DIGITAL MINING IN THE AGE OF SOCIAL AWARENESS

April 2021

WIKISTRAT CROWDSOURCED CONSULTING

SANDPIT

TABLE OF CONTENTS

EXECUTIVE SUMMARY

INTRODUCTION

By 2030, the world will have changed in ways that will have profound effects on the mining industry and the people who rely on it. A shifting geopolitical landscape, demographic change, technological innovations, ecological changes, new methods of transportation, and increasing social awareness among consumers and employees are all drivers of change both today and in the future.

In order to explore the "new normal" that the mining industry will be operating under in the upcoming decade, Wikistrat and Sandpit Innovation partnered together to run an online simulation to explore scenarios for the mining industry in 2030, focused on how Environmental, Social, and Corporate Governance factors and digital technologies will combine and shape the mining industry in the next decade.

THE SIMULATION

The simulation ran online from February 22nd to February 28th, 2021. During this period, a crowd of 90 professionals from within the mining industry and experts from other industries and disciplines collaborated to generate more than 70 scenarios.

The simulation consisted of two phases:

- In the first phase, which ran for five days, the participants were asked to work together and develop scenarios for the future of the mining industry.
    - The participants were given two options for writing their scenarios. The first was by using a method called backtracking, by describing the "new

normal" for the mining industry in the year 2030 and walking the reader through the journey that led to it. The second option was to develop scenarios that were based on storytelling by focusing on the day in the life of a character who is part of the mining industry in the year 2030.

» In the second phase of the simulation, we asked the crowd to rank the likelihood of various trends and potential situations that would impact the mining industry and its ability to operate in the future environment.

FINDINGS

What the Crowd Desire

If all the scenarios, stories, and recommendations were to be condensed into a single insight, it would be this: The main factor that is about to shape the industry is the changing values of its employees. The increasing demand for transparency by the public and investors, the advances and spread in the use of technologies to share information, and the increasing competition to attract technological talent are some of the factors that will lead employees in mining firms to demand managements to accept and apply new norms.

Reading through the scenarios and the discussions, a clear insight has emerged that the crowd is not seeking solutions for the industry to respond to, adapt to, and adjust to the rise in social awareness, but for the industry to become an active force in leading such changes.

What the Crowd Project

The simulation clarified that the crowd is not only projecting that remote work is about to become the new normal, but that it is a necessary phase in the advance of complete automatization of all the mining operations. The driving force behind this will be the increasing value and demand for data in the decision-making process. As a result, mining firms will be valued based on their ability and potential to fulfill such requirements, and not only by the traditional economic performance indicators.

What the Crowd Fear

The main fear the crowd expressed across the scenarios and in the voting was an industry stagnation. This fear was expressed in the need to adjust norms to fit the ones of the employees, but also with a clear understanding that the new normal in which mining firms will be operating in the year 2030 will be one in which the new enforcer and driver of change is no longer the regulators, but the public. End-consumers will be raising the bar and demanding transparency and commitment to ESG standards.

What the Crowd Suspect

Various scenarios explored the possibility of industry disruption by technological companies, and while the crowd suspects that the "Teslaization" trend will spill over to the mining industry sooner rather than later, the majority of participants don't perceive it as an existential industry threat (a Kodak-type disruption) but as the emergence of a new type of actors alongside the traditional Tier I firms that are leading the industry.
The Recommendation

THE RECOMMENDATION

Across the simulation, the crowd primary recommendation to industry executives was to understand that now is the time to experiment, to take an active approach, to not sit on the sidelines, and to increase the number and investments in projects that are aimed at achieving better ESG objectives via the use of new technologies, adoption of new norms, and seeking to achieve higher transparency.

CHAPTER 1

INTRODUCTION

INTRODUCTION

By 2030, the world will have changed in ways that will have profound effects on the mining industry and the people who rely on it. A shifting geopolitical landscape, demographic change, technological innovations, ecological changes, new methods of transportation, and increasing social awareness among consumers and employees are all drivers of change both today and in the future.

However, the synergy between these drivers will combine in new ways that will drive the global dynamics into a different paradigm than that of today. These changes will impact the future for many mining firms, and the mining industry will need to transform itself to respond to the instability impacting many firms that will face novel and familiar challenges.

In order to explore the "new normal" that the mining industry will be operating under in the upcoming decade, Wikistrat and Sandpit Innovation partnered together to run an online simulation to explore scenarios for the mining industry in 2030, focused on exploring how ESG and digital factors will combine and shape the mining industry in the next decade.

The following report presents the key insights, analysis, and recommendations that were synthesized from the work of 90 participants who, over a period of seven days, generated more than 70 scenarios for the future of the mining industry in the upcoming decade, focusing on the impact that digital technology and the rise of social awareness will have on shaping the landscape in which the mining firms will be operating.

CHAPTER 2

STRATEGIC INSIGHTS

STRATEGIC INSIGHTS

- **Electric vehicles are changing the game:** Several experts in the crowd pointed out that the shift to electric vehicles will put consumers in a place where they shape and dictate the relations between manufacturers and the suppliers of raw materials. As a result, the pressure on the mining industry to change the way minerals are extracted will be a new normal that executives in the mining industry must adjust to and adopt as early as possible.

- **Remote work is only a means to an end:** During the simulation, various scenarios explored how various technologies will promote remote working in mines. Yet it was clear that promoting remote work is a step to a greater goal, complete automatization of the mining operations which in return lead to mining operations that are shaped and managed by data collected and easier to customize.

- **Leveraging Transparency:** The ability of some mining firms to provide information on the mining process will open new markets and a wider price range to sell their commodities. Various scenarios in the simulation explored the use and application of blockchain technology for this purpose, and to improve the trading process between buyers and sellers.

- **We are in the time of digital experimentation, and about to enter the era of wide adoption:** The crowd provided various examples of how the mining industry is already experimenting with digital technologies to achieve better ESG ratings. Rio Tinto is using Palantir to improve their decision-making process, Anglo American and De Beers are using blockchain to track high-value diamonds from miner to retailer using blockchain, and BHP is using IoT technologies to increase mine safety. The industry giants are already investing in applying and

experimenting with digital technologies, yet these are still specific cases and not a wider adoption.

» **Local communities are the new partners:** All the scenarios have clearly shown that in the upcoming decade, local communities are going to be at the center of the strategic planning of new and existing mines. As a result, mining firms will be required – by their employees, investors, and the public – to include these communities in the decision-making process and to share profits with them.

