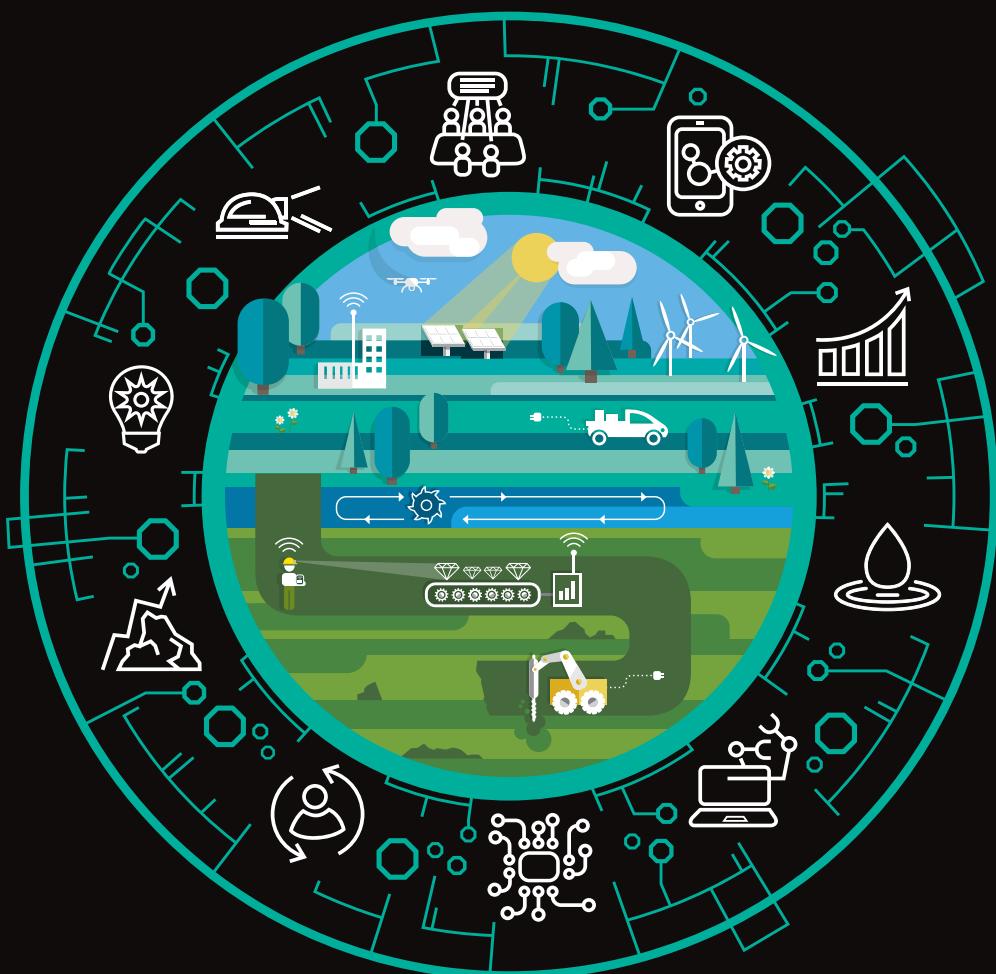


Deloitte.



Tracking the trends 2018

The top 10 issues shaping mining in the year ahead

Contents

Changing for the better	03
1. Bringing digital to life	04
2. Overcoming innovation barriers	10
3. The future of work	16
4. The image of mining	22
5. Transforming stakeholder relationships	28
6. Water management	34
7. Changing shareholder expectations	40
8. Reserve replacement woes	46
9. Realigning mining boards	52
10. Commodities of the future	56
Out with the old, in with the new	63
Harnessing the winds of change	

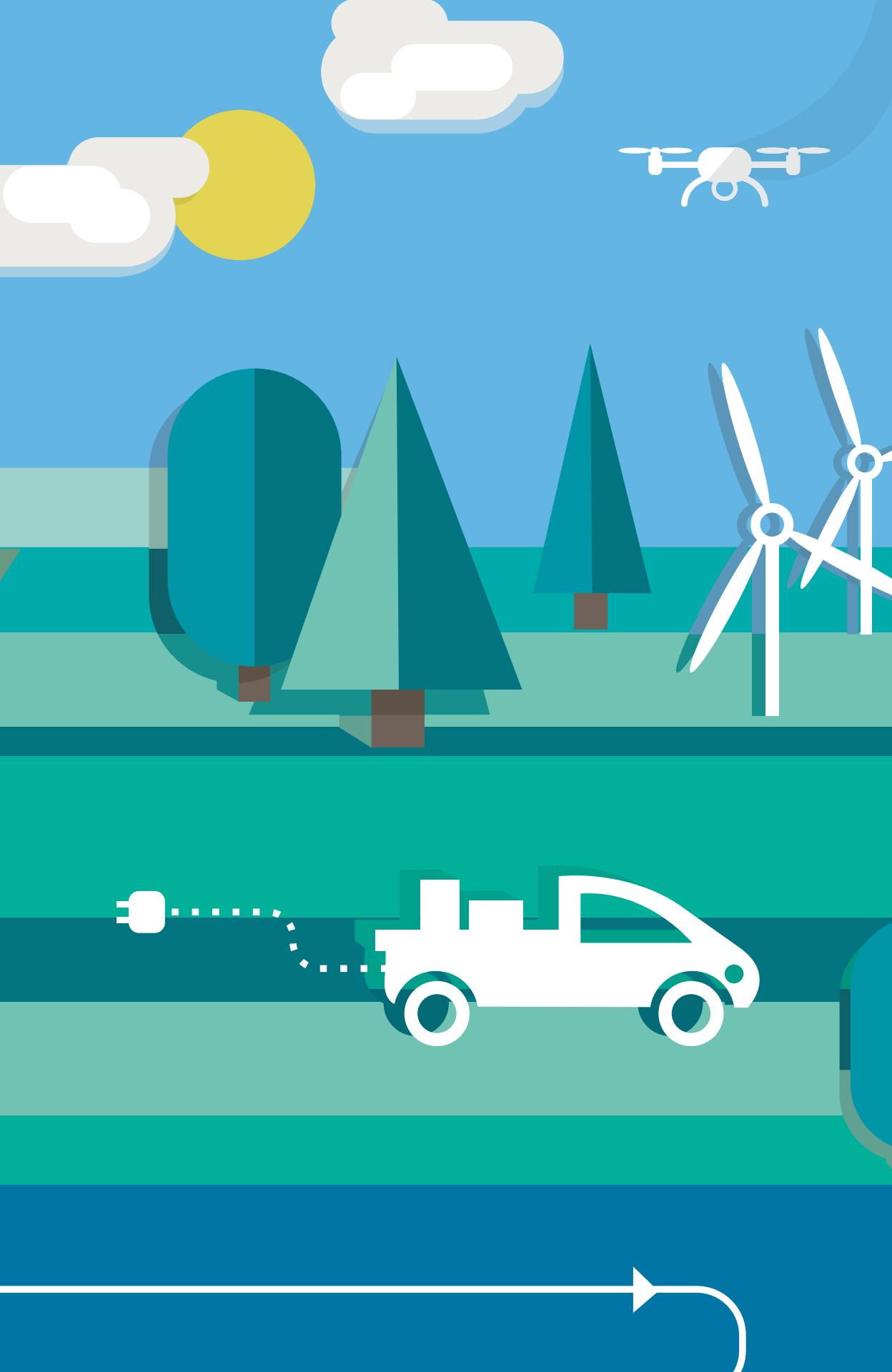


"The last 10 years have seen the rollercoaster of highs and lows in the mining sector continue. During this time, we have seen an emergence of innovative companies adopting transformative practices. As we now stand in the middle of what appears to be another bull run for some commodities, the next 10 years will see the continuation of rapid change in the industry against a backdrop of declining ore body grades, decreasing availability of tier one assets, and continued focus on shareholder returns. To thrive amid this volatility, companies must rethink the traditional mining model. Change is coming and mining companies must find ways to remain relevant."

Philip Hopwood

Global Leader – Mining

Deloitte Touche Tohmatsu Limited



Changing for the better

This 2018 edition of *Tracking the trends* heralds a milestone, marking our tenth year of publication. Over the past decade, commodity prices reached both historic highs and historic lows, mining companies engaged in both significant acquisitions and consolidation, and operational realities shifted irrevocably in the face of a digital revolution. For an industry considered staid, change has been surprisingly constant.

That theme holds true over the past year as well. After hitting the bottom of the cycle, prices for many commodities have been slowly recovering, driven by Chinese government stimulus and improved demand in both developed and emerging economies. Coupled with the industry's commitment

to strengthen balance sheet performance, reduce debt, exercise capital discipline, and simplify portfolios, this has resulted in improved valuation metrics, record free cash flow, and stronger shareholder returns. In many respects, the mining sector is once again poised for growth.

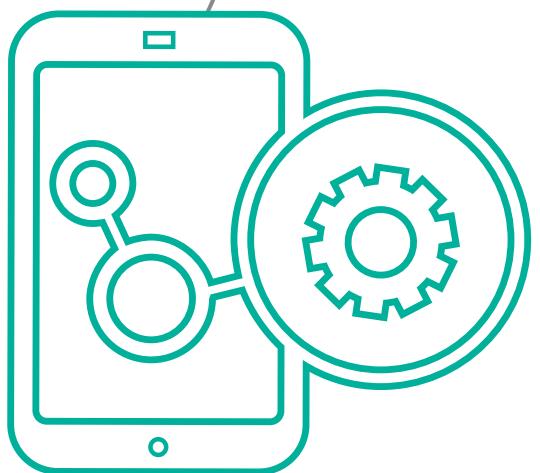
However, unlike previous cycles, mining companies appear to have learned from the lessons of the past. In paving new paths for the future, the aim now is to change for the better. This goal is driving their ongoing investments in innovation and digitization, inspiring their approach to the workforce of the future, manifesting in their commitment to strengthen government and community relations, and guiding their efforts to repair their public

image. It is also resulting in a more disciplined investment approach—one that may ultimately expose the dark side of conservatism as supply shortages begin to loom.

In this tenth anniversary report, Deloitte's global mining professionals once again share their experiences to help identify strategies companies can take to smooth out the recovery and minimize the industry's historical boom and bust cycle. This year, our professionals also share their outlook for the future by identifying, in some cases, potential industry disruptors which may be on the horizon. Thank you sincerely for your years of support. We look forward to your input and feedback.

"As the mining industry's value proposition is increasingly called into question, mining companies are beginning to see that they cannot succeed into the future unless they change the way they operate. This is about more than enhancing efficiencies. It's about re-establishing trust with stakeholders and collaborating to devise better responses."

Glenn Ives
Americas Mining Leader
Deloitte Canada



Bringing digital to life

Using data-driven insights to drive value

In recent years, mining companies have come to realize that value, like beauty, may be in the eyes of the beholder. Once measured by how well a company extracted resources, the industry's value proposition may be shifting to how well a company acts on information to optimize production, reduce costs, increase efficiency, and improve safety. In short, data—and the ability to organize, manage, and process it—is rapidly becoming a competitive differentiator and may even spur new business models.

The adoption of new technologies initiated this shift, as miners recognized the power of digital solutions to remove

waste in the areas of execution, process, structure, and design. Now, however, it is becoming clear that success for mining companies isn't truly about adopting the latest applications (apps) and technologies, which will continue to evolve. Instead, it's about embedding digital thinking into the heart of their business strategy and practices to transform the way corporate decisions are made. To succeed in this effort, miners need a clear vision of how the future digital mine might transform core mining processes, the flow of information, and supporting back office processes.

The future digital mine

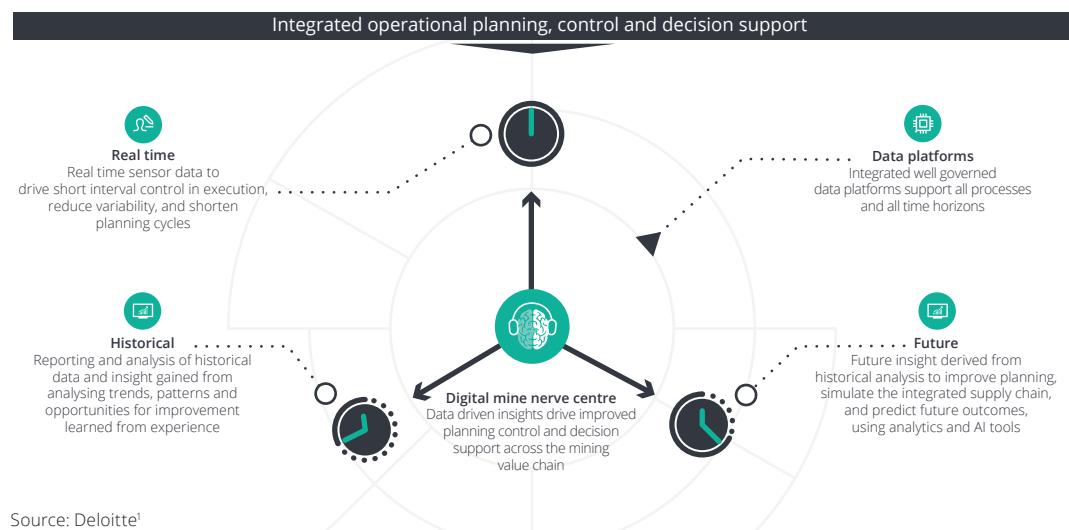
Transitioning to the future digital mine typically begins by focusing on core mining processes with the goal of automating physical operations and digitizing assets. This includes the adoption of autonomous vehicles, drones, three-dimensional (3D) printing, and wearable technologies, all operated through a connected

network that uses Internet of Things (IoT) sensors to capture data in real time.

Yet, the real value comes from unlocking the insights within this data. To do so, companies must rethink the way they generate and process information. This involves using data-driven analytics to

optimize their systems, from pit to customer. The aim is to create an information layer, or digital “nerve center”, that brings together data across the mining value chain in multiple time horizons to improve planning, control, and decision making (see figure 1).

Figure 1: Integrated operational planning, control, and decision support



Source: Deloitte¹

Digital in action

A major global miner in Australia moved its short-term production, planning, and control activities from its mine sites to a new remote operations center. The operations center implemented a supply chain visualization tool that provides an end-to-end (pit-to-port) view of the company's iron ore supply chain, showing key operational metrics in near-real-time, permanently displayed on large screens, with data sourced from 16 disparate systems. This was the first time the company could see its total supply chain in one place, assisting decision making for the whole business.²

To be sure, analysis of historical data will continue to enable insight from trends and patterns to identify opportunities for progress. At the same time, however, miners will rely even more on real-time data, derived from processing equipment and sensors during operation, to identify key drivers of process variability and drive rapid operational improvements. Access to more timely data from across the value chain will allow companies to update their ore body models, mine plans, and financial models more frequently, while shortening planning cycles. Additionally, historical analysis will inform future insight to improve planning and predict outcomes.

Central to enabling this will be an integrated and well governed data platform to support analysis across all time horizons, and a center of excellence in data management, reporting, and analytics. It's up to individual companies, however, to determine the best operating model for realizing this vision. While some organizations are building in-house analytics capabilities, others are outsourcing their data analysis to third-party partners. There is no optimal model, it depends on how the business plans to transform into the future.

Digital in action

A major global miner was looking to identify latent system potential across its pit, rail, and port network. Data-driven analysis generated over two million scenarios to identify significant unrealized value in the system and tested each one against operational reporting data to measure the feasibility of the proposed changes (i.e., based on historical performance, the analysis determined if it was possible to process, move, or operate in each scenario). This determined the most achievable scenario with the greatest potential increase in value. The analysis highlighted that higher production and greater shareholder return could be achieved by adjusting traditional assumptions in mine and system planning, all within a system that was previously considered to be "at maximum capacity". This rapid scenario-based analysis is now being used to augment planning decisions on an ongoing basis.³

Decisions informed by data

Many mining companies have already realized the value of tracking data on specific pieces of equipment. The real payoff, however, will come as they begin to uncover insights capable of informing their operational decisions in areas from maintenance, safety, and compliance to mine planning, fleet movement, and resource allocation. Achieving this level of insight will require miners to go beyond automating core processes and setting up a digital nerve center. They will also need to re-imagine their support processes for functions ranging from supply and human resources (HR) to finance.

In many cases, this is already resulting in companies replacing their enterprise resource planning (ERP) systems with cloud-based solutions, adopting robotic process automation (RPA) to automate repetitive tasks, and using artificial intelligence (AI) to support knowledge workers.

