

GLOBAL BUSINESS REPORTS

**CHILE MINING
2022**



Pre-Release Edition

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Introduction to Mining in Chile

Chile remains the premier mining jurisdiction in Latin America despite political headwinds

On March 11th, 2022, Gabriel Boric was sworn in as Chile's president, one month after his 36th birthday and a decade after emerging as a student protest leader. The election of Boric's left-wing Social Convergence party is the latest surge of the so called pink tide in Latin America, following leftist leaders rising to power in Mexico, Argentina and Peru in recent years.

Boric's appointment, which came on the back of social unrest in 2019 that led to a 2020 national plebiscite that voted overwhelmingly to draft a new constitution, seems to have drawn the attention of mining industry commentators to a greater extent than the aforementioned appointments elsewhere in Latam. After all, as the world's biggest producer of copper and second biggest producer of lithium, what happens in Chile impacts the global mining business. Considering the current focus on global decarbonization, the role of Chilean metal production in the electrification transition has amplified this importance.

Under the new government, two alarming legislative proposals have taken center stage. In November 2021, a bill that would create the heaviest tax burden among major copper-producing nations was approved in an initial vote in Chile's senate. In February 2022, Chile's Environmental Commission of the Constitutional Convention, one of the seven bodies drafting the country's new constitution, put forward a proposal to nationalize 'strategic assets', including lithium, copper and precious metals.

While the above has caused concern, the click-bait headlines and lack of nuance surrounding the reporting of the political changes have created misconceptions about the gravity of what is happening in Chile, or rather what is likely to happen in the months and years ahead. In short, the consensus on the ground in Santiago from investors, consultants and mining professionals alike is that radical changes are unlikely to occur. Chile is undoubtedly facing a critical period of sociopolitical evolution, but it remains the premier mining jurisdiction in Latin America.

Reasons for optimism, if conditions are met

There were clear reasons for the sector to temper its concern during CESCO week 2022, the key industry event in Chile's mining calendar that brings together the region's major copper players in Santiago. On March 28th, Patricio Vergara, vice president of mining resources and development at Codelco, the world's largest copper producer, announced that Chile's state-owned mining firm was preparing to offer the market some 'non-core' exploration assets to become eventual partnerships.

The following day, during the opening keynote presentation at CRU's World Copper Conference, new Minister of Mining, Marcela Hernando, stated that it was not in the government's plans to nationalize mining in Chile or expropriate any assets, adding that the government does not want to scare-off investment. She un-

"The formula for success is simple – if the Chilean government invests in copper, companies can grow, will pay more taxes, and the government will have more revenue to invest in other sectors."

**Eduardo Valente,
Lead Consulting
Partner,
EY Chile**



derlined the will to work with exploration companies that "have placed their trust in our country", and praised the way foreign companies treat their workforces. This was a far cry from the impending communist revolution portrayed in a number of media outlets and a timely reassurance for those in attendance.

Marcelo Awad, executive director of Wealth Minerals, recalled his time as CEO of Antofagasta PLC from 2004 to 2012, during which time Marcela Hernando was mayor of Antofagasta: "I was very pleased when I heard her name as minister, because as well as being mayor of Chile's biggest mining region, she chaired a mining committee in the lower house of congress for over three years," he commented, elaborating: "In other words, she has a lot of experience and knowledge about the industry. Importantly, she is very open and in previous interactions has always listened to the concerns of the mining sector."

David Alaluf, general manager of Endress+Hauser Chile and professor at the University of Santiago, echoed the sentiment that the Chilean Mining Ministry had made sensible appointments, citing the selection of subsecretary Willy Kracht as an example of the type of experienced mining professional the government should look to hire. Alaluf did, however, voice his concern that the current discourse surrounding Chilean politics is contributing to an uncertain climate for investors: "I am worried that new laws will be influenced by social networks instead of being based on technical fundamentals."

The importance of establishing a clear legal framework was emphasized by BHP's president of minerals Americas, Ragnar Udd, who announced that the world's largest mining company intends to invest more than US\$10 billion in Chile, but only if certain conditions are met. "We love Chile. We would like to stay here. We would like to grow in this country. But in order to do that, it will require fiscal stability, legal certainty and a clear pathway to permit," said Udd, speaking at the World Copper Conference.