» **Transparency is already the New Normal:** The complex dynamics of the four Master Narratives described in this report highlight the urgent need for mining executives to adopt new norms in which transparency and information sharing with the public are not avoided but promoted to gain public support which will be in decline in the years to come.

» **AI as a commodity:** Several scenarios explored the possibility of advanced digital technologies such as AI becoming a platform to raise capital and achieve higher valuations from investors. As a result, these capabilities will become a high-end commodity evaluated not only by its operational benefit but also the financial one.

» **The Future of Work in the mining industry is outsourcing:** Participants in the simulation highlighted that the trend of outsourcing mining-related operations is likely to intensify in the years to come. As a result, mining firms will seek to decentralize their organizational models, allowing higher flexibility to outsource services.

» **The industry leaders are about to change, but not be replaced:** Although disruption was perceived by most of the crowd as inevitable, it wasn't seen as fatal. It seems that the crowd doesn't predict a Kodak-type disruption in which an external actor with superior technology will take over the industry, but more of an Airbnb-type one, in which mining firms will learn how to live with the new competition, losing some market share, but adapting to the new reality over time.

» **The public is the new king:** None of the four Master Narratives, which were based on the simulation scenarios, view the role of governments as the main driver forcing the mining industry to change or impacting the market landscape in which it operates. The new normal when it comes to ESG norms will be directed and driven by the public, making it faster, less expected, and harsher.

CHAPTER 3

ABOUT THE SIMULATION

CHAPTER 3

ABOUT THE SIMULATION

OVERVIEW

"The Digital Mining in the Age of Social Awareness" simulation ran for a period of seven days, from February 22nd to March 1st. During this period, a crowd of 90 professionals from within the mining industry and experts from other industries and disciplines collaborated to generate more than 70 scenarios.

The simulation ran online via Wikistrat's collaborative platform, which enabled the participating crowd to review each other's work, to collaborate in developing scenarios, and to engage in interactive discussions.

The simulation had two phases. In the first phase, which ran for five days, the participants were asked to work together and develop scenarios for the future of the mining industry. For this purpose, the crowd was provided with two choices of how to write their scenarios.

The first option was to write a scenario for the future of the mining industry, using a method called backtracking. This method requires the author to write their scenario from the end, by describing the "new normal" for the mining industry in the year 2030 and walking the reader through the journey that led to it. Based on that, we asked the crowd to provide a strategic recommendation to mining executives in terms of actions they should take at the present time. Using this method provided us with a bird's-eye view of various trends that are likely to take place and how they could merge, clash, and develop.

The second option was to develop scenarios that were based on storytelling by focusing on the day in the life of a character who is part of the mining industry in the year 2030. Each such scenario provided a detailed description of what this character's day looks like, focusing on their activities concerning the mining industry. The value

in using this method was that it gave us a ground-floor view of the various trends and how they will impact the individuals within it.

In total, the simulation's crowd of 90 participants generated more than 70 scenarios that looked at specific trends and drivers and the way they will crystallize by the year 2030. The use of two approaches allowed us to learn how these trends will emerge from the ground-floor and bird's-eye view perspectives.

In the second phase of the simulation, we asked the crowd to rank the likelihood of various trends and potential situations that would impact the mining industry and its ability to operate in the future environment. In total, more than 70 participants voted and provided valuable insights. These are further discussed later within this report.

DIGITAL MINING IN THE AGE OF SOCIAL AWARENESS

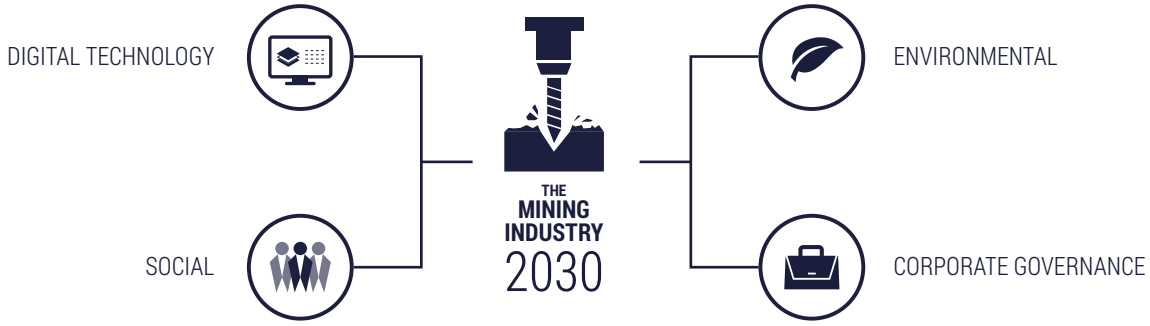
FEBRUARY 22-26, 2021

SIMULATION OVERVIEW

PHASE I: SCENARIO PLANNING

22.2.2021 - 26.2.2021

In the first phase of the simulation, the crowd developed more than 70 future scenarios for the mining industry in the year 2030.



PHASE II: VOTING

27.2.2021 - 1.3.2021

SCREENSHOTS FROM THE SIMULATION

Welcome Message

About The Simulation

Introduction

In 2030, the world will have changed in ways that will have profound effects on the mining industry and the people who rely on it. A shifting geopolitical landscape, demographic change, technological innovations, ecological changes, new methods of transportation, and increasing social awareness among consumers and employees are all drivers of change both today and in the future.

However, the synergy between these drivers will combine in new ways that will drive the global dynamics into a different paradigm than that of today. These changes will impact the future for many mining firms, and the mining industry will need to transform itself to respond to the instability impacting many firms that will face novel and familiar challenges.

The challenge today is determining what the future trends and drivers are, how they will combine to shape the future, what the market implications for the mining industry are, and what capabilities are required to meet these challenges.

Goals

This simulation has three objectives

- Map the technological, ESG, and other trends that will shape the mining industry in the year 2030, and explore how will these trends combine.
- Develop future scenarios for the mining industry in the year 2030 and understand how they will be impacted by the trends identified.
- Identify and explore potential black swans that could disrupt the industry.

Overview

DIGITAL MINING IN THE AGE OF SOCIAL AWARENESS
FEBRUARY 22-26, 2021

SIMULATION OVERVIEW

SCREENSHOTS FROM THE SIMULATION

Instructions

- In this collaborative phase of the simulation, you are asked to work together and develop scenarios for the future of the mining industry.
- We ask that you use a method called backtracking, starting from the end and describing the "new normal" for the mining industry in the year 2030. Then, we ask that you provide a description of the journey that led to this new normal. Finally, we ask that you provide a strategic recommendation to mining executives in terms of actions they should take at the present time.