Convergence of information technology (IT) and operational technology (OT) can further enable automation and digitization—allowing work to be moved to locations which can support a more diverse and inclusive workforce. Similarly, more mature cybersecurity programs can help address the potential threats introduced by exponential technologies.

This vision of the digital mine is based on existing capabilities already being applied in other energy and resources companies, although no organization is yet doing it in an integrated way. Those that do embrace this ideal stand to see more than productivity benefits (typically 10 to 20 percent). They also gain the opportunity to use data-driven insights to forge closer relationships with stakeholders, facilitate knowledge sharing and training, drive new revenue streams, access new markets, and enhance operational safety.

“Many mining organization are not yet using all of the data they are capturing from operational systems, or are still struggling to improve reporting from legacy ERP systems. However, some are now realizing that capturing and managing the right data, and using the latest analytic tools, can deliver significant improvements in operational productivity, maintenance of assets, and safety of employees.”

Paul Klein
Consulting Partner
Deloitte Australia

Leading strategies in focus

Develop a digital strategy

Digital initiatives are often focused on technical solutions and are not always driven by a well-articulated strategy or a direct link to business value. For instance, without a vision, a company may equip operators in the pit with a tablet or headset rather than considering how to remove people from the pit entirely. To avoid unintended outcomes, digital transformation should first define the desired future state and the value of the initiatives to the organization as a whole. Properly conceived, a digital strategy can enable organizations to quickly test new approaches in a pilot or sandbox environment, and either roll them out in phases or shelve them easily.

Start small

Delivering on the digital mine nerve center does not need to be an all or nothing proposition. Organizations can start small by investing in improved visualization tools, integrating data from multiple sources, and reducing reliance on fragmented systems to enable better analysis of data. Real-time data captured from processing equipment and machinery sensors can help identify drivers of process variability to enable operational improvements, allow financial models to be

updated more frequently, and shorten the planning cycle. AI tools can improve planning, simulate the integrated supply chain, and predict future outcomes. RPA can replace some tasks currently performed by humans, presenting an opportunity for cost reduction. Each form of analysis can be enabled by an integrated data platform, supported by data scientists and analysts—either in-house or on an outsourced basis. Yet, even while driving digital in “bite sized chunks”, it is important to work against a plan or broader roadmap to ensure that the system ultimately integrates effectively.

Create a digital twin

Most asset-intensive organizations have difficulty managing their engineering and asset information throughout the asset lifecycle, including data integrity issues and time wasted looking for documents. Creating a digital twin can help address this issue. A digital twin is a digital model of the physical environment constructed using geological, engineering, and asset information—such as ore body models, engineering drawings, parts catalogues, and service manuals. The model is continually updated

with data from sensors and location-aware mobile devices to enable better planning, prediction, and simulation of future outcomes. As an initial step, companies can assess their engineering data management capabilities and maturity to highlight any gaps so they can focus their digitization efforts on the areas of greatest value and impact.

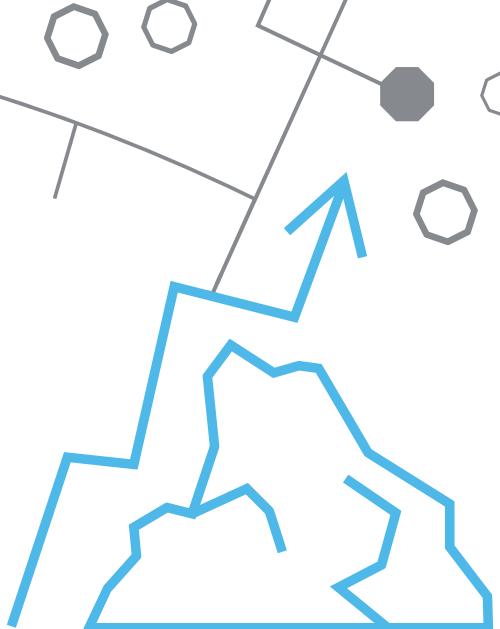
Become an insight-driven organization

To deliver on the digital mine nerve center, companies need the capacity to use data to resolve a wide range of business problems. Yet currently, most organizations only use a fraction of the data they collect, let alone the potential real-time volume they could capture via the Internet of Things (IoT), and many still struggle with limited business intelligence capability from historical ERP environments and non-integrated operational systems. To change this equation, miners must embed data science and analytic skills throughout the organization, by either hiring or partnering with scarce analytic talent, in a bid to rapidly uncover the insights they need to drive intelligent business decisions.

From left field

Mining companies operating with no back office

Could effective use of data evolve to the point that miners can operate with no back office? Some of the major disruptive competitors in the financial services space have turned that industry on its head by running with just a fraction of the overhead required by legacy players. Arguably, unconventional mining competitors could run their entire operations out of the cloud, virtually eliminating the expenses traditional companies face to maintain a back office. This vision may not be so far in the future. After all, many companies already fully outsource their back office functions—such as finance, human resources, IT, and procurement—to shared service centers. Similarly, many senior mining executives currently spend a good portion of their time away from head office, visiting mine sites, meeting customers and governments, and attending investor meetings and conferences, a trend that could ultimately see them running their businesses virtually.



Overcoming innovation barriers

Charting a path towards innovation maturity

Mining executives understand that innovation is necessary for the industry to transform. This isn't confined to just technological innovation; it includes the adoption of more innovative approaches to engaging with stakeholders, re-envisioning the future of work, and identifying the commodities that will be in greatest demand going forward.

Despite the imperative, however, industry players cannot yet be considered truly mature innovators. Deloitte research across Canada, Australia, Africa, and Latin America shows that the sector still lacks systemic consistency and strategic focus when it

comes to innovation⁴. Part of the reason is because mining companies continue to face a number of organizational barriers to innovation.

Identifying the roadblocks

First, mining companies are traditionally averse to take on new risks that may impact their cash flow or license to operate, reducing their propensity to pursue transformational innovation. This is due in part to the way their processes are structured. When innovation initiatives must compete for capital against projects with a shorter-term payback, the latter generally wins. This makes sense in an age of intense shareholder scrutiny.

Innovation in action

In December 2016, Vale opened its largest iron ore mine, in Brazil. The Eliezer Batista S11D Complex includes a mine, plant, railroad, and port logistics designed to vastly reduce the company's environmental impact. By locating in an already-deforested area outside the Carajás National Forest, Vale reduced vegetation clearance in the forest by roughly 40 percent. The company also adopted a range of technological innovations that promise long-term environmental benefits. For instance, rather than using trucks to transport ore to the plant, Vale installed mobile excavators and crushers, a system that will reduce fuel consumption by over 70 percent and reduce waste from used tires, oil filters, and lubricants. Additionally, the ore is being processed using the moisture it naturally contains, cutting down water consumption by 93 percent relative to the conventional process. The company also anticipates saving 18,000 MW of electricity per year—enough to power roughly 10,000 homes.⁵

It just may not bode well for the mining sector's sustainability over the long term.

Second, mining companies' propensity to favor short-term cash flow generation often works to the detriment of creating longer-term net present value. As such, innovations that may reduce costs over a product's or process's lifecycle are often dismissed if their initial costs exceed current costs. Frequently, operators are dis-incented from pursuing initiatives unlikely to deliver rapid returns. Procurement practices are often so focused on lowering per unit costs that there is an unconscious bias against innovators whose costs exceed the lowest cost competitors—even if they're delivering superior offerings. This has become a sticking point among service companies and juniors that have developed

potentially business-altering innovations that majors resist adopting given the challenges associated with calculating the lifetime value of new innovations.

Third, mining companies often lack a clear vision to guide and enable longer-term transformation. Without this vision (i.e., to become the lowest cost operator, minimize the mining footprint, build a fully automated mine, etc.), they struggle to tackle and derive value from innovation. Innovation needs focus and companies need to take their vision and align their innovation efforts against a series of key thematic areas.

Fourth, mining companies are historically inclined to operate in isolation. Concern around intellectual property (IP) rights and competitive advantage makes companies

distrustful of collaboration and hampers the juniors' and service providers' efforts to co-create or co-invent in partnership with the majors, despite the fact that this type of collaboration can accrue to the benefit of shareholders. Mining companies are also accustomed to treating access to capital as a competitive advantage, which was true when the industry was able to rely on high quality ore bodies and economies of scale to drive down costs. Today, however, the technologies that can make a marked impact on mining performance are evolving rapidly and mostly outside the mining industry. As a result, capital is no longer the constraint. Instead, the companies most constrained will be those unable to collaborate with technology leaders and integrate that technology into their operations.

A bold new vision

To some extent, these innovation barriers exist because the design of mines and processing plants hasn't changed in decades. Although the equipment is more modern, miners from 50 years ago would find little has changed if they entered today's mines, a situation that certainly doesn't hold true in other industries. That means that actual transformation requires a new vision for the future, one bold enough to drive a step change in performance and enable more ambitious results from innovation.

The upshot is that mining companies can only achieve true innovation maturity if they go beyond the basics of operational improvements to embrace innovation in a broader sense and embed a series of capabilities within the organization.

“Although commodity prices have begun recovering, mining executives are still feeling the sting of the recent downturn. As a result, they are collectively more cautious than their peers likely were just five years ago. While this is spurring ongoing focus on innovation, it also means their innovation efforts are increasingly constrained by the need to demonstrate near-term returns. The catch is that, unless you are trying new things, you are not learning, and if you are not learning, you will fall behind.”

Andrew Swart

Global Mining Consulting Leader
Deloitte Canada

Ecosystems and the role of mining services in fostering greater collaboration

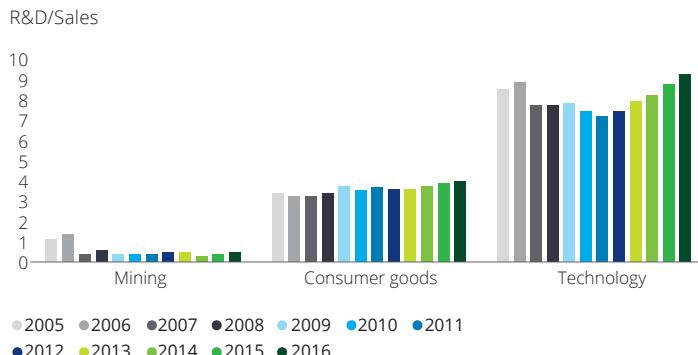
A review of the innovation barriers in the mining industry reveals that collaboration is frequently not within mining companies' DNA. Why? In some cases, organizations have not clearly defined which innovations to collaborate on and which to retain in-house. In other cases, legal agreements between potential partners become so complex that their value is diluted—making collaboration more difficult. The very structure of many mining companies also makes it difficult to drive synergies across mine sites—resulting in siloed operating approaches rather than fostering a culture of collaboration.

Critically, the nature and scope of the industry's challenges are making it less viable to operate

in isolation. The research and development (R&D) groups at most mining majors have been hollowed out, both in terms of human resources and budgets (see figure 2) since their apex in the 1990s. As a result, the model for innovation has fundamentally shifted.

Increasingly, original equipment manufacturers (OEM) and supply companies have access to more innovation capital and resources and hence a challenge for the industry is to figure out a way for miners and the service sector to collaborate more around innovation. This will however require companies to move beyond traditional procurement relationships.

Figure 2: Mining consistently underspends in innovation relative to other sectors



Source: Deloitte analysis

While collaboration is not the only approach to resolving the innovation conundrum among mining companies, it can go a long way towards encouraging the steady stream of innovations needed to build sustainable business models over time. Structured deliberately, collaborative ecosystems allow mining companies to reduce risk in the innovation process.

Through open industry forums, for instance, suppliers and other members of the mining ecosystem can work together to resolve mining company issues. Similarly, events such as “hackathons” encourage large numbers of people to engage

in collaborative development projects, a process that reduces innovation costs while empowering industry stakeholders. Collaborative ecosystems can even enable cross-border collaboration by uniting mining clusters with similar challenges across geographical boundaries.

These types of ecosystems make it clear that innovation does not require prohibitive budgets. As service companies and juniors have amply demonstrated, it can often be accomplished with constrained funds, particularly when external partnerships are leveraged.

The general idea is reciprocity. If juniors, for example, work on improving exploration performance with a focus on high-quality deposits, they will increase their value to majors. If majors work on improved recovery with a focus on lower-grade deposits, they will reduce the pressure on juniors. That’s a win-win where everyone has increased cash for investment, juniors to adopt/commercialize innovations and develop assets, and majors to buy juniors.

Leading strategies in focus

Develop a systematized approach to innovation

To determine the types of innovation to pursue so as to realize transformational change, mining companies must define their innovation strategy and rally their people around it. This includes articulating the dimensions of their vision so they can assess where to innovate (i.e., by focusing on automation, reducing their carbon footprint, partnering with stakeholders, etc.). From there, companies should manage innovation as a portfolio against the thematic areas and have a defined way to move innovations from concept all the way through to commercialization. It involves adopting structured innovation processes that cut across business units and support innovative ideas that arise from every level of the business.

Build the organizational support

To turn innovation into an organizational core capability, companies must make it a leadership priority and

implement governance systems to empower decision making throughout the organization. To become embedded in the organization, innovation needs the support from senior leadership together with an acceptance that not all innovation succeeds and that failing fast is okay. Organizational support should also not only occur from within, but collaboration needs to include external parties like competitors, suppliers and communities.

Secure the right resources and competencies

To progress towards more mature innovation, corporate innovation efforts must be adequately funded and supported with the right resources and capabilities to deliver. In some cases, this may involve hiring ambitious talent from the technology industry, cultivating the types of skills required for different kinds of innovation, making creativity related processes more flexible, and designing more inspiring work environments. Mining companies also need to empower their leaders

to champion innovation by enabling them with the right tools, processes, technologies, and know-how.

Develop metrics and incentives to guide performance

Before innovation can be delivered as a discipline, organizations must have the ability to both measure its effectiveness and incentivize appropriate employee behaviors. This means companies should aim to monitor innovation from concept to prototype to pilot. Similarly, metrics and incentives should be aligned to a company's innovation strategy and reward people for their accomplishments. One global company is tackling this challenge by setting aside small portions of its mine sites as innovation testing grounds where operators are not held to stringent quota and production requirements. This frees them up to think big, test small, fail fast, and iterate quickly before scaling proven innovations to other parts of the mine or to other sites.

From left field

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 tons of polymetallic nodules.⁶

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.

Critically, complex environmental and access issues will need to be balanced against the likelihood of untold and largely untapped mineral wealth lying beneath the waves. Environmental concerns include the impact of plumes of dust, stirred up by excavation of the ocean floor, on a delicate ecosystem. As a result, some companies are pursuing less intensive exploration techniques. DeepGreen Resources, for example, is focused on the exploration and development of polymetallic nodules from the seafloor, which lie on the top part of the seafloor. Due to their distinct mineralogy, polymetallic nodules lend themselves to metallurgical processing solutions that offer the potential for significant environmental benefits. DeepGreen's patented process is aiming for zero tailings, representing an important step change for the minerals industry.



The future of work

Re-envisioning talent management in the digital age

As the digital mine becomes a reality, the nature of work is poised to change dramatically, at both the mine site and in the back office. In essence, the digital mine envisions that a lean set of corporate processes will be augmented by RPA to automate repetitive human activities, by autonomous equipment to reduce labor intensity and enhance safety, and by AI to support knowledge workers. Fully integrated communications networks will

support the mobile workforce across all platforms, and digital systems will simplify work scheduling, while more robust cybersecurity programs mitigate the risks. These technologies will enable core mining activities to be performed from locations that can support a more diverse and inclusive workforce, including primary caregivers, part-time workers, and people with physical disabilities.

Automation is transforming the labor market. Deloitte estimates that by 2035 approximately 35 percent of current jobs in the UK will be automated.⁷ Similar trends are expected in other parts of the world.

Inside the future of work

A global mining and metals organization was a relatively early adopter of RPA within the industry. After an initial proof of concept focused on the invoicing process in its global shared services center, it is now applying automation within its supply function. The objective was to automate the manual work of the supply team in expediting material orders and seek to increase expediting coverage beyond the top 25 vendors, which it was limited to due to a manual time-consuming process, high volume of work, and frequency of updates. The solution included automation of SAP supply data into an integrated data platform, the development of a dashboard for faster inventory analysis and reporting to site supervisors, and RPA for automation of the vendor communication process.⁸

Charting the implications

While digital solutions will augment human performance by empowering people at all levels with information to enhance their performance and insights to drive better decisions, they will also cause upheaval. As manual jobs are automated or replaced by robotic processes, labor dynamics in local communities will shift significantly.