Joshua Olmsted, president and COO Americas at Freeport-McMoRan, acknowledged the “huge opportunity” for continued investment in the Chilean mining industry, but also made clear this is dependent on how legal frameworks progress over time. “Uncertainty in the last couple of years has caused a number of us to step back and see how this plays out before we make any major decisions on future projects,” reflected Olmsted, hinting that Freeport would probably be moving faster with the expansion of its El Abra project if there was more clarity around the fiscal and regulatory issues in Chile. He concluded: “We are hopeful that the process will conclude in a manner that will be beneficial to all parties.”

Navigating constitutional reform

Although the most extreme constitutional proposals put forward to alter Chile’s mining industry are unlikely to pass, one of the dangers is that the public discourse surrounding such radical ideas will influence a general public that does not fully

“We call on the honorable senators who make up the finance committee to think about the long term. The situation could transform into ‘bread for today and hunger for tomorrow’, and if mining companies leave the country, there will be those responsible for killing the goose that lays the golden eggs.”

**Manuel Viera,
President,
Chilean Mining Chamber**



understand the reality of mining. “I am going to reference German sociologist Niklas Luhmann who suggested that a group of people with beliefs and a series of myths or values often end up deciding for an entire population,” said Manuel Viera, president of the Chilean Mining Chamber, who also noted, however, that Chile has been by nature a very conservative country. Diego Hernández, president of Chile’s National Mining Society (SONAMI) and former CEO of Codelco, is optimistic that a compromise will be reached because

of mining’s importance to Chile’s development, representing 14% of GDP in the last 10 years, 20% of the economy once the service sector and salary recirculation are considered, and 60% of the country’s exports. The statements made by Minister Hernando and Codelco executives during the World Copper Conference indicate that the government understands the financial realities of governing a country, particularly in a post-Covid landscape, are very different from populist rhetoric used during a campaign trail.

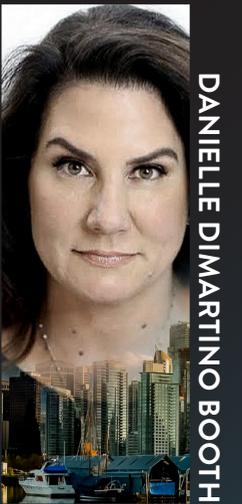
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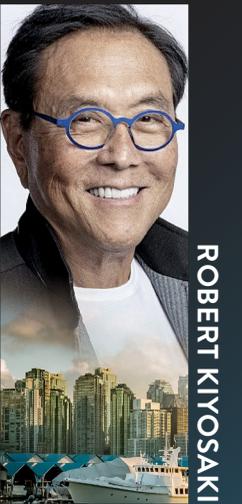
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“If enough medium-sized companies with competitive projects are active in Chile, it would add significantly to the country’s production. I think there is interesting room for growth there, and it has the advantage to be within reach of national investors.”

**Diego Hernández,
President,
National Mining Society of Chile
(SONAMI)**



If radical proposals are unlikely to pass, what then are the main risks that Chilean mining has to navigate in the months ahead from a constitutional standpoint? One of them revolves around timing. After initial proposals to amend the constitution have been generated, voted on and amended, a ‘harmonization period’ will take place from May 17th to June 19th, whereby everything that is inconsistent between the proposals from the commissions is highlighted to create a list that will be discussed in the plenary. Unfortunately, this process has been shortened because everything else took too long, meaning that the 40 people assigned to review the norms will have less time to take decisions. For such a crucial part of the constitutional process, which requires a holistic view that considers multiple scenarios, this raises the possibility of actions being rushed. With the first draft of the new constitution due to be filed on July 5th, time is of the essence.

There is also the risk of bills passing through congress that appear less radical but create legal uncertainty, such as the constitutional convention’s 430-5 proposal, which allows private companies to own concessions and operate mines, but these concessions must be administrated by a State-run entity and have a time limit, after which they would be returned to the State. It remains to be seen whether such a bill will pass, or if it did, how feasible implementing its measures would be, but it serves as an example of the type of judicial hurdle the industry must debate and navigate in the coming months.