How to Start:

There are several ways in which you can contribute:

- **Comments** – You can review the entries, leave comments, and engage in discussion with other experts.
- **Writing new entries** – Click on the **"Add a scenario "** button. You will be directed to a template that you can edit by either clicking on **"edit"** in the top right corner or typing **"e"** on your keyboard.
- **Directly editing the text** – You can dive in and directly edit the text in a scenario with additional information and knowledge.

This video explains how to add a scenario (tutorial)

Geopolitical | Economy | Social | Technology | Environmental | Other

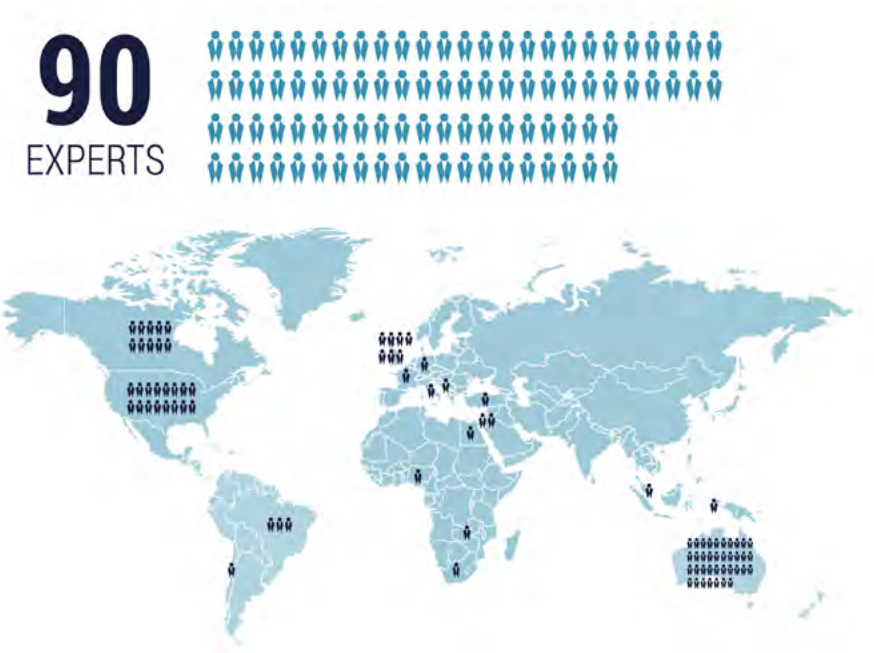
Page	Summary	Author	Replies	Likes
A renewal of risk management	The limits on reliability and security of artificial intelligence and automation lead to a new risk management culture.	 Feb 23, 2021 @Russell King	4	6
An intelligent mining solutions company ROVMINE founded by former NASA Mars Perseverance engineers and geologists has now become a market leader in the field	Mining giants now a days have become only the leasing agents obtaining mining leases from the government while the real mining operations are run by SME companies which specialises in intelligent solutions working on data gathered from instruments which are larger version of certain instruments used on Mars Perseverance rover...	 Feb 04, 2021 @Sourabh Sharma	3	0
Applications of Technology to New Mining Challenges and Opportunities	The mining industry has a long history of technical evolution in response to physical, environmental and social challenges. It is probable that this tradition will continue and, by 2030, the mining industry will have adopted a number of technological innovations in response to new and emerging challenges: • The dramatic drop...	 Feb 18, 2021 @Andrew Shook	21	5
At the gate	At the gate, once you arrive to any mine, you will stand on an AI totem where just in one read will create the following information: 1. Visit status: by voice ID number will be tracked to contracts or visit pass. Creating room number if needed, transportation, food availability, among other...	 Feb 18, 2021 @Pamela Chavez Crooker	22	2

ABOUT THE CROWD

In total, more than 90 people from more than 15 countries took part in the simulation, with more than 60% of them linked to the mining industry. Although the crowd consisted of professionals from the oil and gas, energy, and automobile industries, the miners were the "loudest voice in the room."

The overwhelming majority of the crowd was Western, with 42% of participants from Australia and another 36% from the US, Canada, and the UK. As a result, most scenarios were written from a Western perspective, with a focus on Western values and norms.

The crowd was generally fairly experienced, with the average years of experience of participants being over 15. This is quite common in simulations related to mining, yet it is worth mentioning that the technology experts were younger in age.



DIVISION OF EXPERTS BY:
GEOGRAPHICAL LOCATION

AUSTRALIA 37	ITALY 1	MONTENEGRO 1
BRAZIL 3	LATVIA 1	US 16
CANADA 10	ISRAEL 2	UK 7
CHILE 1	MALAYSIA 1	TURKEY 1
FRANCE 1	SINGAPORE 1	ZAMBIA 1
EGYPT 1	SOUTH AFRICA 3	
GERMANY 1	NIGERIA 1	

DIVISION OF EXPERTS BY:
INDUSTRY

- CONSULTING (MINING) 32
- MINING 25
- TECH 18
- ACADEMY 5
- GOVERNMENT 2
- NON PROFIT 2
- ENERGY 3
- FINANCE 3

CHAPTER 4:
METHODOLOGY

CHAPTER 4

METHODOLOGY

SCOPE

The simulation's scope was limited to a time frame of ten years into the future, which focused on how the mining industry market landscape will be shaped by digital technologies such as AI, Blockchain, Machine Learning and more.

In addition, we asked the participants to analyze how these technological developments will combine with the trend of increasing social awareness, with a specific focus on norms and values in relation to Environmental, Social, and Corporate Governance (ESG) factors.

The simulation did ask participants to explore scenarios using backtracking, in order to identify potential pathways and trajectories for the future landscape in which it will operate. This approach is limited, as it focus on how macro trends and external factors will shape the projected landscape. The crowd was also provided with the possibility to write stories for characters within the industry, in order to explore scenarios of the future from the individual perspective. This approach is limited as it focus less on how and why certain scenarios developed, and more on the impact they will have on individuals day-to-day life.

In addition, the simulation didn't ask participants to review other domains and topics such as the global economy, geopolitics, internal politics in the home countries, or changing demographics. Neither did the simulation focus on specific commodities, new products, or new business models.