On the positive side, this can translate into new employment opportunities as new roles are created. It can deliver significant safety benefits for the mining industry by literally moving workers out of harm's way, and boost productivity by reallocating those workers to more productive occupations. It can accommodate the realities of shifting global demographics by enabling more women and seniors to enter and remain in the workforce. It can position companies to achieve greater diversity by attracting workers from historically under-represented populations.

As more work moves to shared service centers and centers of expertise, the available pool of labor will also expand as companies begin to employ a mix of on-shore, off-shore, and robotic workers located anywhere in the world.

The implications are equally as dramatic for frontline workers. With sensors, for instance, maintenance workers can get alerts before equipment breaks down, allowing them to improve scheduling and increase equipment uptime. Similarly, shift supervisors can pinpoint the location of equipment in real time, enabling faster decision making and improving worker safety. With interactive dashboards, mine managers and supervisors can electronically interact with engineers with greater levels of precision. And, by optimizing mine plans in real time, the whole nature of work and scheduling will change.

Not only can work be redesigned, but equipment can

as well. For instance, Worsley Alumina—a South32 business—created gender-neutral drilling equipment that enabled the deployment of its first all-female drilling crew.⁹

The ramifications on work scheduling are similarly significant. In the not too distant future, mining organizations will be able to post available work shifts online and enable employees to use a mobile application to choose the shifts they prefer to work. In this way, mining companies could attract a more diverse workforce, while giving frontline workers greater freedom to manage their careers.

On the other hand, greater reliance on digital solutions could result in job losses, raising concerns about companies' social responsibility towards their existing workforce. Given the imperative of mining companies to work in harmony with local communities, the industry's shift to the future of work will need to be measured.

Rather than eliminating jobs wholesale, this will likely translate into concerted efforts to retrain people to use technology or redesign jobs to take better advantage of people's existing human skills. To this end, mining companies should think through how to reskill and retrain people to learn technology and tools faster, and how to design the technology so it takes almost no training to use.

A new kind of miner

As automation becomes more prevalent and technology transforms the nature of work, organizations will also be forced to redesign certain jobs. At the mine site, manual workers will need to learn how to integrate technology into their job functions. Those who are more comfortable working with technology will also need to train and mentor employees who have less digital experience.

In the back office, the convergence of IT and OT is driving the emergence of a new kind of mining professional, one that combines traditional mining skills with advanced technology skills. Mining professionals now need to be digitally literate, along with having strong problem solving skills and the ability to think creatively.

When it comes to hiring, this means mining companies will require access to a broader array of systems experts to operate and monitor autonomous machines, and data analysts to turn growing volumes of data into meaningful insight. This quest for scarce digital talent, including software engineers and experts in robotics and mechatronics, will put mining companies against more attractive industries in the attraction and retention of key talent.

As such, miners may have to redefine roles, change corporate cultures, attract and train in new ways, and reimagine traditional career paths. They will also need to rebrand to raise their appeal among the millennial talent joining the workforce. This is particularly salient for organizations that continue to run their back office functions in antiquated ways. A lack of innovation in these areas will make it harder to attract those people who will be in greatest demand going forward.

Leadership skills will also have to evolve. As the workforce becomes more diverse, distributed, and connected, mining leaders will need the ability to foster and support an inclusive culture, manage across generations, and model the

use of social tools that improve communication, collaboration, and connectivity. Leaders will also require the capacity to align competency frameworks to account for new robotics, cognitive, and AI requirements; deploy employees replaced by these technologies; and reskill employees to complement these tools.

Although these issues raise potentially uncomfortable challenges, the future of work has arrived and companies that fail to embrace this disruptive opportunity could find themselves at a competitive disadvantage in today's digital age.



“Companies need to realize that they will not be able to recreate previous career paths as we head into the future. Job descriptions and the skills required are changing wholesale, mandating a complete re-conception of the way in which miners must attract and retain talent.”

Ian Sanders

Mining Leader
Deloitte Australia

Leading strategies in focus

Retrain and upskill

Gaps in employee digital knowledge are undermining technology transformation efforts. In a 2016 global survey of managers and executives conducted by MIT Sloan Management Review and Deloitte, only 11 percent of respondents said their company's current talent base can compete effectively in the digital economy. The main barriers include lack of agility, complacency, and inflexible cultures.¹⁰ This speaks to the imperative for mining companies to compare their current talent pipeline against skillsets they anticipate needing in the future and hiring or retraining to close identified gaps.

Adopt new attraction and retention strategies

To attract and retain scarce digital talent, miners should place greater emphasis on nurturing and developing their people, creating interesting and purposeful work, and building an environment with career flexibility and tools that enable employees to collaborate and exchange ideas transparently.

Source and integrate talent across networks

Attracting new skillsets from other industries may be a particular challenge to mining organizations. As a result, there is a growing need for miners to partner with organizations that have deep technology expertise. Companies will need to design and evolve their partnership networks to access the best talent for specific work and cultivate a continuum of talent sources—on and off balance sheet, freelancers, crowds, and competitions.

Redesign work for technology and learning

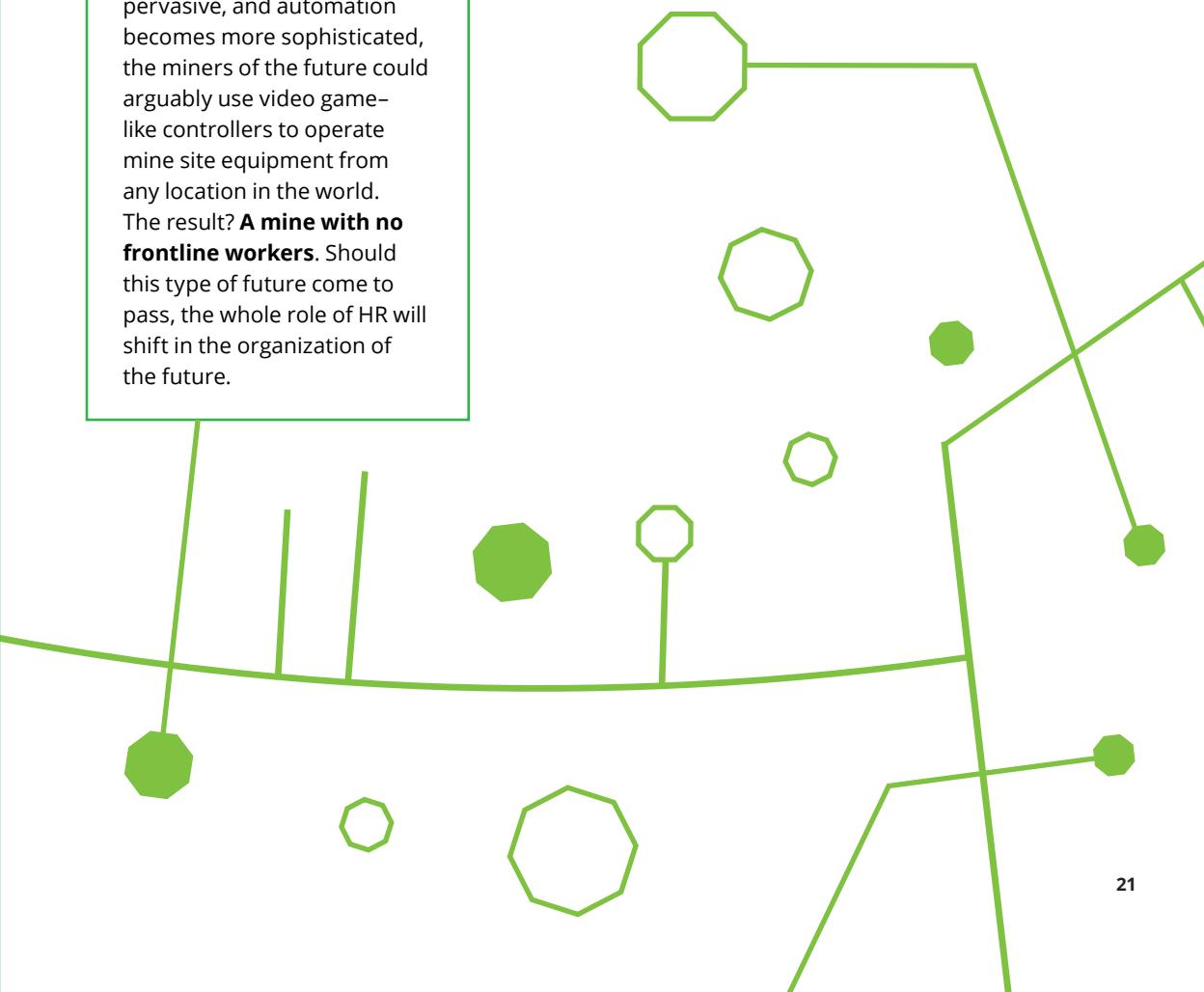
As the future of work becomes a reality, companies must move beyond process optimization to find ways to enhance machine-human collaboration. This includes identifying areas where digital technology can augment worker performance as employees shift to more productive work—for instance, by harnessing technology to give workers richer real-time information or using AI to complement human judgment.

Create a new social contract with communities and governments

To prevent potential backlash, it is important for mining companies to work with key stakeholders to develop a shared vision for the future of work. This can include working with schools to ensure the future labor force is properly trained, explicitly discussing labor issues with mining community stakeholders, and committing to employee retraining.

From left field

If AI technologies follow the tenets of Moore's Law, then the cost of automation, robotics, and cognitive solutions are bound to continue falling over time, leading to a notable uptick in adoption rates. As remote operations become more pervasive, and automation becomes more sophisticated, the miners of the future could arguably use video game-like controllers to operate mine site equipment from any location in the world. The result? **A mine with no frontline workers.** Should this type of future come to pass, the whole role of HR will shift in the organization of the future.





The image of mining

Changing public, employee, and customer perceptions

Although the sector has taken significant strides to improve the image of mining in recent years, in some cases, it is still operating under a legacy of weak environmental practices, fractious community relations, stock price underperformance relative to other sectors, and a historic lack of workforce diversity.

Despite the significant contribution of the mining sector to the world's economy, the industry's reputation remains tarnished in many countries due to perceptions that mining companies contribute to environmental damage, cause a negative impact to the community,

and engage in dubious practices abroad.

As mining companies know from harsh experience, negative perceptions can do more than damage reputations and affect stock prices. They can also spill over into community protests and violence, and result in the loss of a social license to operate.

In a world increasingly influenced by round the clock news cycles and opinions aired in the court of social media, this type of backlash is only bound to spiral. This mandates mining companies to take proactive steps to address, and change, their reputations.

Raising the bar

In recent years, Rio Tinto set a new bar for tax transparency by voluntarily disclosing details of the taxes and royalties it pays on an annual basis. BHP followed suit in 2015, committing to develop detailed taxes-paid reports—making the two companies industry leaders in their goal to enhance public accountability and improve corporate credibility.¹²

New behaviors

Notably, companies are coming to realize that this is not simply a public relations (PR) issue. To rebuild trust with employees, investors, communities, governments, and the public, mining companies must back up their messages to these groups with action. This mandates a change in behavior.

Increasingly, leading companies are taking more decisive public stances around corporate social responsibility. For instance, in addition to enhancing the transparency of their tax disclosures and anti-bribery stances, many have begun to demonstrably reduce their exposure to countries where the perception of corruption has been on the rise. Several mining companies have begun adhering to voluntary sustainability standards, including those set out by the Taskforce for Climate-related Financial Disclosure, the Global Reporting Initiative, and the Carbon Disclosure Project. Additionally, in the past year, Anglo American, Glencore, and

Rio Tinto all passed shareholder resolutions regarding increased disclosure on climate change.¹¹

“Mining companies are coming to realize that radical transparency is now a prerequisite for trust,” explains Carole Cable, a Partner at Brunswick, a communications firm focused on helping companies build trusted stakeholder relationships. “This requires them to marry their social purpose with their financial purpose and craft a narrative that clearly articulates the value they bring to society.”

This imperative is playing out in interesting ways. In some instances, mining companies now enable local communities to test the quality of a site’s water emissions by setting up CCTV cameras or apps that provide citizens with online access to water quality data. Others give community members the option to physically visit water discharge sites to conduct their own tests. In addition to empowering local communities, this type

of radical transparency encourages companies to keep themselves honest, creating an environment of shared responsibility.

In other instances, mining companies have begun going beyond philanthropic donations that typically end once a mine site shuts down. Instead, some miners have begun contributing a portion of their local revenues to foundations that empower community members to allocate funds based on local needs.

Re-engaging employees

These efforts to regain trust are also happening internally, as companies work to create a new culture to support their visions for growth and re-engage employees.

One indicator of this shift is the mounting focus on mental health as mining organizations work to address the pressures many employees face both within and outside the workplace. The Mental Health Commission of Canada, for instance, recently began offering a mental health first aid course to the mining industry in Northern Ontario.¹⁴ In Australia, as part of a state-wide campaign to generate awareness of mental health issues and the support available, Rio Tinto's Hunter Valley mines traded their standard yellow truck trays for blue to indicate their improved capacity to provide peer support and related mental health programs.¹⁵ Glencore also introduced the Mates in Mining program in Queensland to encourage more open talk about the risk of suicide.¹⁶

If companies truly hope to repair their reputations, however, they must also recognize that new operational realities are required, especially if they hope to attract the talent of the future. This likely means making structural changes at the mine site to automate the physically-challenging or dangerous tasks that may not appeal to a new generation of workers. It also means fostering a culture of diversity and inclusion so typically under-represented employee groups feel a sense of belonging.

Although some companies have begun to embark on the arduous task of shifting perceptions, there is little doubt that much work remains. The alternative, however, is untenable. Miners simply cannot hope to sustain their license to operate, cultivate employee loyalty, or win the hearts and minds of other key stakeholders if they don't engage in a concerted, and multi-year, effort to repair their reputations and regain public trust.

Raising the bar

The BHP Foundation was established to help address some of the unprecedented development challenges society currently faces. Through its Natural Resource Governance program, it aims to reduce the potential for corruption and bribery across the resource value chain by enhancing transparency. Its goal is to provide citizens with access to information that shows the flow of funds related to natural resources in their country, giving them both the data and the tools required to hold local institutions to account.¹³

"If mining companies truly hope to repair their image, they must do more than change their messaging. They must also fundamentally change their behaviors around the way they mine how they engage with communities, attract talent, and deliver on their promises."

James Ferguson

Global Mining Tax Leader
Deloitte UK

Reimagining reputations

When the ePrix, the electric vehicle version of the Grand Prix, makes its debut in Santiago in 2018, it will be sponsored by Antofagasta Minerals. The company's decision to put its name on this first edition of the all-electric race was not simply a PR exercise. In fact, its aim was to bring attention to the company's commitment to help contribute to a cleaner world by reducing carbon emissions. Antofagasta is demonstrating this commitment in myriad ways, not least by using renewable sources, including wind and solar, to generate 45 percent of its power at its Los Pelambres mine.¹⁷

Creating a new image with customers

In addition to rebuilding trust externally and among employees, some companies are trying to reposition themselves in the eyes of their customers by demonstrating their capacity to deliver greater value. As the industry works to articulate its value proposition to shareholders, there's been a collective soul searching that has led, in some cases, to the development of differentiated, higher margin, proprietary products tailored to meet the needs of certain customer segments.

With economies moving along the urbanization curve and demanding more sophisticated products, miners may increasingly

begin offering products over which they can exercise more control, particularly relative to pricing. China's new modern steel furnaces, for example, are configured to run on high quality iron ore and met coal, encouraging steel mills to favor higher grade iron ore. This is true across commodities. China's drive to reduce emissions and improve the environmental footprint of individual processes will underpin demand for higher quality raw materials. Similarly, India is structurally short of high quality coal reserves.

Some companies have already taken steps to meet this demand by creating more differentiated products. Rio Tinto's Pilbara blend is a case in point. By blending Marra

Mamba ores with higher phosphorous Brockman ore, Rio Tinto created a premium product to meet the unique demands of steel mill customers. Since its introduction into the market roughly one decade ago, the Pilbara blend has become the world's most traded iron ore product.¹⁸

As mining companies continue to remake themselves from the inside out, leaders will likely focus more diligently on understanding customer needs and developing boutique or niche products to meet them—reaping the rewards of both improved customer satisfaction and higher margins.

