controlling costs and boosting demand are behind much of the core reasons behind corporate venturing programs but in mining, the ambitions can go further than in most sectors.

But by opening up a traditional industry to digitisation could create opportunities for third-party disruptors to join. Deloitte asked: could "a company like Amazon buy into the mining sector with the aim to uncover hidden opportunity?"



“The idea may not be as far-fetched as it seems, particularly as the line between mining companies and technology companies blurs. As the digital mine becomes a reality – and mining companies increasingly embrace artificial intelligence, advanced data analytics, drones, autonomous machines and cognitive computing, technology companies could move up the value chain in search of the uniquely high margins that can be generated from owning, extracting and

marketing minerals and metals.”

Something similar has already happened in other minerals. As the Financial Times noted with luxury goods maker LVMH’s takeover offer for Tiffany’s, “from being a fragmented industry with only a few brands of any size, controlled by miners in the De Beers cartel, it is steadily becoming a luxury business similar to fashion. Its core technology is increasingly digital marketing, rather than diamond mining.”

### **Anglo American’s data platform underpins mine of the future strategy**

Barro Alto, Anglo American’s nickel mine and processing plant located in Brazil, has two rotary kilns and two electric furnaces that smelt nickel ore, and the company is looking at predictive maintenance efforts on key pieces of high-power equipment. In its annual report, Anglo said: “By building a comprehensive data platform that monitors 38 major elements of the Barro Alto operation, we are increasing our knowledge of the performance of the equipment and we are using data to accurately forecast failures before they happen. Soon, we will be able to dynamically manage maintenance intervals – only replacing parts when required, thereby ensuring greater operational uptime and product throughput. The implementation is expected to improve furnace reliability, as well as realise cost savings for the nickel business.

“The learnings from Barro Alto are also being applied to fixed-plant assets in other operations. This nascent project is on track to deliver considerable value from just one data analytics application. Data analytics augments the intelligence in our people by

helping them make better, confident data-driven decisions. Remote monitoring of assets takes people away from physical equipment and helps avoid high-energy failures, which leads to a safer working environment. Reducing unplanned equipment failures can also bring significant environmental benefits owing to the reduced likelihood of spillages. We plan to extend the reach of data analytics to all aspects of our value chain and extend operational decision support to the mining and processing phases of our assets.”

This fits with extraction and processing improvements. Anglo’s Concentrate the Mine integrates three enabling technologies – advanced fragmentation (its shock break technology uses less than 50% of current energy requirements, while also improving recovery rates), bulk sorting increases mineral output and upgrades ores, as well as simplifying the mining process and coarse particle recovery raising throughput, reducing the water required for processing (80% recovery rates targeted) and delivering dry stackable waste – to precisely target the metal and mineral, with less waste, water and energy.

Anglo’s The Waterless Mine strategy is based on more than 70% of its

operations being located in water-stressed areas where conservation is critical. "As we work towards developing waterless mines in water-scarce regions, we are focused on innovative approaches to the separation and transportation of ore and waste, evaporation measurement, dry-tailings disposal and waterless processing."

Anglo's The Modern Mine theme has been built on the fact that mineral resources have become ever more difficult to access at depth. "Automated and continuous rock-cutting vehicles safely extract the targeted ore deep underground without the need for explosive blasting. Such innovations make it possible to mine lower grade ores and complex mineralogy, creating a safer environment and lower operating costs, while enhancing the value of the mineral resource."

Altogether, Anglo's FutureSmart Mining program "is a different way of thinking that is beginning to transform

the nature and experience of mining and how we can make a positive difference to improve people's lives.

"In terms of the physical activities of mining and processing ore, our aim is to more precisely target the metal or mineral, with radically less waste rock, lower water and energy intensity and, ultimately, a much-reduced physical footprint.

"These are step-change technologies that we believe hold the key to the future of mining. Our far-reaching Sustainable Mining Plan, launched in 2018 as part of FutureSmart Mining, commits us to a series of ambitious medium- and longer-term goals. These relate to three major areas of sustainability aligned to the UN's Sustainable Development Goals: trusted corporate leader (i.e. advocating for the highest standards of governance to drive transparency and trust in mining and mined products); healthy environment; and thriving communities."