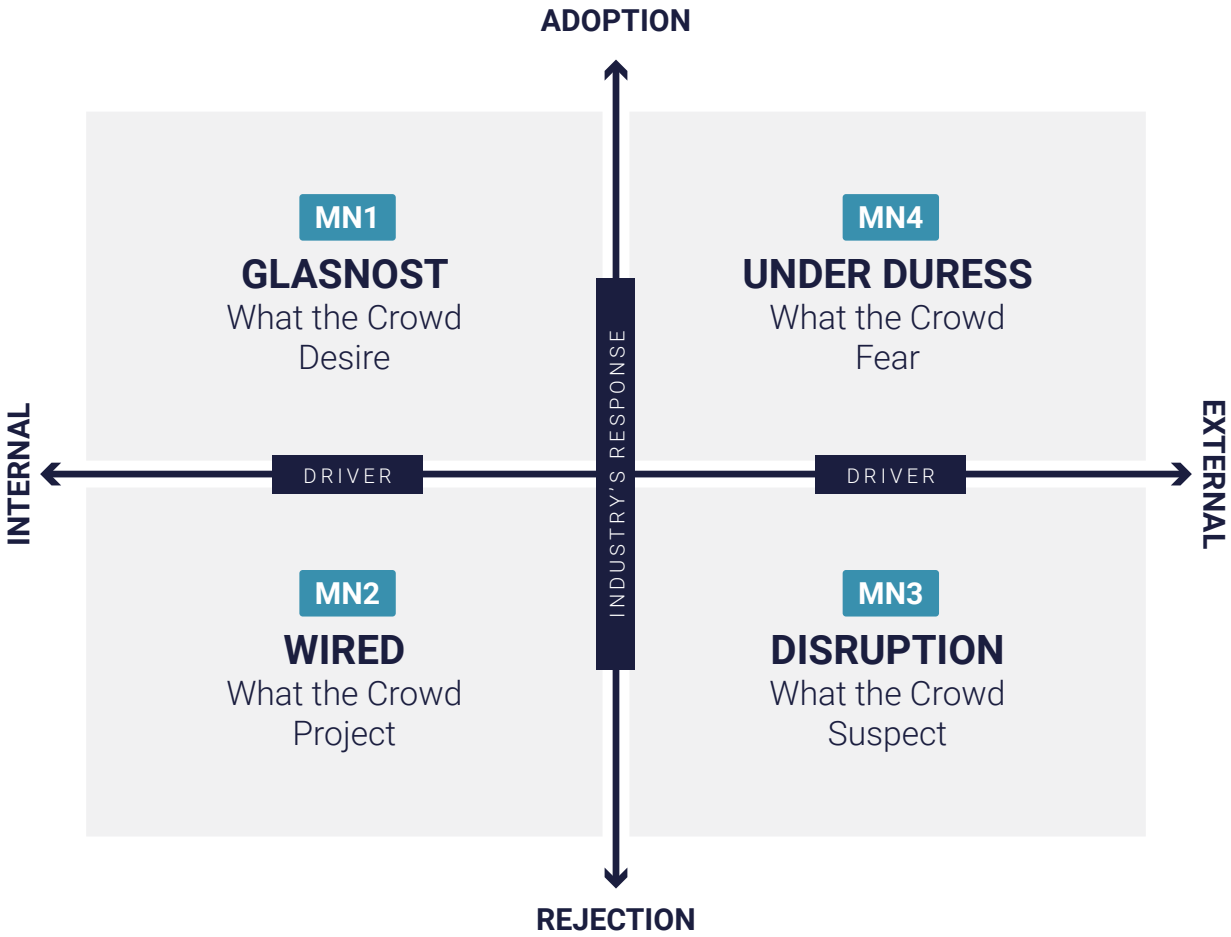
OVERVIEW OF MASTER NARRATIVES

A Master Narrative consists of a distinct grouping of individual scenarios, together forming an alternative world in which the mining industry will be operating in the year 2030, with a specific focus on the impact digital technology and ESG norms will have on shaping that future (in in accordance with the simulation's scope).

In total, more than 70 scenarios were developed by the crowd that participated in the simulation. The following chart has been generated by clustering these scenarios into four main Master Narratives, which are organized along two fundamental axes.

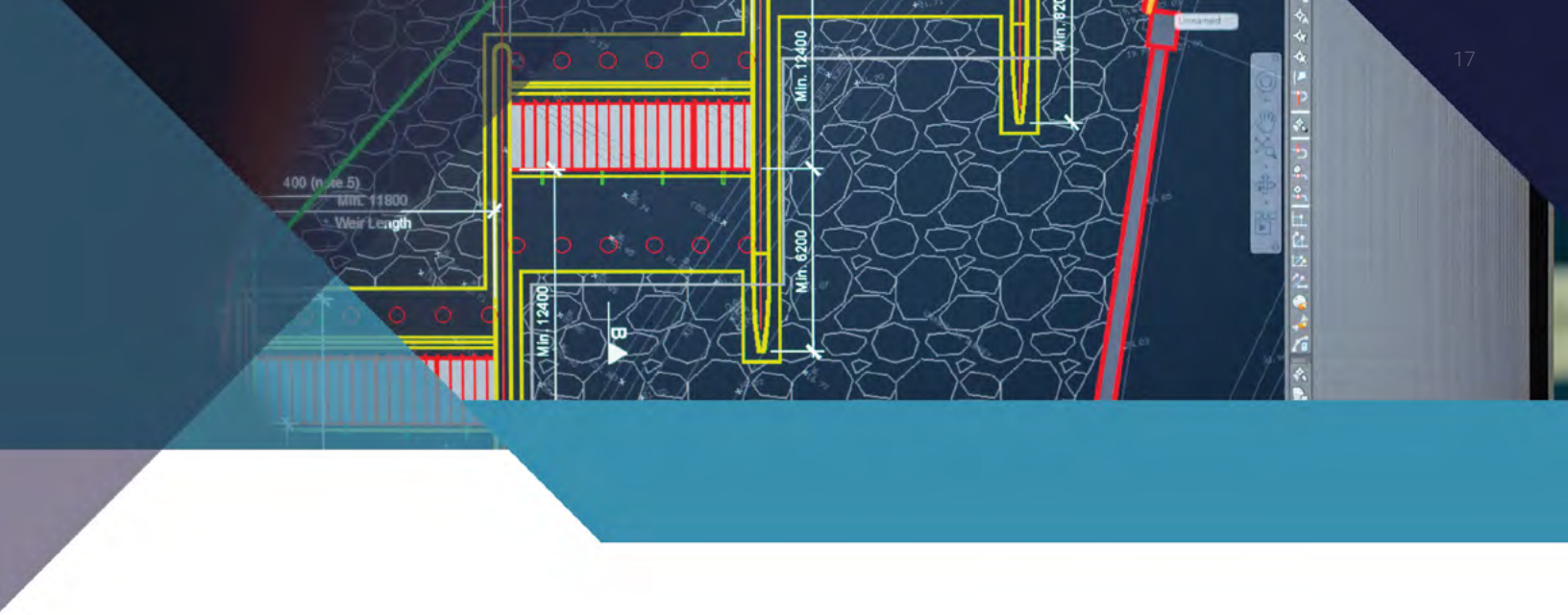
The horizontal X-axis addresses whether the mining industry is shaped by internal industry dynamics or external drivers that will be shaped by the competition and demand. The vertical Y-axis addresses whether the tier one companies leading the mining industry will quickly adopt and accept the changing environment in which they are operating or, rather, reject change and try to hold onto the current state of affairs for as long as possible.