Leading strategies in focus

Enhance transparency

Companies have already taken great strides to improve the transparency of their tax disclosures. A similar spirit will likely need to pervade a broader range of activities going forward. Mining companies need to more clearly demonstrate the role the industry plays in supporting and sustaining economic growth. Companies must continue sharing examples of the efforts they are making to remediate any environmental damage they cause. They must be more proactive in sharing the impact they are making in local communities and countries, not only in terms of employment, but in terms of infrastructure investments, improved access to education,

and the development of healthcare programs. They may also need to give key stakeholders an inside look at their operations, by empowering citizens to monitor the quality of their water outputs, for instance, or explaining the rationale behind changes in strategic direction to employees at all levels of the company.

Up efforts to build, measure, and report on sustainability

While many governments now require certain disclosures, over-reporting shows a real commitment to sustainability. Companies can only do this, however, if they invest in tools that can help them report consistently and with the same rigor used for financial

disclosure. The technology required to do this may even end up providing valuable data companies can use in decision-making.

Develop a crisis management response plan

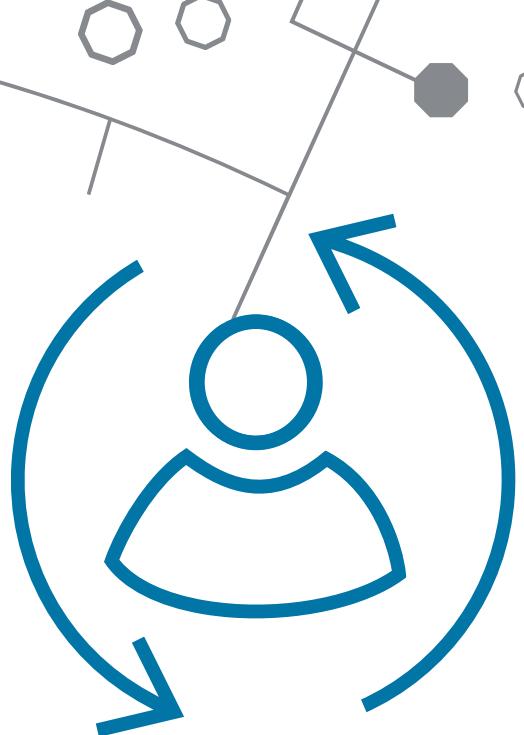
Mining companies must continually work to educate their stakeholders about the industry and keep them apprised of corporate activities. This means staying ahead of the curve by anticipating criticism and having a ready response. To repair reputations, mining companies must consistently be honest and upfront about any incidents and how they are addressing them, even if they are only minimally involved.

Align operational decisions with stated commitments

To shift public perceptions, mining companies must walk the talk. This means avoiding jurisdictions rife with bribery and corruption, reducing safety incidents and fatalities, and rigorously adhering to the most stringent environmental practices possible. It may also mean shifting corporate cultures to ensure employees truly prioritize the maximization of value over the maximization of production. To turn culture into a productivity lever, mining companies should seek out best practices from organizations that already understand that their real assets are their people.

Work directly with governments and communities

Most large mining companies already do this, but all miners should meet regularly with key stakeholders before, during, and after a mine is operational. This is about more than good optics. It is good business—and it will provide companies with confidence in the face of criticism when they know they are actively respecting and incorporating the views of the communities they operate in.



Transforming stakeholder relationships

The growing need to achieve measurable social outcomes

To expand local employment opportunities, increase tax revenues, and meet increasing community demands for improved infrastructure and greater environmental protection, many governments of resource-rich countries continue to put pressure on the mining industry. As a result, mining companies in many jurisdictions still face considerable obstacles to investment, ranging from high royalty rates, permitting challenges, and uncertain tax rules to growing requirements for local beneficiation.

Mounting volatility

These demands are taking various forms. In Russia, for instance, community concerns around coal dust pollution may result in a ban on the use of grabbing cranes, which are used by ports to load more than 50 percent of Russia's seaborne exports. If passed, these measures could see Russian coal exports fall by up to 80 million tons, dropping back to 2007 levels.¹⁹

Stakeholder management in action

Diamond producer De Beers has been operating in Botswana since 1967, the year after the country achieved independence. As part of a public-private partnership that has extended over 50 years, the company entered a 50/50 joint venture with the government to form Debswana, the primary producer of diamonds in the country. In recent years, De Beers moved both its diamond sorting operations and its international sales function to Botswana. An analysis of the partnership in 2014 showed that it employed almost 8,000 people, of whom 96 percent were Botswana citizens, including almost 85 percent of management. A further 12,870 jobs in the broader economy were supported through the partnership's supply chain contribution. In addition, the partnership spent approximately US\$6 million on 550,000 hours of training and skills development for employees. Today, the partnership is the largest single contributor to the Botswana economy, besides the government itself.²⁴

In Colombia, the mining industry has been beset not only by protests, road blockades, and new tax measures, but also by mining bans that have forced some major miners to halt operations in certain municipalities.²⁰ El Salvador went one step further, banning mining entirely.²¹

In Tanzania, Acacia Mining was hit by a US\$190 billion fine, US\$40 billion in unpaid taxes plus an additional US\$150 billion in interest and penalties, prompting the company to reduce its operational activity in the country.²² The total bill represents roughly 40 times Acacia's 2016 revenues and comes in at four times the size of Tanzania's GDP.²³

New approaches

Although many of these regulatory risks can be traced to politically volatile jurisdictions, there may also be a secondary underlying cause. Some of the social initiatives mining companies have undertaken in the past have failed to deliver on their intended results. Increasingly, the industry is coming to realize that its traditional approaches to community and government relations must change.

This imperative will only heighten in the digital age. Despite the benefits that automation, robotics, and AI deliver, their effect on local employment is bound to spark government concern, particularly in regions where

the mining industry remains a major employer. Historically, the contract between mines and communities has revolved around job creation. As mines move towards more digital operations, however, the basis of this social contract will shift. To prevent unrest and mitigate backlash, companies will need to leverage the digital infrastructure on behalf of communities, potentially using it to create new education models, improve communication, develop suppliers, or deliver other digitally-enabled services. This will require companies to be more creative in uncovering the real needs of these communities.

This isn't to imply that transforming key stakeholder relationships will be easy. The mining industry as a whole has an inconsistent performance record in this space, one hampered by the considerable challenges associated with reaching consensus across multiple stakeholder groups. If mining companies truly hope to change for the better, they must do more than create stakeholder maps in the various markets where they operate to identify key decision makers and potential detractors; partner with industry and trade groups to gain a more intimate understanding of the local political climate; and build targeted relationships with specific political entities, community leaders, NGOs, and agencies to uncover pressing local needs. They must also create a stronger sense of shared value with both local governments and local communities. This means moving beyond the unilateral actions companies typically adopt (such as donations and philanthropy, preferential hiring, and legal compliance) to embrace more collaborative modes of engagement designed to get local communities more invested in the mine's operations.

Stakeholder

management in action

In 2016, Fort McKay First Nation made history by entering a participation agreement with Suncor for the purchase and sale of a 34.3 percent equity interest in Suncor's East Tank Farm Development, valued at approximately US\$350 million.²⁵ This example of communities taking a major equity stake in an organization's operations highlights the potential of partnerships to not only earn a social license to operate but to bring sustained value to local parties.

"If there's one area where the industry needs to both collaborate and innovate, it's around how it deals with communities and governments. It's time for miners to change the lens on stakeholder management. Rather than approaching it as a cost of compliance, companies must determine how to make a concrete social impact that inures to the benefit of different stakeholder groups."

Andrew Lane

Mining Leader
Deloitte Africa



Leading strategies in focus

Move beyond financial transparency

In recent years, many regulators and NGOs have demanded enhanced disclosures, prompting mining organizations to heighten their financial transparency in an effort to demonstrate the contributions they are making to local governments and communities. Unfortunately, it is becoming clear that numbers alone don't tell a compelling story. As such, it would likely compel companies to provide more concrete examples of how their investments and activities translate into measurable social outcomes—such as a certain percentage increase in local employment or the number of workers successfully transitioned to new jobs following a mine closure. Rather than an information dump, it's time for companies to share messaging that paints a picture of what their numbers mean.

Provide communities with equity stakes

To encourage communities to be more vested in local mines and developments, it may make sense to provide them with significant equity stakes in mining company operations. In addition to strengthening companies' social license to operate, this approach allows communities to realize long-term financial advantages tied to corporate fortunes, building a true sense of shared value.

Strengthen local supply chains

Local businesses often lack the scale to deliver on large procurement contracts, putting them at a competitive disadvantage. To overcome this barrier, some organizations now focus on systematically helping local partners gain the skills they need to participate in the procurement process through business development training, mentoring, and formal suppliers development programs. Mining companies that support this type of strategy can realize cost savings by reducing reliance on global suppliers who must fly in and out of regions around the world to meet the company's needs. For their part, local supplier gain access to the processes and technologies they need to grow, enabling them to become strong players in the local market. At the same time, this approach can deliver outsized economic benefits for host countries, creating both direct and indirect jobs, enabling the transfer of skills and technology, strengthening business networks and industrial clusters, and increasing tax revenues.

Enable community-led evaluations

Traditionally, organizations monitor their behaviors to ensure legal compliance and determine their impact on local communities. Now,

however, some companies are democratizing this process through the use of community-led evaluations. By focusing on greater transparency between the mine and local communities, companies can empower communities to select and track the metrics that matter to them most.

Collaborate

Collaboration, both among adjacent mine operators and through public-private partnerships, can help mining companies meet critical public and community needs while also enhancing operational performance. While collaborative approaches will hinge on specific project goals, common success factors typically include building a multi-disciplinary team committed to working closely with industry stakeholders, engaging multiple stakeholder groups, and starting negotiations as early as possible given that the timelines associated with these types of projects can frequently span years.

From left field

Blockchain

Growing reliance on data in the mining sector introduces the potential to use blockchain technology to create fully transparent, secure, and traceable transaction histories. Blockchain is often thought of for finance applications like enhancing accounts payable (AP) processes by eliminating the need to reconcile purchase orders (PO) and invoices or streamlining trade finance by supporting the creation of smart contracts to automatically execute payments. But could it be used to create new value for communities? Take Canadian start-up Peer Ledger²⁶ as an example. Using blockchain technology, the company can track precious metals through the supply chain to ensure they were derived from ethical sources and do not include conflict minerals. Just as organizations like Fair Trade impacted the coffee industry, it's not a far stretch to think through ways in which blockchain enabled solutions could transform the relationship with mining companies and communities.



Water management

Finding sustainable solutions to a pressing issue

With each passing year, water has become a more critical issue for the mining sector. As ore grades decline, more water is needed to extract the same amount of ore pushing up water requirements in the industry. At the same time, water demand is rising globally, driven by population growth, industrial development, expansion of irrigated agriculture, and increases in per capita water consumption.

Critically, this growing demand is not offset by available supply. According to the United Nations (UN), water scarcity now affects more than 40 percent of the global population and is

expected to worsen. Currently, over 1.7 billion people live in river basins where water use exceeds recharge and, by 2050 at least one in four people are likely to live in a country affected by chronic or recurring freshwater shortages.²⁷

As concerns around water availability grow, communities and environmental groups are turning the spotlight on water-intensive industries, including mining. In fact, since 2000, roughly 58 percent of the mining cases lodged with the World Bank Group's Compliance Officer have related to water issues.²⁸

New approaches needed

Water scarcity is not the only issue mining companies face. In some regions, floods, ice melt, and severe storms have the potential to create excess water, increasing the risk of effluent leakage. In 2015, for instance, heavy rainfall in Vietnam deluged the roads with potentially toxic floodwater runoff from 16 open pit coal mines and three coal-fired power plants.³⁰

In light of these challenges, mining companies must enhance their approach to water management. This means finding more innovative ways to reduce, reuse, and recycle water in water-scarce regions; contain and treat wastewater to prevent spillage or contamination of downstream water flows; and monitor their water usage and purity. As BHP recently noted,

“...ethical water stewardship is expected increasingly to emerge as a competitive advantage for those operators that get it right. For those that do not, their ability to maintain their social license to operate may come into question.”³¹

To reduce freshwater needs, mining companies are already investing in process innovation, wastewater recycling, and digital monitoring. They are collaborating with commercial technology providers to devise solutions for tailings storage and management, dust suppression techniques, and seawater desalination plants. They are also increasingly collaborating with governments and other industry players to devise a shared water use approach to available water resources.

Approximately 25 percent of mining production will be vulnerable to climate-related risks such as water shortages by 2030.²⁹

Water in the spotlight

These action items are becoming particularly important given the growing regulatory focus on water management, spurred, at least in part, by serious disasters.

Regulatory pressure is even mounting in regions where water management has been traditionally less rigid, mandating companies to adopt best practice approaches wherever they operate or face serious penalties.

Although approaches will differ depending on the regions where they operate and the water challenges they face, one thing is clear, mining companies need a sustainable water management strategy if they hope to thrive into the future.

Water management in action

In keeping with its goal to catalyze innovation by connecting the whole mining ecosystem, the Canada Mining Innovation Council (CMIC) is working to transform mining into a zero waste industry. As part of its environmental stewardship initiative, the organization provides companies with online access to 15 million water quality data points in a geospatial format in the hopes that the portal could ultimately be used to curate or provide water quality monitoring data for regulatory reporting purposes.³²

Water management in action

In a notable example of intra-sector collaboration, Anglo American and BHP teamed up in 2007 to build South Africa's eMalahleni Water Reclamation plant. This was the world's first facility to treat acid rock drainage (which can contaminate aquifers and river systems) and purify it to potable standards. The revenue generated from the sale of water to BHP and the local municipality offsets 60 percent of the operational cost for Anglo American. The plant also meets 12 percent of municipal daily water requirements and generates roughly 30 million liters per day. Other companies and municipalities in water-stressed areas are now replicating this effort.³³

Water management in action

Goldcorp is engaged in a multi-year strategy designed to move the company towards zero water use. By substantially reducing freshwater consumption and eliminating the use of traditional slurry tailings, the company currently aims to consume 50 percent less water than its existing sites do today and move at least half of its existing operations to water reuse/recycle rates of more than 80 percent. To give this initiative a worldwide impact, Goldcorp is also sharing its information and best practices with other industry leaders.³⁴

“Mining companies understand how much water they use. Yet this understanding does not always translate into action. To address community concerns around resource competition, it’s time for miners to improve their water management by rethinking their production processes and partnering with technology companies to implement real-time water monitoring solutions.”

Karla Velásquez

Mining Leader
Deloitte Peru

Leading strategies in focus

Conduct a water risk assessment

Risk assessments allow companies to gain a clear understanding of the risk factors associated with their current water use, such as impact on operations if local water levels drop or the potential disruptions they may face due to extreme weather conditions. In addition to bolstering scenario planning, these assessments can help companies identify appropriate adaptation measures and internal controls to mitigate potential risks.

Put a cost to water

Water access costs are only the tip of the iceberg when it comes to assessing the full price of water. In an age of water scarcity, it is becoming imperative to price water on a full cost basis, taking into account not only its access cost, but also the costs associated (for instance) with its treatment and chemical alteration, to monitor wastewater or tailings facilities over the course of decades, and to build treatment or desalination plants.

Use digital technology to manage water use

New technologies give companies the ability to monitor the quantity of their water intake in real time, determine how much water is required for various mining processes, and track the quality of the water they retain in their tailings facilities or release into the environment. In addition to enabling early detection of potential problems, this equips companies to be more transparent about their local water impacts and share critical data with key stakeholders to better drive engagement with communities, governments, and special interest groups.