MASTER NARRATIVES



CHAPTER 5:

INSIGHTS



MASTER NARRATIVE I

GLASNOST

The following Master Narrative, which explores an industry response of adoption pressured by internal drivers, is the one the crowd – the majority of whom are from the mining industry – desire the most.

This explores how critical trends and dynamics within the mining industry might intersect to create a future in which, by the year 2030, mining firms will be pressured by their employees to adopt a new set of social and environmental standards and norms.

This adoption will lead to a policy Glasnost, referencing the policy instituted by Mikhail Gorbachev in the late 1980s that set in motion the democratization of the Soviet Union. Similarly, in this alternative future, mining firms will adopt transparency and open discussion on social and environmental issues, which will ultimately lead to a fundamental change in how decisions are made.

When participants were asked to rank to what extent they expect fear to be a factor in preventing the industry from acting, only 34% of participants voted it to be such a factor, suggesting the cultural environment is ripe for change.

In addition, almost all the scenarios that were developed in the simulation have shown a strong indication of the wish to see the industry moving from where it is now to this new normal. The discussions about change primarily explored the mining industry's relations with local communities, which is the focus of this Master Narrative, and on the working conditions and the corporate culture within it.

Drivers of Change:

Various scenarios in the simulation presented the need for mining firms to better acknowledge local communities in the strategic mine plans and involve indigenous owners in the workforce and in the boards.

According to this simulation's participants – more than 60% of whom work within the mining industry – this trend is likely to intensify in the upcoming five years and will be

led by employees within the industry who are seeking cultural change, transparency, and openness.

Another factor within this trend that was highlighted by the crowd was the shift to hybrid teams that would require mining firms to recruit and work with employees from high-tech industries, who in return will be serving as agents of change, importing the "do no evil" norms and values that are highly regarded in the high-tech sector into the mining industry. Participants cited the 2018 Google Walkouts as an example of the type of actions we are likely to see spilling over and carried by employees within the mining industry.

Another trend that will accelerate this process and was explored by the participants was the adoption of new digital technologies, such as AI, VR, IoT, and blockchain being used by mining firms to increase transparency, engage communities, and ensure mining standards and responsible practices.

More than 15 scenarios explored how digital technologies, which are going to be more readily available and cheaper, will be used for leveling the knowledge access for community members, the gathering of information by the public, and the sharing of information by mining firms, with the goal of connecting indigenous communities with miners and increasing their involvement and interaction with miners on the ground.

The New Normal

The shifting social norms within the mining industry, accelerated by digital technologies that will better connect communities to miners, will lead to a new normal in which mining firms will adopt a corporate culture that focuses on restoring and gaining the trust of local communities by providing them with access to information in real-time. This will allow them to be incorporated in the decision-making and easily connect them to mining executives.

> *"Already mines do a full Environmental and Social Impact Assessment prior to permitting and development, and this almost always includes local healthcare data.*
>
> *The idea of that social baselining is to be able to track trends in the area over time, following arrival of the mining activities. The potential for vastly superior quality of localized data in these kinds of social performance monitoring activities is certainly exciting and a key part of company-public transparency."*
>
> ***Elizabeth Freele***
> *Chief Communications and Sustainability Officer at Hyphae*

EXECUTIVE INTERVIEW

NEW NORMS ARE SHAPING THE INDUSTRY

Click here to listen to the full interview

Therese Muirhead is a Senior Consultant at Sandpit. She is a psychologist and organizational development specialist with 14 years of experience working within and for organizations across various industries.

David Andrews is a Principal Mining Engineer at Sandpit, and he has more than 20 years of experience in the mining industry, most of it with Vale, where he was the Director for Mining Technical Services at the North Atlantic region.

Oren Kesler: What are the changes in behavior that we are likely to see within the mining industry concerning relations with the local communities?

Therese Muirhead: I think, particularly here in Australia, one huge step would be to acknowledge and tell the truth around the history and the story of Aboriginal people in this country so that group of people in our community can really be engaged in the mining industry, which is where a lot of that work happens in these traditional communities. So, I think having a greater understanding of the truth of our history will lead to better engagement, which will only lead to those solutions for how we engage with local communities.

Another one is around no FIFO, so no fly in, fly out. That just doesn't exist anymore. So if that's the case, what is the community that's built around a processing plant or a mine site, and how does the business set up to, kind of, come into that community and to support that community? And that is an ongoing and evolving conversation and set of, kind of, actions.

The third point that I'd make is around the interaction with the community around regeneration. So, we have thousands and thousands of mine sites in Australia that have been mothballed, and there's more opportunity to regenerate those mine sites and combine industries like agriculture and mining with that community input to create something that's better.

David Andrews: I think what we're starting to see within the broader industry – and we see this even in the consultancy that we both work in – is that there's a whole new group of employees in the younger generation that value choice over some of the other more traditional values that I personally might have grown up with. And so if you have choice, and you can choose to work for a company that is adaptable and changes fast and can respond to your requests, that is naturally going to change and shape the pace at which these organizations can grow.

I'm also seeing a shift in broader capital markets, in terms of their willingness to fund company projects. So there are very different criteria emerging, other than just return on investment and country risk. And it's more in what is your engagement program? What is the baseline study that you've done, and can you prove it to me? How are you at engaging with the community?

And these are very much in the environmental, social side of things. And so you kind of get a hit from two sides, where the companies that have the ability to react and move fast will both be able to attract funding faster and from different sources, but they're also going to attract a

very different and much more willing employee base. And I think that those are two significant drivers in this industry, which runs largely on people, currently, to do work, but also is a very capital intensive industry. So the requirement for upfront funding is necessary.

Oren Kesler: Therese, do you think there is a way for mining firms to change the narrative in their favor?

Therese Muirhead: One thing that comes to mind specifically is there's a lot of work in the space at the moment around changing the kind of language of economics. And I referenced donor economics in my simulation, and there're countries that are working on a well-being economy. So, looking at measures that are more than just growth. It's not about forgetting growth or focusing on de-growth, but it's growth and building communities, growth and saving the environment, or putting a halt to carbon emissions and putting a halt to climate change.

I think one thing that I'd love to see or hear coming out of mining companies is just kind of shifting their own mindset on the measures of success and the measures that are important at an executive level. That is, yeah, returning funds and value to shareholders, but also returning value to the communities we operate in, the people who we employ and their families, and also the environment or reducing emissions from an environmental climate change perspective. So I think that would be one thing to be talking about publicly, which would give me hope that they're legitimately looking at this problem from the edges and every part of the system.

Oren Kesler: Dave, in your opinion, how can digital technologies be used by mining firms to better connect local communities and improve the norms within the industry?

David Andrews: In the last couple of months, I've very much been working with a local machine learning data science organization in Perth, and very much in the learning curve for myself. And also working with some founders and co-founders of local tech startups. And so I come from a world inside a major mining house where we had the same ambitions that are generally spoken about on the street, which is are we going to do automation and become a digital company? And what I've realized, stepping outside that world, is there's actually an absence of a true tech knowledge base at the leadership level in big mining companies. And I don't mean to say that in a negative sense, it's a huge opportunity. But the tech world is a very different culture, and so to bring those two groups together takes effort and conversation and learning about what the other does and what actually is possible.

And so the first step is to start the conversation about what is and is not possible. And that's beyond some of the buzz words. And when you get into the world of things like machine learning and artificial intelligence, one of the big reactions we've been faced with from some clients is when you start to speak about those things, you get an initial fear response from the employee base, fearing to be replaced. And then the opposite response, generally from a management side, which is if I replace those people with machines I can save X amount of money. But what I've actually come to realize in talking to the digital technology folks is that machines have some fairly significant limitations. And they do really well at structured things, repetitive things, and that all fits in sort of this explicit knowledge task that humans in a lot of companies do.

But when you think of a world where you could start to automate or use tech to really enhance the speed in some of those things, the people in your organization, they get freed up to be able to do spectacular things in the world of problem solving and innovation. So I think really, to bring this thought back to the beginning of where I started, it's about changing the narrative and the conversation about mining and digital. And it has to happen at a much more open dialogue, I think, so that you really start to find a place for how the world of tech going to enhance your people's ability to really start to transform your business.

MASTER NARRATIVE II

WIRED

The following Master Narrative, which the crowd project to be very likely, explores how the slow adoption/rejection of digital change by the industry giants will allow Tier II companies to grow by quickly adopting digital mining.

In this future, digital technology will be accessible and used by Tier II mining companies, which are likely to adopt it at a faster rate and will use it to improve production while, at the same time, decrease costs and reduce their environmental footprint.

A potential side effect of this trend would be the emergence of a "mining Tesla," a mining company that will be valued primarily for its innovation in areas related to digital technology and sustainable mining, and not for its productivity and profits.

Participants predicted that by the year 2030, the use of data to increase mining efficiency will have the same impact on mining as fracking technology had on the oil and gas industry in the previous decade. A new set of technologies will help smaller companies to tap and explore areas that were considered not profitable, opening the market to new deposits and increasing productivity and efficiency, creating a market that is highly proliferated with new suppliers in comparison to today's situation. This trend is likely to accelerate as the prices of raw materials such as copper, zinc, gold, and uranium continue to increase.

> *"Increasing speed of execution and therefore also increasing production volume does not necessarily lead to a 'better mine.' I would prefer to have a mining operation that can quickly respond to customer pull based on the demand of downstream products. With a fully automated mine and a flexible 'ore manufacturing' system, combined with making a direct link between raw material supply and end product consumption, we could turn the tap on/off as needed."*
>
> ***Laura Mottola***
> *CEO of Flow Partners Inc*

When asked to rank the likelihood of digital technology disrupting the mining industry in the upcoming 10 years, 71% of the participants voted it to be likely to very likely.

In addition, the simulation's scenarios that focused on technology were categorized by the proliferation of what used to be exclusive technologies and the emergence of new service providers, allowing tier two companies the ability to acquire new capabilities, with new companies joining the exclusive tier one club, making it more crowded and competitive.

Drivers of Change:

Participants in the simulation viewed COVID-19 as the accelerator to digital trends and processes that were already in motion prior to the pandemic. **Yet many of them think that smaller companies are likely to benefit the most from these trends, as they will be able to adapt faster than the bigger ones.**

One of the trends that participants pointed to was the increase in the use and the development of remote operations of mobile mining equipment, which they predict will eventually become autonomous. This trend, combined with the developments in data aggregation and analysis of fuel consumption, is likely to provide Tier II mining firms with the ability to reduce cost and extract minerals at a higher efficiency.

This trend will also include an improvement in the ability to measure and seek hidden value points. The crowd constantly engaged in a discussion as to which activities will be measured and what parameters will be used in order to increase mining efficiency, but it was clear that mining firms are actively investing and seeking new ways to collect and analyze data.

For example, one of the scenarios explored how dust analysis will command where and how much water to use. Another set of scenarios explored how tailings monitoring using nanotechnology, AI, and predictive analysis will provide performance-based, risk-informed decision-making and allow investors and the public to learn about the environmental impact. A different scenario looked at how digital technologies will allow Tier II firms the ability to promote their resources as part of a circular process, allowing them to set different price points in the market.

The New Normal:

The crystallization of this new normal will happen when the movement from remote work to complete automatization of work starts to take place. As less labor will

> *"In the past, I've seen a lot of structures whereby teams are created around specific initiatives, but a lot of companies are moving away from that model. Already within our group, we have squads of individuals who actually belong to different companies. Whether they are an internal employee or part of a consulting firm or third party developer, we see this notion of individual employees moving from project to project as opposed to remaining with a single company."*
>
> ***Adrian Heieis***
> *Product Owner at Teck Resources Limited*

be required to operate mining equipment, Tier II mining firms will increase the use of technology companies that offer SaaS products, with a focus on remote and autonomous operations.

The use of digital technologies will also allow Tier II mining firms to use their size as an advantage when streamlining operations, equipment maintenance, and supplying spares to the mine sites, which participants predict will probably increase in volume and frequency.