Rethink traditional mining processes

Companies that are achieving true innovation in water management tend to take regional factors into account before a mine is ever built. This has seen some companies adopt increasingly innovative water management approaches, including dry processing, where mining is

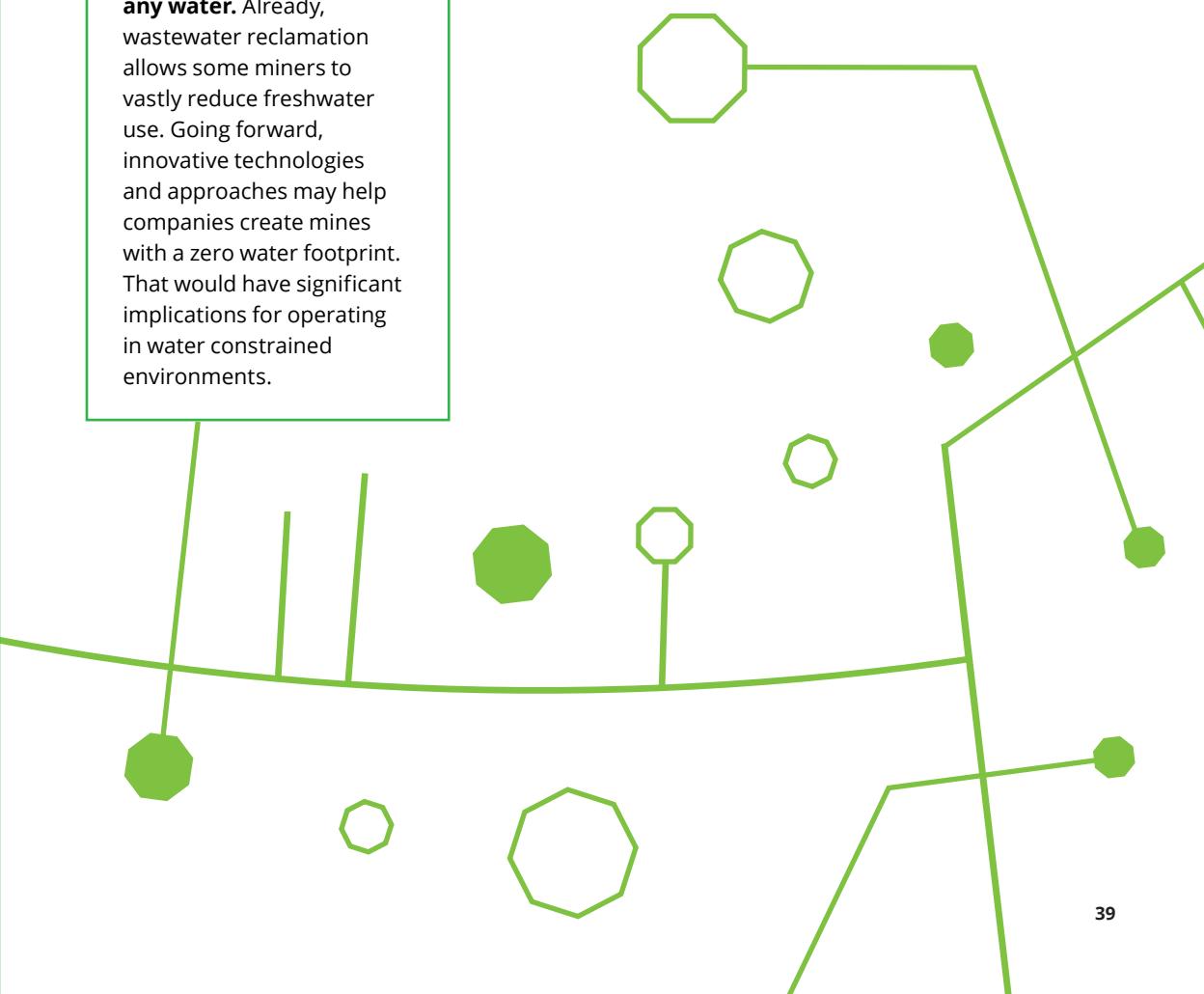
done using the ore's natural moisture; substituting raw seawater for freshwater; treating generated wastewater with technologies such as reverse osmosis, ion exchange, and membrane filters; and using micro-organisms in tailings facilities to mine mineral waste.

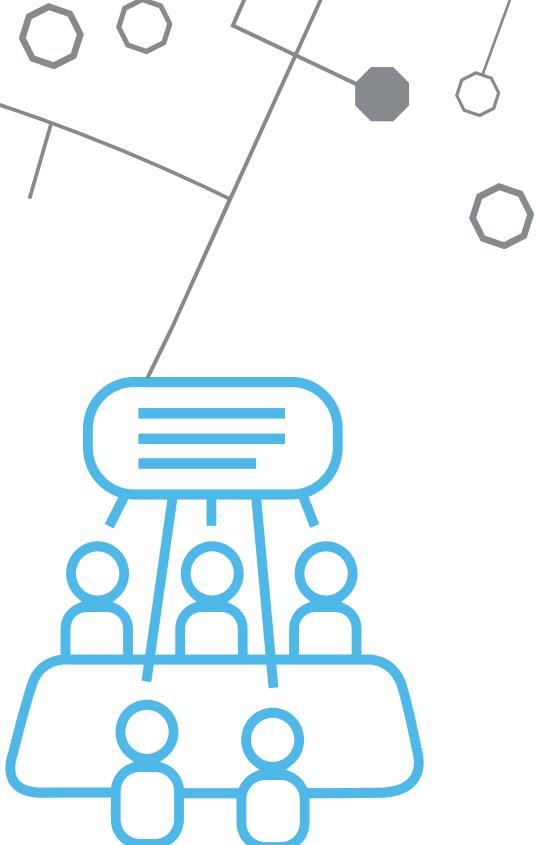
Take a shared value approach to water use

Mining companies need to look at water through an integrated water management framework to determine how to share this critical resource among competing stakeholders. The aim is to ensure that downstream water users are not negatively affected by decisions made by upstream players. This requires companies to take water use across the catchment into account and work with key stakeholders—including governments, water authorities, and communities—to set targets for water use, effluent treatment, and discharge rates.

From left field

As technological progress continues apace, it may ultimately be feasible to **operate a mine without any water**. Already, wastewater reclamation allows some miners to vastly reduce freshwater use. Going forward, innovative technologies and approaches may help companies create mines with a zero water footprint. That would have significant implications for operating in water constrained environments.





Changing shareholder expectations

Investors demand greater accountability

For decades, mining company behavior largely hinged on prevailing market realities. While lower commodity prices traditionally heralded retrenchment, cost cutting, and risk aversion, a rising price environment often signaled a period of over-spending, sometimes to the detriment of long-term corporate value. So with commodity prices on the uptick, it's no surprise that shareholders and institutional investors are carefully monitoring the sector to assess if companies are in danger of once again tipping towards excess.

This more rigorous oversight is manifesting in a number of ways. In some cases, shareholders are making it clear that they expect a return of value as corporate fortunes rise—in the form of increased dividends, share buybacks, and a higher total return to shareholders.

In other cases, shareholders are becoming more vocal by engaging in activism in a bid to influence operational decisions. In the summer of 2017, for instance, Elliott Advisors began campaigning for changes to BHP's strategy and board, pointing to missteps that saw the company's US\$30 billion investments in US shale fall in value to US\$6.5 billion.³⁵ In an attempt to influence BHP to sell its US shale business, the activist fund increased its stake in BHP to an estimated five percent, giving it the right to call an extraordinary general meeting or table a shareholder resolution.³⁶

Similar activism appears alive and well among smaller companies too. At Petropavlovsk, a London-listed gold miner, the chairman was recently voted off the board following shareholder opposition.³⁷ And in September 2017, New York-based hedge fund manager Paulson & Co called for the world's biggest investors in gold mining stocks to form a coalition to speak out on issues such as executive pay, board constitution, and

mergers and acquisitions (M&A), in light of the fact that average total shareholder returns from gold mining investments were negative 65 percent since 2010 during a time when the gold price rose by 20 percent.³⁸

In some jurisdictions, activist shareholders have also begun voting against the executive remuneration reports presented at the annual general meeting. This is not necessarily because they are opposed to the proposed remuneration, but as a way to force reconstitution of the board of directors.

The dangers of short-termism

As shareholder expectations grow, mining companies have begun focusing on re-establishing their credibility in the investor community and with analysts. Rather than pursuing mega-mergers or building new mines, for instance, many are exercising higher degrees of fiscal discipline.

Of course, while this conservatism can help to bolster shareholder returns

in the short term, it does raise concerns around potential supply shortages. Which begs the question, is the traditional corporate governance model based on shareholder returns appropriate for a cyclical sector like mining? Some say no.

A recent Harvard Business Review article³⁹ pointed out that the maximization of shareholder value only became a goal for shareholders and boards fairly recently. The concept arises from the "agency theory", which posits that shareholders own the company and that their primary objective is to maximize their own economic returns. The issue with this assumption is that shareholders have no legal duty to protect or serve the companies they invest in. This gives certain types of shareholders the power to force the change of a company's board or management, only to sell out as soon as the share price rises. The article's authors argue that this form of activism is less about value creation and more about value transfer.

Ira M. Millstein, founding chair of the Ira M. Millstein Center for Global Markets and Corporate Ownership at Columbia Law School, author of *The Activist Director*, and Senior Partner at international law firm Weil, Gotshal & Manges LLP, holds a similar view. At a recent presentation in Toronto, he noted the dilemma directors face in responding to shareholder expectations, given the divergent expectations of long-term shareholders, short-term shareholders, hedge funds, mutual funds, and institutional investors. In his opinion, it is incumbent on directors to ensure that activist shareholders actually represent the interests of all shareholders before meeting their demands.

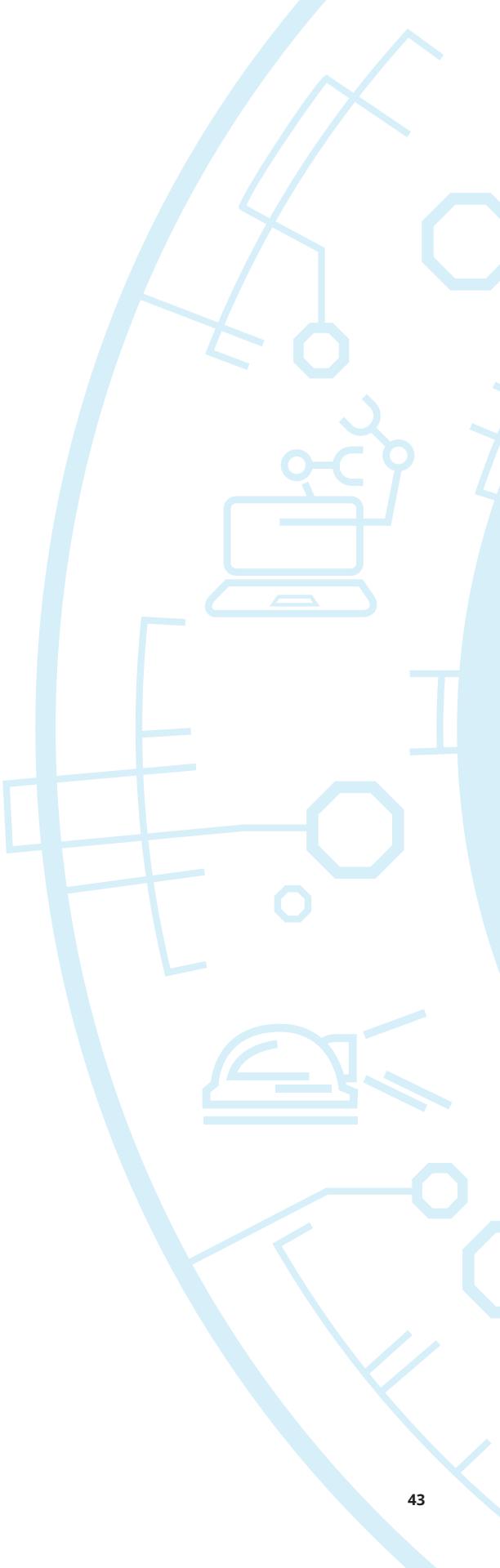
"When confronted with an activist shareholder, directors need to figure out if that shareholder's interests align with those of the larger shareholder constituency. If so, they should listen to the activist's idea. If not, however, they should vote against—even if it costs a quarter of earnings."⁴⁰

Ira Millstein

Founding chair of the Ira M. Millstein Center for Global Markets and Corporate Ownership at Columbia Law School, author of *The Activist Director*, and Senior Partner at international law firm Weil, Gotshal & Manges LLP

Instead of buying into the traditional model of corporate governance, it may make better sense to acknowledge that corporations need to create value for multiple constituencies—including customers, employees, suppliers, and communities—not just for shareholders. Their performance measures should consequently reflect these varied objectives. This would free up boards to focus more on long-term strategies, succession planning, and leadership development, while linking executive compensation to broader corporate goals—including those related to good corporate citizenship and ethical behavior.

While this argument should not absolve mining companies from being called to task on their poor track records, it can help counter the negative effects often associated with an overly short-term investor outlook—which include the danger of overlooking innovation, exploration, and sustainable growth in favor of boosting quarterly share prices. Boards that successfully steer the market's focus towards long-term strategy can help limit the effects of focusing on the short term.



“Responding to rising shareholder expectations requires companies to walk a fine line. While it is important to avoid decisions that can result in an erosion of value, shifting corporate direction to meet shareholder demand for short-term returns can work to the long-term detriment of the company.”

Tim Biggs
Mining Leader
Deloitte UK

Leading strategies in focus

Commit to greater transparency

Mining companies can only hope to win back investor confidence if they consistently demonstrate an ability to deliver on their promises. This requires companies to improve their forecasting, project management, and reporting abilities so they can adhere to their publicly-articulated policies around capital allocation and consistently meet their earnings forecasts.

Adopt a longer-term governance model

Rather than prioritizing shareholder returns over all other corporate objectives, it may be helpful for mining companies to move towards a model that recognizes the breadth of functions they serve in society—from generating shareholder wealth to providing employment, paying taxes, and contributing to local communities around the world.

Shine a spotlight on activism

While shareholder activism can shed a light on instances of corporate misconduct, the interests of activist shareholders may not always align with the interests of all shareholders. In these cases, it is incumbent on boards to disclose the pertinent details of any potential conflict so that shareholders at large can make more informed voting decisions.

From left field

In recent years, the move towards green investing has impelled many pension funds and investment managers to reduce the number of mining companies in their portfolios. This stance, however, is now being called into question given the mining industry's role in supplying raw materials for electric vehicles, which are expected to have a beneficial effect on the environment. Going forward, **renewable energy and sustainability benchmarks may need to expand to include mining companies** if they are to reflect the full value of the electric vehicle supply chain, a move that could vastly shift shareholder perceptions of the industry.





Reserve replacement woes

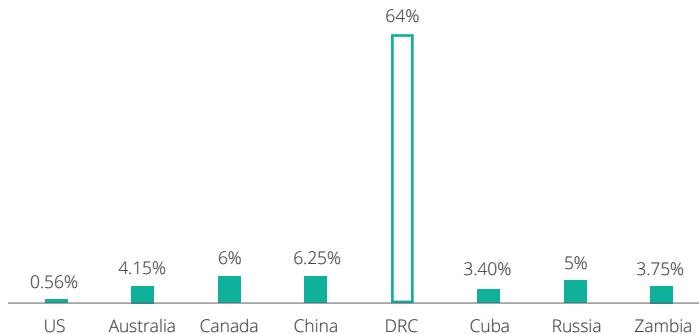
Finding a balance between caution and courage

Thanks to intense cost cutting, a focus on fundamentals, and a commitment to portfolio simplification, the fortunes of many mining companies are on the rebound. Yet this tentative turnaround cannot remedy the supply constraints that currently plague the industry.

For the 10 years prior to 2016, the amount of gold discovered declined by 85 percent, while reserves have fallen by 40 percent since 2011,⁴¹ prompting Randgold Resources' CEO to warn that, by 2020, the industry will face a dramatic supply shortage.⁴²

Ongoing grade decline, resource depletion, and supply disruptions are resulting in a similar trend for copper, which is expected to fall into a deficit by 2018.⁴³

For the first eight months of 2017, silver production had fallen by a significant 20 percent in Chile and 19 percent in Australia,⁴⁴ while nickel entered its first material deficit since 2010.⁴⁵ Recent under investment in zinc also pushed that commodity's inventories to their lowest levels since 2007.⁴⁶

Figure 3: Share of 2016 global cobalt production

Source: Wealth Research Group⁴⁷

Cobalt supply shortages are also often in the news, with companies struggling to find conflict-free sources of the metal outside of the Democratic Republic of the Congo (DRC), where 60 percent of the world's current supply is located⁴⁸ (see figure 3).