In addition, participants developed scenarios in which Tier II companies will operate new circular business models that will use the data collected to reduce the environmental footprint of their products, allowing them to brand themselves as innovative and green in comparison to tier one firms that will be slow to adopt the new technologies.

> *"There are more and more cases where open data and transparency have beneficial results to the organization even though it seems to go against the norm of keeping data under lock and key for fear of being undercut. While I do believe there is some information that is important to keep confidential, I've noticed that organizations tend to put almost all of their data in that category not realizing that it is actually hurting them."*
>
> ***Steve Rader***
> *Deputy Director for the Center of Excellence for Collaborative Innovation at NASA*

MASTER NARRATIVE III

DISRUPTION

The following Master Narrative, which the crowd suspect is already shaping, explores how the mining industry will be disrupted by external actors that will take advantage of the industry's slow adoption of digital technology to gain a foothold in it.

In this future, companies with superior digital technology capabilities and available capital will gain market share by merging and acquiring mining firms, mines, and knowledge. This, in turn, will lead to a situation in which new investment capital will flow into the mining industry, accelerated not only by physical assets but also intellectual ones.

When asked to rank the likelihood of the potential trend in which companies from outside the mining industry (i.e. Tesla) will disrupt the industry in the upcoming 10 years, 66% of participants voted it to be likely to very likely.

Participants also predicted that, by the year 2030, the auto industry will fully transition to producing electric vehicles, which will pressure the mining industry to invest in digital technology that provides consumers with more information about the origin of the resources used to build the car and about the environmental impact that building the car had, a trend that will also impact the price of resources.

Drivers of Change:

Participants in the simulation viewed technological developments that are taking place outside of the mining industry as the main driver shaping this future. Developments in the areas of quantum computing, AI, 5G, cloud capabilities, decision intelligence, and Big Data and analytics are just some of the trends that were discussed by the participants as potential developments that will accelerate the mining industry transition to complete automatization.

One of the scenarios that were developed by the crowd explored how, by 2030, Tesla will be operating several deposits without a material impact on the above or below ground ecosystem. While, initially, this process would be expensive and deposits acquired by Tesla would be small/ lower quality, through continuous optimization, automation, and digital analytics, the costs would quickly decrease. This mining division of Tesla

would be acquiring lower-grade deposits around the globe, positioning itself as a world-first sustainable producer of minerals such as copper and iron.

Another trend that could accelerate this process is potential mergers between companies developing space technology and small mining firms. The idea explored by these scenarios was that a specific group of tech companies, such as SpaceX, will seek to acquire more experience and knowledge in mining as part of their goal of developing space mining capabilities by testing new technologies used for autonomous exploration systems, use of satellite data, and other operational solutions that will be based on complete automatization.

The New Normal:

From the scenarios developed by the crowd – the majority of whom are working within the mining industry – it was clear that although they view digital technological developments as game-changers in the transition to mining 2.0, none of the mining giants are currently working on developing such capabilities in house; they are strategically seeking to acquire these in the form of services (SaaS) or to outsource it.

This trend will lead to a shift in the landscape of the mining firms operating in the sector (as described in Master Narrative II), but also will make the industry more vulnerable to disruption in the form of technological firms seeking to expand into new markets.

> *"Companies like Tesla, who are manufacturers of batteries and electric vehicles and so on… What we're seeing them do is reach back down the supply chain to set up off-take agreements with mining companies directly. And so, what they're doing is they're leveraging their commercial muscle to establish the terms under which they will buy those raw materials. And they're doing it both from an environmental sustainability perspective, but also for the security of supply. So, I think that's a more obvious mechanism where we're seeing a change in the behavior, and we're seeing different companies actually starting to, I guess, work directly with mining operators, and step through the sales marketing, supply, logistics, and get all the way back to the source. That's one potential pathway we are seeing evolve."*
>
> ***Dr. Alan Bye***
> *Director of Digital Value Chains at Curtin University and founder of Imvelo Pty Ltd.*

EXECUTIVE INTERVIEW

CHANGE IS COMING

Click here to listen to the full interview.

Dr. Alan Bye was most recently Vice President of Technology at BHP, accountable for the execution of major innovation programs across five commodity value chains covering both digital and extractive technologies. In this interview with Wikistrat's CEO, Mr. Oren Kesler, Dr. Bye talks about the trends shaping the mining industry today and in the future.

Oren Kesler: One of the alternative futures that we have seen also crystallizing in this simulation was the idea of the industry being disrupted by external actors. How likely do you think this kind of scenario is? How much do we see companies such as Tesla posing a threat to the traditional mining firms that are operating in the mining industry today?

Alan Bye: Disruption is the radical change to an existing industry or market due to technological innovation. So, with the emphasis there, it's a radical change to an existing industry where technology is driving that change. And so, when you frame it in that way, the mining industry has a number of barriers to entry. And so, while we'll see some disruption to different parts of the industry, it's difficult to predict that there's going to be a wholesale disruption of the entire mining industry. And part of the reason is that geographically, the resources industry has different endowments in the ground in terms of quality of resources. There is varied ownership of the tenements to access those resources, and also mining licenses, and these licenses are awarded for long periods of time. The legislative environment is quite onerous if you want to actually operate these mines. And it's a very capital-intensive industry.

And so, when you think about those aspects of the industry, and you compare it to the media industry where there's been massive disruption through digital technology in the last ten or fifteen years, the barriers to entry are quite different. And so, while we can definitely expect disruption. I wouldn't forecast that it's going to disrupt the whole industry and all parts of the industry. I will say, though, that I think we can expect more change in the next ten years than we've seen in the last 50 years, because of all of these mega-trends that are coalescing around the mining supply chain at the moment.

Oren Kesler: Do you think it's plausible for a company that is very strong on the technology side – let's take, for example, Tesla, or Google – will look into getting into the mining industry doing it through mergers and acquisitions?

Alan Bye: It's definitely plausible, Oren, but I think that is an extreme case. So, if you look at the OEMs and companies like Tesla, who are manufacturers of batteries and electric vehicles and so on, what we're seeing them do is reach back down the supply chain to set up off-take agreements with mining companies directly. And so, what they're doing is they're leveraging their commercial muscle to establish the terms under which they will buy those raw materials. And they're doing it both from an environmental sustainability perspective, but also for the security of supply. So, I think that's a more obvious mechanism where we're seeing a change in the behavior, and we're seeing different companies actually starting to, I guess, work directly with mining operators, and step through the sales marketing, supply, logistics, and get all the way back to the source. That's one potential pathway

we are seeing evolve.

Oil and gas companies have to be looking at different futures and how they leverage their capabilities and their technology base. And so, it's possible that they could see the resources industry, or the mining industry, as a way to generate new businesses for themselves. We can also see the oil and gas service providers, who are extremely advanced in their technology solutions, looking to diversify across into the mining industry. That's not new news. I think that's been spoken about for a long time, but we haven't really seen the penetration happening yet.

Oren Kesler: How do you think the mining industry is likely to adopt new environmental regulations and how will they impact it? Which kind of approach do you think the mining executives will choose to take?

Alan Bye: The tier one players within the mining industry are very likely to be at the front end of adopting best practice, leading the environmental and responsible management of resources, because they're very visible, and they tend to have contracts with the premium consumers and customers for their products. Now, there are three aspects to this. There is a commercial driver for these environmental regulations, and these are groups like the EU who are very much setting high standards around what they will commercially procure, what they will allow to be shipped into the EU.

So, that's one aspect of the regulations. The second one is compliance. And these are government environmental agencies that are continually raising the standard of approvals and operating requirements. And it's fair to say that in first-world jurisdictions, these environmental standards are very high, and they're onerous and the companies work very hard to make sure that they achieve them. It's also fair to say that there's more of a compliance issue than a regulation issue. So, tailings dams are a good example. The problem there is not regulations, the problem is around compliance and quality assurance in terms of achieving those regulations.

Now, the third driver for the adoption of these regulations is investors. So, we're definitely seeing investors being vocal around their expectations. If they're going to provide capital, they want to make sure that it's being invested into resources that are going to be sustainably operated, that have environmental credentials, and that take care of climate change impacts. And so, these are the three drivers that are pushing the mining industry to adopt the regulations around environmental and sustainability standards.

Oren Kesler: Do you think there's a chance that we're going to see those kinds of regulations separating the tier one companies from the tier two and tier three even more?

Alan Bye: I definitely think it's going to cause an even bigger spread of performance in the mining industry. And the reason for that is the consumers are quite different. A consumer in Europe and the US will have very clear requirements around their off-take agreements, and the tier one miners will supply that. There are other consumers, in other parts of the world, that don't have those standards or expectations, and they effectively buy products on a price basis.

And so, for a long time, there'll be space for companies to participate in supply chains that don't have the same level of regulation or quality assurance around those products. So, there'll be a very uneven application of the impacts of these environmental regulations over a long period. And so, to your point that the tier ones will have an even higher performance standard and there'll be a long tail in terms of performance and timing with the rest of the industry.

And I think there's also a perception that there'll be a price premium to be had for those companies that have the best performance in this area. I'm not sure that's necessarily the case, because the market is big and diverse and price generally dominates transactions.

I think what you might see, though, is a greater spread in the prices. So, for those companies that have very low performance, they may only be able to get a low price for their product because the market is smaller. And for the bigger companies, it will be an expectation that if they're going to sell their product, they meet these requirements. This is why improving productivity is so important for the mining industry to be able to fund these additional expectations.

MASTER NARRATIVE IV

UNDER DURESS

The following Master Narrative represents what the crowd fears the most – an industry pressured by the public, investors, and regulators to adopt changes in its corporate governance.

When participants were asked to rank the impact ESG regulation have on changing the practice of mining companies, 79% of participants voted it to be high to very high and 55% answered that, in their opinion, the mining industry in its current form has a low to very-low likelihood of thriving under ESG regulations.

In this Master Narrative, by the year 2030, mining firms will struggle to adapt to the new ESG norms. As a result, they are not going to be on the side that benefits from digital technology, but will be pressured by it. In this future, digital technology will be used to monitor mining activity not only by regulators but also by clients, consumers, and investors seeking to enforce new corporate culture.

In addition to public pressure to follow ESG regulations, EV companies will be under increasing scrutiny for environmental practices as the oil and gas industry and incumbent auto lobbies will try to slow them and save market share. As a result, EV

> *"The new normal for developing a mine through project phase and into production will be proactive engagement and transparency with the locally impacted communities and close and cooperative relations with regulatory agencies and officials who have jurisdiction, at all levels of government. Several forward-thinking mining projects in the USA use this approach since it is proving to be the most effective to ensure success of the mining project while minimizing the impacts of mining by engaging with and addressing public concerns."*
>
> ***Wilhelm Greuer***
> *Geotechnical Consultant at Stantec*

manufacturers will pressure mining firms to quickly adopt and apply sustainable mining practices, and to include circular economy models in their operations.

Drivers of Change:

A common trend in all the scenarios that focused on the mining industry adopting new ESG norms was that the pressure to do so will be mostly driven by market forces, and not by regulatory ones.

Scenarios that were developed by the participants emphasized how end consumers will seek to learn more about where and how the products they purchase are made. For example, one scenario explored the spread and adoption of impact labeling, similar to Rio Tinto's digital sustainability label (SMART). Another scenario explored the pressure on mining firms to accelerate the rate of tailings treatment and disturbed landscape restoration by delivering public quarterly reports. Twenty-, thirty-, and fifty-year timetables for the recovery of mined areas will no longer be acceptable and, by 2030, mining firms will be demanded to demonstrate progress in the short term.

Another scenario described how Tesla will be a poster child for both sides. It will invest significant resources in new and clean mining techniques and will use its market positioning to bring preferred miners on board to do it. It will focus further on robotaxis so that greater demand can be met with given EV production and more internal combustion engines (ICE) vehicles can be taken off-roads. It will build several strategic alliances and lobby for better incentives and preferential access for companies contributing most to climate change, and it will cause a super cycle for EV manufacturing and adoption.

The New Normal:

The current social and political landscape, in which environmental activists such as Greta Thunberg and Disha Ravi are encouraging the public to demand political change from their governments on aspects related to sustainability, is likely to intensify and spread toward social activism focused on changing both corporate culture and individual consumption patterns.

In this future, the mining industry will be at the center of attention in the upcoming decade, and despite attempts to exhibit a change in its ESG norms, it will always be too little too late, with mining executives learning to operate under constant duress while adapting to a changing market environment.

> *"Governments, EV manufacturers, and end-users will require more stringent traceability of metals such as cobalt to ensure they are not sourced from child labor or conflict mining. Blockchain-based mineral traceability platforms will ensure a transparent mineral supply chain."*
>
> ***Mwamb Auxence Tshibang***
> *Senior Mechanical Engineer at Klohn Crippen Berger*

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