Constrained supply

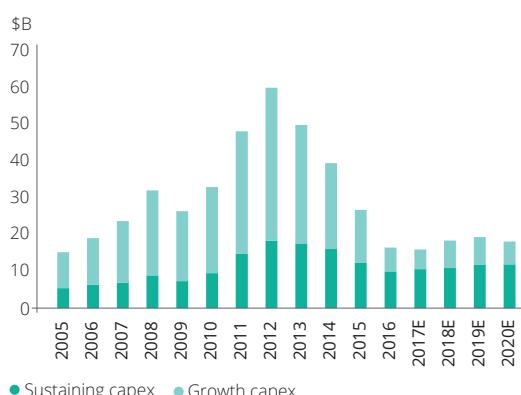
Some of the reasons for this reserve depletion are well known. Capital expenditures,

while currently on the upswing, have declined sharply since their peak in 2012 (see figure 4). Exploration budgets are also down (see figure 5).

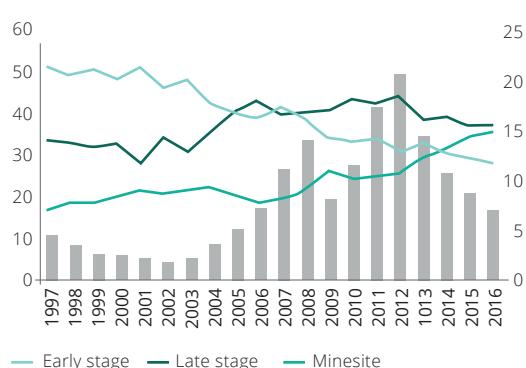
Yet these are not the only factors contributing to supply shortages. Still burdened with high debt loads and rising price/earnings (P/E) multiples, mining companies are struggling to free up the exploration and development budgets required

to exploit new resources. At the same time, they remain extremely hesitant to engage in acquisitions to feed the exploration pipeline.

Competitive pressures may also play a role in limiting future supply. In recent years, for instance, the three major iron ore suppliers have improved efficiencies to such an extent that new suppliers are being priced out of the market.

Figure 4: Mining capex

Source: Barclays European Metals & Mining report, released in March 2017.

Figure 5: Exploration budgets by stage of development and world totals

Source: S&P Global Market Intelligence

Arguably, this trend could extend to other commodities, impelling major players to drive efficiencies and ensure low cost production by acquiring competitors. If niche players begin to dominate certain market segments, the future of diversified miners could be called into question.

Too little, too late?

Admittedly, the transactional environment is gaining steam, with some M&A returning. Significantly, Chinese investment in key commodities appears to be resurging. In April 2017, Shandong Gold acquired a 50 percent stake in Barrick Gold's Veladero mine in Argentina in a transaction valued at just under US\$1 billion.⁴⁹ This was followed by a June 2017 deal involving a consortium led by Fosun, which agreed to acquire up to

15 percent of Polyus, Russia's largest gold producer—marking the first big Chinese investment in Russia's mining industry.⁵⁰

However, despite this activity, mining companies are eager to avoid the losses they experienced in the past, when industry M&A often proved to be value destructive. As a result, they are now making smaller, more conservative investments accretive to shareholder value rather than engaging in major transactions and going full tilt towards building new mines. They are pursuing earlier stage exploration projects; looking for grassroots investments rather than engaging in major takeovers; and entering joint ventures to uncover new deposits and share the costs and risks of new project development. In March 2017,

for instance, Goldcorp and Barrick Gold entered a 50/50 joint venture to work together to develop several gold mines in Chile's Maricunga belt.⁵¹ For their parts, both Newcrest Mining and AngloGold Ashanti both teamed up with junior explorers to expand their exploration pipelines.⁵²

Yet concern remains that these measures may be too little, too late. Without a concerted focus on reserve replacement—and the dedication of significant investment funds—the danger of falling into a historical boom and bust mentality remains real.

New approaches in action

To position itself for future growth and gain a competitive advantage, Rio Tinto has committed to managing its asset portfolio more actively. To this end, it set up Rio Tinto Ventures to gain access to commodities that are set to benefit from megatrends, such as industrialization and urbanization, technological disruption, and the interconnection of global markets. Rio Tinto Ventures aims to enter joint ventures and partnerships with asset owners where its engineering excellence, sales and marketing channels, and technical expertise allow it to add value. The company hopes these investments will position it to uncover new greenfield opportunities in partnership with junior miners.⁵³

“Going forward, mining companies will need to find a more agile way of replacing reserves, one that allows them to engage in exploration and development without sinking in large amounts of capital for long periods of time.”

Kevin Xu

Mining Leader
Deloitte China

Leading strategies in focus

Shorten the cycle

To reduce the risk of long-cycle megaprojects, resource companies often engage in short-cycle projects designed to rapidly generate a positive cash flow. In addition to reducing capital expenditures, these short-cycle investments help to preserve the production capacities needed to expand as demand factors shift. Canada's IAMGOLD strategy has been focused on both long and short-cycle projects. The short-cycle project approach has been considered by the company for several years to achieve sustainable reserve growth by focusing on identifying near-mine deposits that can lead to more greenfield discoveries. In addition to enabling the company to transform its balance sheet, this approach has also positioned it to profitably grow production by 20 to 25 percent in the next three years.⁵⁴

Build a portfolio of early stage projects

To expand their exploration pipeline, several mining companies have been entering joint ventures with junior explorers. In these types of deals, majors typically offer to share intellectual property (IP), engineering resources, technical expertise, and exploration costs with juniors in exchange for first rights to new mineral discoveries.

Find local capital

To avoid undue risk, blue chip mining companies

typically prefer to invest in near-mine exploration in known geologies. This focus, however, may hamper their ability to succeed in emerging nations. To overcome this hurdle, a new kind of investor may be required—one who understands the risks, regulatory environment, and cultural issues that prevail in less developed regions and is consequently willing to inject local capital into the sector.

Consider more creative funding models

In a bid to become more nimble operators, mining companies are on the lookout for more creative funding models that may not require investors to commit large amounts of capital for long periods of time. This is spurring a rise in alternative funding approaches, such as supply chain financing, streaming arrangements, and royalty agreements. Deals involving underperforming assets have similarly seen a trend towards nominal purchase price structures, deferred consideration, contractual royalties, and seller commitments to fund ongoing project expenditures in return for buyers accepting take-or-pay obligations in respect of rail and port access and environmental liabilities.

Use analytics to optimize portfolios

One of the greatest difficulties organizations face when trying to structure optimal portfolios is making informed

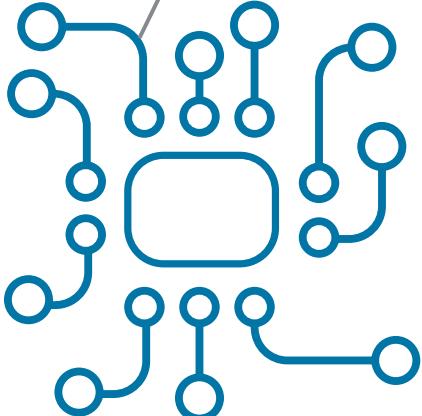
choices about which assets to buy or sell, and when. Too often, these decisions hinge on subjective factors that cannot be effectively measured or improved. To remove some of that subjectivity, leading organizations are increasingly relying on data analytics to rank and score potential investment opportunities. Properly implemented, these analytical tools can help mining companies improve their financial models, uncover new business opportunities, and make more intelligent investment and divestment decisions.

Leverage new technologies

As geomatic technologies evolve, companies have begun to develop more advanced surveying capacities. New mobile technologies now allow for portable laser scanning; remotely controlled drones are delivering high resolution aerial images; and satellite imagery is being used to detect new ore bodies. Advanced software solutions, such as MineRP, even allow companies to consolidate all the available spatial information in the mining environment to establish detailed mine plans and schedules, and shift mine design fluidly as internal and external factors change—improving planning and workflows, while optimizing budgets.

From left field

Mining companies are no strangers to the boom and bust cycles typically associated with shifting commodity supply and demand. Yet this familiarity may be the very thing that makes it difficult for them to devise truly novel operational approaches. Other less progressed industries have fallen prey to this trap in recent years—making them ripe targets for unanticipated disruption. Which begs the question: **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 AI, 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.



Realigning mining boards

New skillsets are needed to help drive transformation

There is little doubt that the mining sector is in the midst of a transformation. To transition to the mine of the future, companies must embrace the full power of digitization and innovation and attract a new brand of talent. Heightened scrutiny from governments, communities, investors, and other key stakeholders mandates new forms of cooperation and collaboration. To repair broken relationships and tarnished reputations, miners must also explore ways to operate more sustainably.

These drivers and more make it clear that companies will need to make substantive cultural shifts.

Some companies have already taken steps in this direction by engaging in cross-functional collaboration, seeking out best practices from other industries, strengthening their executive teams, and setting targets to achieve greater diversity and inclusion.

To cement these changes, however, mining companies will also need to ensure that their boards are properly constituted to support transformation. From a governance perspective, boards can only help drive the changes the industry needs if they are comfortable embracing new operational realities—including the need to operate in an ecosystem, transform stakeholder relationships, and weigh the pros and cons of novel business models. This is especially critical as shareholder activism ramps up, companies are held to higher standards of corporate governance, and technological disruption alters industry dynamics.

Rising expectations

While there was a time when directors were predominantly focused on oversight, this notion is also shifting. Today, directors are increasingly expected to weigh in on corporate strategy, digital disruption, talent management, and emerging risk factors. In fact, studies show that the best boards go beyond their fiduciary responsibilities to take a more active role in constructively challenging the executive team.⁵⁵

Critically, boards mired in old ways of thinking will increasingly struggle to fulfil this mandate. Although past experience can help inform opinions, it can also inhibit directors from questioning their current assumptions—leading to a form of cognitive bias that prevents them from considering non-traditional solutions. Low levels of diversity among mining board members only complicate the issue by limiting their ability to uncover outside views or challenge their habitual thought processes. In essence, diverse perspectives are necessary if mining boards are to effectively challenge organizational assumptions, assess the validity of new ways of thinking, and help determine if the organization is taking on too much risk, or perhaps not enough.

New skillsets, broader outlooks

To help evaluate the strategic decisions mining executives must make to transform operations, it is becoming clear that board members will require different skillsets. While they may not need to be digital experts, directors will have to improve their technological

literacy so they can ask the right questions about the company's technological transformation and understand the answers they receive. They will need to be well-versed in new compensation and incentive structures so they can effectively guide and review executive performance. They must learn about prevalent talent constraints so they can help develop effective succession plans. They should understand how to assess the effectiveness of corporate cybersecurity strategies, particularly as cyber breaches become more prevalent. They also need to understand how to exert greater governance and oversight over the major construction projects that will increasingly be required as companies work to replace reserves.

As mining companies work to drive the transformation agenda, they will also require board members capable of imagining a new future rather than adhering to the practices of the past. This speaks to the need for greater diversity among boards of directors.

The key here is to blend the visible aspects of diversity—such as race, gender, age, and physical ability, with diversity of thinking. This means deriving value from people's different perspectives on problems and different ways to

address solutions. By approaching diversity in this way, organizations, and their boards, can avoid the risk associated with homogeneity and promote a new model of inclusion. After all, a significant body of research shows that diverse teams are more innovative and perform at higher levels.⁵⁶ By composing more diverse boards of directors, companies can reap the benefits of new ideas, more debate, and, ultimately, better business decisions.

“Mining companies are considering new business models and driving step change through innovation and digitization. To enable this broader transformation, they need the right board composition. Rather than having a firm grasp of how things were done in the past, today’s board members need to understand how the industry is evolving into the future.”

Amy Winsor
Mining & Minerals Consulting Leader
Deloitte US

Leading strategies in focus

Create a vision for transformation

Before corporate boards can be properly constituted to support mining company transformation, the management team must first articulate a clear vision for the future. The aim is to then realign the board's skillsets, committees, and processes to ensure it is properly composed to achieve that vision for transformation.

Look for board members with a broader set of attributes

While board members are frequently selected based on their functional industry experience, mining companies can benefit by broadening the attributes they seek out, with the aim of attracting directors with more varied demographic backgrounds (e.g., gender, race, ethnicity, generation/age) and wider bases of knowledge (e.g., people with expertise in technology, cybersecurity, global risk factors, transactional success, performance management).

Be creative

Most boards seek directors who are either current or retired C-suite mining officers,

which can make for a small pool of female candidates. It's further limited by the fact that women with boardroom experience are often over subscribed and don't have time to serve on additional boards. To overcome these challenges, boards should look beyond mining, to industries that are already advanced in some of these transformational elements. They may want to look beyond the top corporate officers for candidates and give them mentoring to help them succeed in the boardroom. The adoption of an explicit policy to increase board diversity is also an important factor, as is a more proactive approach to promote women into executive positions so they can develop the experience they need to join a board.

Invest in board training

Board members must walk a fine line between fostering a collaborative environment with senior executives while still challenging management by asking hard questions. To help them find this balance, it can be useful to ensure that board members understand corporate governance best practices both within and beyond the mining sector.

Review board refreshment policies

To ensure they are capable of overseeing evolving strategies and risks, well-run boards typically adopt an ongoing approach to refreshment. This means regularly assessing the board's composition; considering the average and range of tenure; reviewing the board's size and committee structure; and ensuring the board has access to appropriate skills, expertise, experience, and diverse representation. Rather than relying on only age limits to allow for refreshments, leaders also establish a more proactive process, by engaging in full board self-evaluations and even conducting peer evaluations of individual directors to ensure the board continues to attract and cultivate the best candidates.



10

Commodities of the future

Predicting tomorrow's disruptors

Given how inextricably socioeconomic trends link to commodity demand, mining executives have long had to double as futurists. To assess which commodities to invest in, and which to divest, miners need to keep their fingers on the pulse of fluctuating consumer demands, global demographic and economic shifts, and the effects of environmental change. In recent years, they have also had to track a rapidly-evolving trend, the emergence and adoption of new technologies.

The battery

As economies mature and technological advancement progresses, mining companies are seeking greater exposure to later-stage commodities such as tech metals and boutique minerals. One of the most frequently cited examples these days is lithium, an integral component of battery technology. In anticipation of the exponential growth of electric vehicles (EVs) and energy storage systems, the global battery supply chain is mobilizing.

By 2030, for instance, members of the Electric Vehicle Initiative (Canada, China, France, Germany, Japan, the Netherlands, Norway, Sweden, the UK, and the US) plan to increase the market share for EVs in their countries to 30 percent.⁵⁷ According to the International Energy Association, 14 countries have already announced quantitative targets for EV adoption, supported by subsidies and significant investment in charging infrastructure. Collectively, this is expected to result in up to 20 million EVs on the road by 2020.⁵⁸

Tesla alone, at its Nevada Gigafactory, is already producing more battery capacity than in any one single plant elsewhere in the world, with an annual capacity of 35 gigawatt-hours (GWh).⁵⁹ Yet, surprisingly, that amount may be overshadowed by China, which plans to build additional factories by 2021 with the capacity to produce more than 120 GWh per year.⁶⁰

In light of these factors, most analysts predict that global demand for lithium will double or even triple by 2030.⁶¹ The key now will be meeting that demand. Although supply of lithium is growing in both

Western Australia and Canada, 70 percent of the world's known lithium reserves are in Argentina, Bolivia, and Chile, the so-called lithium triangle.⁶² While a number of companies are focused on that region, several lithium projects have faced delays due to technical problems, while lead times for new capacity can be four to five years. This environment has created a very positive dynamic for lithium prices, which rose by over 70 percent between November 2016 and November 2017.⁶³

Graphite is another commodity currently in the spotlight. Like lithium, its demand is linked to battery power and storage, driving analysts to predict that demand for battery-grade graphite will triple by 2020.⁶⁴ While China supplied just under 70 percent of the graphite used in 2016,⁶⁵ rising costs, grade depletion, and stricter environmental regulations may see the country's share of the market drop.

For its part, cobalt—yet another integral component of battery technology—is facing a global supply deficit that may grow from 885 tons in 2018 to 5,340 tons in 2020.⁶⁶ To complicate matters, almost 70 percent of the world's cobalt supply

comes from the DRC.⁶⁷ This may explain why there are few dedicated producers. In fact, roughly 95 percent of cobalt is produced as a by-product (largely of nickel or copper),⁶⁸ so when those markets deteriorate, cobalt production falls.

On the plus side, both nickel and copper are re-inventing themselves as commodities of the future as well. EVs are expected to contain four times as much copper as combustion-powered engines,⁶⁹ driving analysts to predict that the market will slip from a surplus into a deficit of 130kt by 2018.⁷⁰ Similarly, while nickel laterites (nickel pig iron and ferronickel) make up the majority of today's production and will likely remain in oversupply, demand for nickel sulfides (battery-grade nickel) is expected to increase 50 percent to three million metric tons by 2030.⁷¹

The impact of these trends on the mining industry can be transformative.

Waning fortunes

On the other hand, not all emerging megatrends will increase commodity demand. Shifting global factors may also cause certain commodities to fall out of favor. Thermal coal is an often cited example as countries around the world inexorably move towards renewable energy sources. Over 160 countries and counting have publicly announced commitments to increase the share of renewables in their electricity mix,⁷³ with 59 countries planning to shift to 100 percent renewable energy in the coming decades.⁷⁴

Yet coal is not alone. Consider, for instance, the implications of recycling on commodity demand. Already, the US produces over 70 percent of its steel from scrap metal, reducing demand for iron ore. Conversely, China only produces 11 percent of its steel from scrap. As that rate picks up, the risk to iron ore is bound to rise. In 2016 alone, China generated a record 143 million tons of scrap steel, an amount expected to rise to 200 million tons by 2020.⁷⁵

The future in play

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.⁷² Planetary Resources has successfully launched two spacecraft into orbit (2015, 2018), demonstrated its technology in Earth-bound mining operations, and is aiming to launch the first commercial Space Resource Exploration Mission by 2020.

Wealth from waste

Already, the pervasiveness of technology means that each person generates roughly six to seven kilograms of electronic waste a year—and only 10 to 12 percent of that waste is recycled on an annual basis.⁷⁶ This likely explains why some believe the global metal recycling market will grow to US\$406 billion by 2020, at an estimated compound annual growth rate of 7.95 percent.⁷⁷

Tracking the trends

Given the pace of change, making predictions about the commodities of the future is no easy task. There is little doubt, however, that it heightens the imperative for mining companies to diligently track evolving market forces, while also potentially developing the skills to mine and process a range of different, and less familiar, ores.

“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.”

Andre Joffily

Mining Leader
Deloitte Brazil



Leading strategies in focus

Keep an eye on disruptors

Disruption can be either a threat or opportunity, depending on how it is managed. For mining companies, turning disruption into opportunity requires the cultivation of a long-term view capable of assessing how emerging market trends may affect the demand for specific commodities. To uncover these often unanticipated market shifts, it can be helpful to keep tabs on the places where disruption frequently emerges, such as the start-up community, within business incubators and accelerators, and among educational institutions.

Look for vertical integration opportunities

As competition for the commodities of the future heats up among various industry players (i.e., manufacturers of EVs, batteries, electronics, and new technologies), corporate end users may try to secure their own sources of supply. Mining companies should keep abreast of these emerging opportunities to potentially partner with corporate end users to secure development funds or to enter direct-to-customer supply contracts.

Explore scenario design

One emerging forecasting approach combines human intuition with AI to enhance organizational ability to develop future-oriented strategies. By comprehensively evaluating external risks and their implications, organizations gain the ability to turn risks into opportunities. By monitoring market developments, companies can also devise more robust and flexible business strategies.

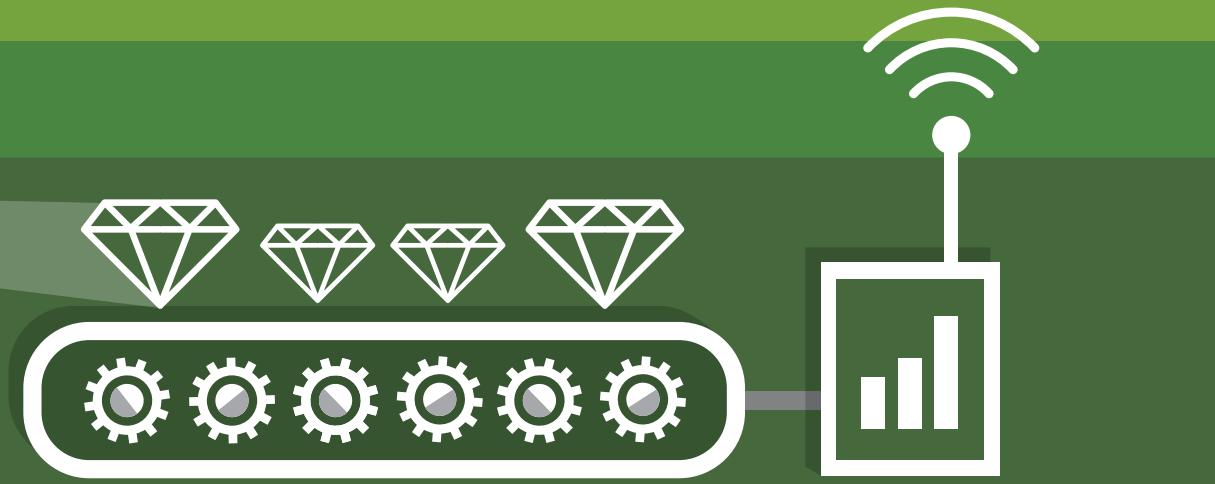
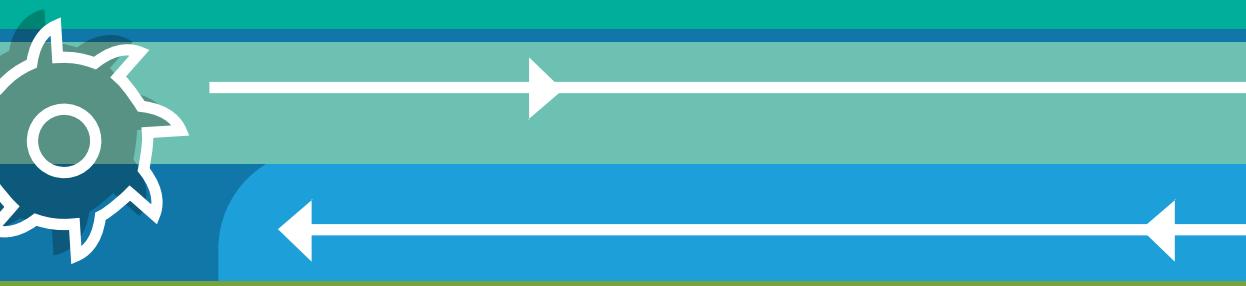
Go in prepared

Although the commodities of the future could potentially represent a transformational opportunity for mining companies, organizations need the capacity to differentiate the reality from the hype. This goes beyond conducting appropriate transactional due diligence before pursuing potential acquisitions. It also includes assessing the viability of potential market opportunities and the capabilities required to capture them, and developing strategic responses to both short- and long-term changes in the market.

From left field

In identifying the commodities of the future, mining companies must keep track of a range of disruptive market forces. One of those may be the advent of a viable deep space industry. Since 2000, more than US\$13 billion has been invested in space-related businesses⁷⁸ that extend far beyond established industries like satellites and launchers. In fact, space may ultimately support a commercial market worth over US\$37 billion,⁷⁹ comprised of opportunities such as manufacturing (the low-gravity environment can deliver significant productivity improvements), space tourism, and exploration support.

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. The iron alone is potentially worth US\$10,000 quadrillion.⁸⁰



Out with the old, in with the new Harnessing the winds of change

In 2009, when we first launched this mining report, the global financial crisis was in full swing. As commodity prices plummeted, many mining companies found themselves operating at the brink of a loss, driving much of the sector into full retrenchment mode. As a result, executives began refocusing on fundamentals such as cost containment, risk management, and supply chain efficiency. In essence, they were repeating the acts so symbolic of previous down cycles.

Over the past decade, however, the mining industry has radically transformed itself. Those companies that successfully

weathered years of market volatility have taken the lessons of the past to heart. Rather than engaging in age old responses with the expectation of different results, they have come to understand that new times call for reinvented measures. In short, they are not simply reacting to external pressures. Instead, they are adopting transformative strategies designed to help them change for the better.

Profound change takes time. Despite mining companies' quest to use data as a differentiator, enhance innovation maturity, position for the future of work, and

create new operational cultures, they are still battling against a tide of negative public perception, contentious stakeholder relationships, and increasingly vocal shareholder demands. Their test now will be maintaining the resolve to back up their words with consistent, unwavering, and determined action.

"Miners have finally realized 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."

Rajeev Chopra
Global Leader – Energy & Resources
Deloitte Touche Tohmatsu

For more information, please contact a Deloitte mining professional:

Global contacts

Global Leader, Mining

Phil Hopwood

+1 416 601 6063

pjhopwood@deloitte.ca

Global Leader, Energy & Resources

Rajeev Chopra

+44 20 7007 2933

rchopra@deloitte.co.uk

Region/Country contacts

Africa

Andrew Lane

+27 11 517 4221

alane@deloitte.co.za

Africa

Tony Zoghby

+27 11 806 5130

tzoghby@deloitte.co.za

Americas

Glenn Ives

+1 416 874 3506

gives@deloitte.ca

Argentina

Edith Alvarez

+11 4320 2791

edalvarez@deloitte.com

Argentina

Alejandro Jaceniuk

+54 11 4320 2700 ext. 4923

ajaceniuk@deloitte.com

Australia

Ian Sanders

+61 3 9671 7479

iasanders@deloitte.com.au

Australia

Paul Klein

+61 08 9365 7060

pauklein@deloitte.com.au

Brazil

Andre Joffily

+55 21 3981 0490

ajoffily@deloitte.com

Canada

Phil Hopwood

+1 416 601 6063

pjhopwood@deloitte.ca

Canada

Andrew Swart

+1 416 813 2335

aswart@deloitte.ca

Canada

Ben-Schoeman Geldenhuys

+1 416 775 7373

bgeldenhuys@deloitte.ca

China

Kevin Xu

+86 10 85207147

kxu@deloitte.com.cn

Chile

Christian Duran

+56 22 729 8286

chrduran@deloitte.com

Colombia

Julio Berrocal

+57 5 360 8306

jberrocal@deloitte.com

France

Damien Jacquart

+33 1 55 61 64 89

djacquart@deloitte.fr

India

Kalpana Jain

+91 11 4602 1406

kajain@deloitte.com

Mexico

Cesar Garza

+52 871 7474401 x4401

cgarza@deloittemx.com

Peru

Karla Velásquez

+51 1 211 8559

kvelasquez@deloitte.com



Poland

Zbig Majtyka
+48 32 508 0333
zmajtyka@deloittece.com

Russia – CIS

Igor Tokarev
+74 95 787 0600 x 8241
itokarev@deloitte.ru

Southeast Asia

Rick Carr
+65 623 27138
RickCarr@deloitte.com

Switzerland

David Quinlin
+41 58 279 6158
dquinlin@deloitte.ch

Switzerland

Matt Sheerin
+41 58 279 7235
masheerin@deloitte.ch

Turkey

Uygar Yörük
+90 312 295 4700
uyoruk@deloitte.com

United Arab Emirates

Salam Awawdeh
+971 4 376 8888
SAwawdeh@deloitte.com

United Kingdom

Tim Biggs
+44 20 7303 2366
tibiggs@deloitte.co.uk

United Kingdom

James Ferguson
+44 20 7007 0642
jaferguson@deloitte.co.uk

United States

Sandeep Verma
+1 214 840 7182
sxverma@deloitte.com

United States

Amy Winsor
+1 303 312 4156
awinsor@deloitte.com

Endnotes

1. Deloitte, February 2017. "The digital revolution: Mining starts to reinvent the future." Accessed at <https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Energy-and-Resources/gx-er-digital-revolution-report.pdf> on October 23, 2017.
2. Deloitte, February 2017. "The digital revolution: Mining starts to reinvent the future." Accessed at <https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Energy-and-Resources/gx-er-digital-revolution-report.pdf> on October 23, 2017.
3. Deloitte, February 2017. "The digital revolution: Mining starts to reinvent the future." Accessed at <https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Energy-and-Resources/gx-er-digital-revolution-report.pdf> on October 23, 2017.
4. Deloitte, "Innovation in mining series" Accessed at <https://www2.deloitte.com/global/en/pages/energy-and-resources/articles/innovation-in-mining-series.html> accessed on October, 24, 2017
5. Vale, December 16, 2016. "Vale inaugurates the largest project in the history of the mining industry." Accessed at http://saladeimprensa.vale.com/en/Paginas/Articles.aspx?r=Vale_inaugurates_the_largest_project_in_the_history_of_the_mining_industry_&s=Mining&rID=979&sID=6 on October 24, 2017.
6. World Economic Forum, November 10, 2014. "Deep sea mining: the new frontier in the struggle for resources?" Accessed at <https://www.weforum.org/agenda/2014/11/deep-sea-mining-the-new-frontier-in-the-struggle-for-resources/> on October 24, 2017.
7. Deloitte, November 2014. "Agiletown: the relentless march of technology and London's response." Accessed at <https://www2.deloitte.com/uk/en/pages/growth/articles/agiletown-the-relentless-march-of-technology-and-londons-response.html> on October 25, 2017.
8. Deloitte, February 2017. "The digital revolution: Mining starts to reinvent the future." Accessed at <https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Energy-and-Resources/gx-er-digital-revolution-report.pdf> on October 23, 2017.
9. South32, 2017. "Women workers are a valuable resource." Accessed at <https://www.south32.net/sustainability/case-studies/women-workers-are-a-valuable-resource> on December 6, 2017.
10. Deloitte Review, July 31, 2017. "Tech fluency: A foundation of future careers," by Anthony Stephan, Martin Kamen, Catherine Bannister. Accessed at <https://www2.deloitte.com/dup-us-en/deloitte-review/issue-21/tech-fluency-mastering-the-language-of-technology.html> on October 26, 2017.
11. Hermes Investment Management, 2017. "Climate Change Shareholder Resolutions receive Board support of Anglo American, Glencore and Rio Tinto." Accessed at <https://www.hermes-investment.com/uki/blog/press/climate-change-shareholder-resolutions-receive-board-support-of-anglo-american-glencore-and-rio-tinto/> on December 7, 2017.
12. Brisbane Times, February 4, 2015. "BHP Billiton to follow Rio Tinto's tax transparency lead," by Amanda Saunders. Accessed at <https://www.brisbanetimes.com.au/business/companies/bhp-billiton-to-follow-rio-tintos-tax-transparency-lead-20150204-135thq.html> on November 30, 2017.
13. BHP.com. "BHP Billiton Foundation." Accessed at <https://www.bhp.com/community/bhp-billiton-foundation> on December 7, 2017.
14. Sudbury Mining Solutions Journal, November 14, 2016. "Mental Health training available to mining industry," by Kathy Stackelberg. Accessed at <http://www.sudburyminingsolutions.com/mental-health-training-available-to-mining-industry.html> on October 31, 2017.
15. Mining Magazine, August 25, 2017. "Aussie trucks go blue for mental health." Accessed at <http://www.miningmagazine.com/management/workforce-wellbeing/australian-trucks-go-blue-for-mental-health/> on October 31, 2017.
16. Mining.com, July 16, 2017. "Glencore tackles difficult subject through new charity," by Andrew Topf." Accessed at <http://www.mining.com/glencore-tackles-difficult-subject-new-charity/> on October 31, 2017.
17. Blackbook Motorsport, October 16, 2017. "Antofagasta Minerals named as title sponsor of Santiago ePrix," by George Dudley. Accessed at <http://www.blackbookmotorsport.com/news/antofagasta-minerals-named-as-the-title-sponsor-of-santiago-eprix> on December 7, 2017; Energy and Mines, November 8, 2017. "Chile's Antofagasta moves to renewable energy," by Kate Dougherty. Accessed at <http://energyandmines.com/2017/11/chile-antofagasta-moves-to-renewable-energy/> on December 7, 2017.
18. Rio Tinto, August 2017. "Iron Ore – delivering optimal value," by Chris Salisbury. Accessed at http://www.riotinto.com/documents/107089_Presentation_Iron_Ore_roadshow.pdf on October 31, 2017.
19. Hellenic Shipping News Worldwide, June 10, 2017. "Russia coal exports may be slashed by dust control measures." Accessed at <http://www.hellenicshippingnews.com/russia-coal-exports-may-be-slashed-by-dust-control-measures/> on November 1, 2017.
20. Mining.com, May 17, 2017. "Here's why Colombia's mining sector is losing its shine," by Cecilia Jamasmie. Accessed at <http://www.mining.com/heres-colombias-mining-sector-losing-shine/> on November 1, 2017.
21. The New York Times, April 1, 2017. "El Salvador's Historic Mining Ban." Accessed at <https://www.nytimes.com/2017/04/01/opinion/sunday/el-salvadors-historic-mining-ban.html> on November 1, 2017.
22. BBC News, July 25, 2017. "Acacia Mining rejects \$190bn Tanzanian tax bill." Accessed at <http://www.bbc.com/news/business-40714086> on November 1, 2017.
23. Quartz Africa, July 25, 2017. "Tanzania has hit a British mining company with a fine worth two centuries of revenue," by Yomi Kazeem. Accessed at <https://qz.com/1038094/tanzania-has-hit-acacia-mining-with-a-190-billion-fine-and-tax-bill/> on November 1, 2017.
24. De Beers Group of Companies, 2015. "Turning finite resources into enduring opportunity." Accessed at http://www.debeersgroup.com/content/dam/de_beers/botswana/media/reports/De_Beers_Impact_Botswana_2015.pdf on November 1, 2017.

25. CBC News, September 6, 2016. "Fort McKay First Nation to put \$350M into Suncor oil sands tank farm." Accessed at <http://www.cbc.ca/news/canada/calgary/first-nation-puts-350m-oilsands-project-1.3749640> on December 4, 2017.
26. Mimosi Peer Ledger Rangold, accessed at <http://mimosi.peerledger.com/> on December 14, 2017
27. The AusIMM Bulletin, June 2017. "How miners can improve water management," by Ralph Heath. Accessed at <https://www.ausimmbulletin.com/feature/miners-can-improve-water-management/> on November 6, 2017.
28. International Council on Mining & Metals, International Finance Corporation, 2017. "Water in the Mining Sector." Accessed at <http://www.ifc.org/wps/wcm/connect/ee079cb5-222c-4fe7-8844-8210ac77f0dc/ICMM-IFC-Water-and-Mining-FINAL.pdf?MOD=AIPERES> on November 6, 2017.
29. CDP, July 19, 2017. "World's mining heavyweights put \$16 billion at risk in climate costs." Accessed at <https://www.cdp.net/en/articles/investor/press-release-worlds-mining-heavyweights-put-16-billion-at-risk-in-climate-costs> on November 7, 2017.
30. ABC News, August 1, 2015. "Flooded Vietnam coal mines leaking toxic slurry into World Heritage-listed Ha Long Bay: environmentalists." Accessed at <http://www.abc.net.au/news/2015-08-01/heavy-rain-floods-vietnam-coal-mines-threatening-ha-long-bay/6665570> on November 6, 2017.
31. BHP, November 28, 2017. "Ten reasons why we like copper." Accessed at https://www.bhp.com/media-and-insights/prospects/2017/11/ten-reasons-why-we-like-copper?utm_source=Twitter&utm_medium=Organic&utm_campaign=Prospects&utm_content=TopReasonsCopper on December 4, 2017.
32. Canadian Mining Journal, 2017. "Getting to CMIC's zero waste vision." Accessed at <http://www.canadianminingjournal.com/features/getting-cmics-zero-waste-vision/> on December 4, 2017.
33. Shared Value Initiative. "Anglo American eMalahleni Water Reclamation Plant," by Chile Hidalgo, Kyle Peterson, Dane Smith, and Hugh Foley. Accessed at <https://sharedvalue.org/groups/anglo-american-emalahleni-water-reclamation-plant> on November 6, 2017.
34. Goldcorp. "Towards Zero Water (H2Zero)." Accessed at <https://www.goldcorp.com/strategy/reducing-costs/default.aspx> on December 4, 2017.
35. The Telegraph, July 19, 2017. "Elliott attacks 'disastrous' BHP Billiton plan to build potash mine," by Jon Yeomans. Accessed at <http://www.telegraph.co.uk/business/2017/07/19/elliott-attacks-disastrous-bhp-billiton-plan-build-potash-mine/> on November 7, 2017.
36. Financial Times, August 16, 2017. "Elliott raises stake in miner BHP Billiton to 5%," by Henry Sanderson. Accessed at <https://www.ft.com/content/e4a2f4c2-825f-11e7-a4ce-15b2513cb3ff> on November 6, 2017.
37. The Telegraph, June 22, 2017. "Peter Hambrø ousted from gold miner Petropavlovsk after losing board battle with Russian investors," by Jon Yeomans. Accessed at <http://www.telegraph.co.uk/business/2017/06/22/peter-hambrø-ousted-gold-miner-petropavlovsk-losing-board-battle/> on November 7, 2017.
38. Reuters, September 26, 2017. "Hedge fund Paulson & Co declares war on poor gold mining returns," by Nicole Mordant. Accessed at <https://ca.reuters.com/article/businessNews/idCAKCN1C120J-OCABS> on November 7, 2017.
39. Harvard Business Review, May–June 2017. "The Error at the Heart of Corporate Leadership," by Joseph L. Bower and Lynn S. Paine. Accessed at <https://hbr.org/2017/05/managing-for-the-long-term> on November 7, 2017.
40. Vimeo, November 17, 2017. "Ira Millstein at Ramsay Talks." Accessed at <https://vimeo.com/243664449> on December 6, 2017.
41. Bloomberg Markets, December 21, 2016. "Gold Miners Are Running Out of Metal: Five Charts Explaining Why," by Kevin Crowley. Accessed at <https://www.bloomberg.com/news/articles/2016-12-21/gold-miners-are-running-out-of-metal-five-charts-explaining-why> on December 4, 2017.
42. Mining.com, November 24, 2017. "Gold CEO lashes out against his industry." Accessed at <http://www.mining.com/web/gold-ceo-lashes-industry/> on December 4, 2017.
43. CNBC, October 24, 2017. "Goldman says market not 'fully appreciating' what's sending copper higher, as it ups forecast," by Patti Domm. Accessed at <https://www.cnbc.com/2017/10/24/goldman-says-market-not-fully-appreciating-whats-sending-copper-higher-as-it-ups-forecast.html> on December 4, 2017.
44. Money Metals Exchange, November 15, 2017. "Two-Thirds Of The Top Primary Silver Miners Suffered Production Declines In 2017," by Steve St. Angelo. Accessed at <https://www.moneymetals.com/news/2017/11/15/silver-miner-production-decline-001269> on December 4, 2017.
45. Mining.com, February 23, 2017. "Glencore sees zinc, nickel, copper price rally continuing," by Frik Els. Accessed at <http://www.mining.com/glencore-sees-zinc-nickel-copper-price-rally-continuing/> on December 4, 2017.
46. BloombergGadfly, August 18, 2017. "Zinc's Supply Surge Is Coming," by David Fickling. Accessed at <https://www.bloomberg.com/gadfly/articles/2017-08-18/zinc-s-supply-surge-is-coming> on December 4, 2017.
47. Wealth Research Group. "This Trend Is Truly Unstoppable," by Lior Gantz. Accessed at <https://www.wealthresearchgroup.com/fcc/> on January 12, 2018.
48. Mining.com, May 1, 2017. "Elon Musk's worst nightmare: child labor and cobalt supply." Accessed at <http://www.mining.com/web/elon-musks-worst-nightmare-child-labor-cobalt-supply/> on December 4, 2017.

49. Barrick, April 6, 2017. "Barrick Announces Strategic Cooperation Agreement with Shandong Gold." Accessed at <http://www.barrick.com/investors/news/news-details/2017/Barrick-Announces-Strategic-Cooperation-Agreement-with-Shandong-Gold/default.aspx> on November 9, 2017.
50. Financial Times, May 31, 2017. "Fosun buys stake in Russian gold miner Polyus," by Henry Foy and Henry Sanderson. Accessed at <https://www.ft.com/content/e5652edc-45fd-11e7-8519-9f94ee97d996> on November 9, 2017.
51. BNN, March 28, 2017. "Goldcorp buys Exeter, teams with Barrick on Chile mining projects," by Nicole Mordant. Accessed at <http://www.bnn.ca/barrick-goldcorp-team-up-to-develop-chile-mining-projects-1.708086> on November 9, 2017.
52. Steel Guru, July 25, 2017. "Mining Giants join juniors in the hunt for minerals. Accessed at <https://steelguru.com/mining/mining-giants-join-juniors-in-the-hunt-for-minerals/486005> on January 9, 2018.
53. Rio Tinto, July 6, 2017. "Digging, Data, and Disruption," by Bold Baatar. Accessed at http://www.riotinto.com/documents/170706_Digging_Data_and_Disruption_Mining_in_a_world_of_change.pdf on November 9, 2017.
54. South China Morning Post, November 13, 2017. "IAMGOLD leverages existing infrastructure and robust exploration to sustain reserve growth." Accessed a <http://www.scmp.com/country-reports/business/topics/canada-business-report-2017/article/2119085/iamgold-leverage> on December 5, 2017.
55. McKinsey & Company, September 2016. "The CEO guide to boards." Accessed at <https://www.mckinsey.com/global-themes/leadership/the-ceo-guide-to-boards> on November 14, 2017.
56. Deloitte Insights, March 7, 2014. "From diversity to inclusion," by Juliet Bourke, Christie Smith, Heather Stockton, Nicky Wakefield. Accessed at <https://dupress.deloitte.com/dup-us-en/focus/human-capital-trends/2014/hc-trends-2014-diversity-to-inclusion.html> on November 14, 2017.
57. International Energy Agency, 2017. "Global EV Outlook 2017." Accessed at <https://www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017.pdf> on November 15, 2017.
58. International Energy Agency, 2017. "Global EV Outlook 2017." Accessed at <https://www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017.pdf> on November 15, 2017.
59. The drive, August 8, 2017. Accessed at <http://www.thedrive.com/sheetmetal/13297/teslas-gigafactory-is-already-dominating-ev-battery-production-and-is-aiming-for-an-annual-lithium-ion-battery-production-capacity-of-35-gigawatt-hours-GWh> accessed on November 15, 2017.
60. Bloomberg, June 28, 2017. "China Is About to Bury Elon Musk in Batteries," by Joe Ryan. Accessed at <https://www.bloomberg.com/news/articles/2017-06-28/china-is-about-to-bury-elon-musk-in-batteries> on November 15, 2017.
61. BloombergGadfly, September 27, 2017. "Peak Lithium? Not So Fast," by David Fickling. Accessed at <https://www.bloomberg.com/gadfly/articles/2017-09-27/take-peak-lithium-forecasts-with-a-pinch-of-andean-salt> on November 15, 2017.
62. MarketWatch, October 13, 2017. "The Shift to Lithium is Much Bigger Than Predicted." Accessed at <https://www.marketwatch.com/story/the-shift-to-lithium-is-much-bigger-than-predicted-2017-10-13-8203463> on November 15, 2017.
63. Trading Economics. Accessed at <https://tradingeconomics.com/commodity/lithium> on November 15, 2017.
64. Benchmark Mineral Intelligence, May 4, 2016. "Graphite Demand From Lithium Ion Batteries To More Than Treble in 4 Years." Accessed at <http://benchmarkminerals.com/graphite-demand-from-lithium-ion-batteries-to-more-than-treble-in-4-years/> on November 15, 2017.
65. Graphite Investing News, October 23, 2017. "10 Top Graphite-producing Countries," by Siv Padhy. Accessed at <https://investingnews.com/daily/resource-investing/critical-metals-investing/graphite-investing/top-graphite-producing-countries-china-india-brazil-canada/> on November 15, 2017.
66. Cision PR Newswire, April 25, 2017. "Cobalt Prices to Rocket as Tesla and Apple Scramble for Supplies." Accessed at <https://www.prnewswire.com/news-releases/cobalt-prices-to-rocket-as-tesla-and-apple-scramble-for-supplies-620374383.html> on November 15, 2017.
67. The Economist, March 11, 2017. "Mining companies have dug themselves out of a hole." Accessed at <https://www.economist.com/news/business/21718532-electric-vehicles-and-batteries-are-expected-create-huge-demand-copper-and-cobalt-mining> on November 15, 2017.
68. RFC Ambrian, July 2017. "The Alchemist, Issue 31." Accessed at <http://www.rfcambrian.com/wp-content/uploads/2017/07/The-Alchemist-Issue-31-Cobalt.pdf> on November 15, 2017.
69. The Economist, March 11, 2017. "Mining companies have dug themselves out of a hole." Accessed at <https://www.economist.com/news/business/21718532-electric-vehicles-and-batteries-are-expected-create-huge-demand-copper-and-cobalt-mining> on November 15, 2017.
70. CNBC, October 24, 2017. "Goldman says market not 'fully appreciating' what's sending copper higher, as it ups forecast." by Patti Domm. Accessed at <https://www.cnbc.com/2017/10/24/goldman-says-market-not-fully-appreciating-whats-sending-copper-higher-as-it-ups-forecast.html> on November 15, 2017.
71. The Globe and Mail, October 31, 2017. "One metal will be transformed by the electric car boom" by Mark Burton and Jack Farchy. Accessed at <https://www.theglobeandmail.com/globe-investor/investment-ideas/nickel-forecast-charges-ahead-on-electric-car-battery-demand/article36784954/> on November 15, 2017.
72. Astronotes, September 22, 2017. "Asteroid Mining, the Next Frontier." Accessed at <http://www.armaghplanet.com/blog/asteroid-mining-the-next-frontier.html> on November 15, 2017.
73. World Resources Institute, May 25, 2016. "Countries' Clean Energy Commitments, by the Numbers," by Katherine Ross. Accessed at <http://www.wri.org/blog/2016/05/countries-clean-energy-commitments-numbers> on November 15, 2017.



74. Go 100% Renewable Energy. Accessed at <http://www.go100percent.org/cms/> on November 15, 2017.
75. Mining.com, July 5, 2017. "Getting scrappy: China iron ore demand may falter as steel recycling grows," by Manolo Serapio Jr and Muyu Xu. Accessed at <http://www.mining.com/web/getting-scrappy-china-iron-ore-demand-may-falter-steel-recycling-grows/> on November 15, 2017.
76. Mining Weekly, June 12, 2015. "Urban mining has long-term potential to contribute significantly to gold supply." Accessed at <http://www.miningweekly.com/print-version/urban-mining-has-long-term-potential-to-contribute-significantly-to-gold-supply-2015-06-12> on November 15, 2017.
77. Recycling International, November 4, 2016. "Ferrous scrap to gain 'maximum traction' in US\$406 billion metals market," by Kirstin Linnenkoper. Accessed at <https://www.recyclinginternational.com/recycling-news/10030/ferrous-metals/global/ferrous-scrap-gain-039-maximum-traction-039-us-406-billion-metals-market> on November 15, 2017.
78. CNBC, April 6, 2017. "In a new space age, Goldman suggests investors make it big in asteroids," by Lauren Thomas. Accessed at <https://www.cnbc.com/2017/04/06/goldman-sachs-tells-investors-to-consider-new-space-age.html> on November 15, 2017.
79. Planetary Resources. "A potential commercial space station market." Accessed at <http://www.planetary.org/multimedia/space-images/charts/a-potential-commercial-space.html> on November 15, 2017.
80. Futurism, May 28, 2017. "NASA Is Fast-Tracking Plans to Explore a Metal Asteroid Worth \$10,000 Quadrillion," by Karla Lant. Accessed at <https://futurism.com/nasa-fast-tracking-plans-explore-metal-asteroid-worth-10000-quadrillion/> on November 15, 2017.

Notes



www.deloitte.com/mining

Deloitte refers to one or more of Deloitte Touche Tohmatsu Limited, a UK private company limited by guarantee ("DTTL"), its network of member firms, and their related entities. DTTL and each of its member firms are legally separate and independent entities. DTTL (also referred to as "Deloitte Global") does not provide services to clients. Please see www.deloitte.com/about to learn more about our global network of member firms.

Deloitte provides audit & assurance, consulting, financial advisory, risk advisory, tax and related services to public and private clients spanning multiple industries. Deloitte serves four out of five Fortune Global 500® companies through a globally connected network of member firms in more than 150 countries and territories bringing world-class capabilities, insights, and high-quality service to address clients' most complex business challenges. To learn more about how Deloitte's approximately 245,000 professionals make an impact that matters, please connect with us on Facebook, LinkedIn, or Twitter.

This communication contains general information only, and none of Deloitte Touche Tohmatsu Limited, its member firms, or their related entities (collectively, the "Deloitte Network") is, by means of this communication, rendering professional advice or services. Before making any decision or taking any action that may affect your finances or your business, you should consult a qualified professional adviser. No entity in the Deloitte Network shall be responsible for any loss whatsoever sustained by any person who relies on this communication.