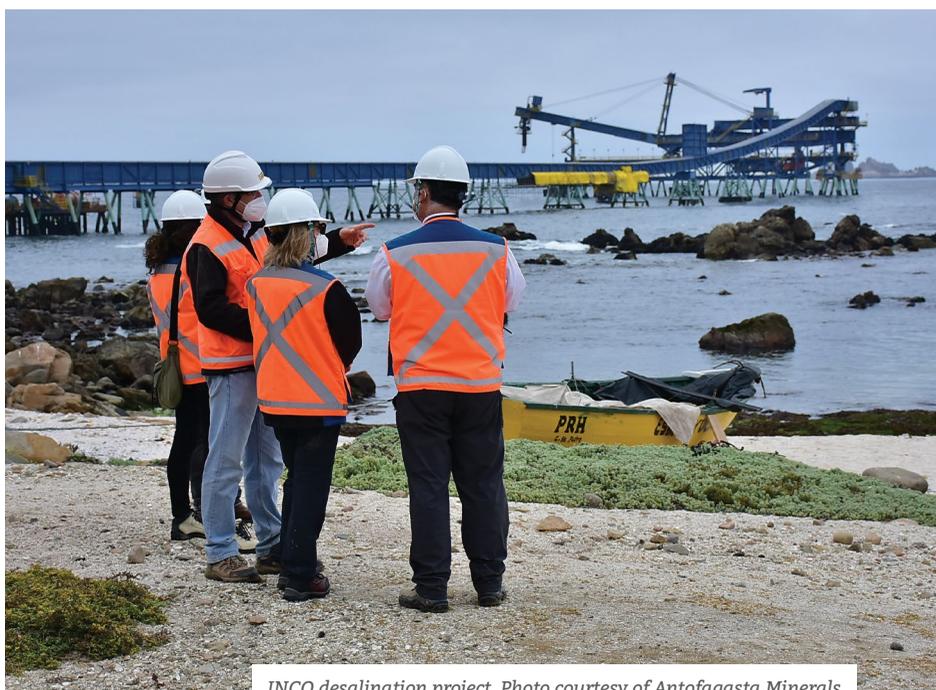
Two of the potentially more problematic focuses of the new constitution revolve around decentralization and the environment, particularly water rights. The em-

powerment of regional authorities, while attractive in theory, often leads to extra avenues for corruption and cumbersome bureaucracy, as seen in the years proceeding the Peruvian decentralization process in 2005.

Of the 40 articles presented to congress by the Environmental Commission, 36 were rejected, with water rights expropriation being one of the four to pass through an initial vote. Central Chile has suffered a 12-year drought and the country has a deficit of water infrastructure so investment is needed, but the proposal would ironically kill the influx of capital. Alejandra Fernandez of Fitch Ratings, when presenting the risks behind the constitution rewriting process, revealed that Fitch Ratings assigns a very low probability of this bill passing.

Even if water rights expropriation does not happen, potential changes to the legislature surrounding water could be particularly impactful for mining, especially considering the amount of operations located in the Atacama – the world’s driest desert. “In Colombia, for example, rivers have the same rights as human beings, and considering how delicate this subject is in mineral rich parts of Chile, radical constitutional changes could be taken that could have a bigger impact on mining operations than the royalty bill,” stated Daniela Cuellar, senior consultant at FTI Consulting, who mentioned FTI is watching this space very closely for its mining clients.

The implementation of desalination projects has been underway for a number of years in Chile, and this trend looks set to gain further traction under Boric’s government. Antofagasta Minerals’ (AMSA) Los Palabres project is located in the Choapa Valley in central Chile, and the company is due to start operation at its INCO desalination plant the second half of 2022, according to Iván Arriagada, CEO. AMSA plans to double the capacity of INCO as soon as the necessary permitting is obtained. Arriagada expects to be operating at its expanded capacity in 2025. “Desalinated and reused or recycled water will then account for more than 90% of the mine’s total consumption, freeing up some 500 l/s of water for surrounding communities,” said Arriagada.



INCO desalination project. Photo courtesy of Antofagasta Minerals

Attracting sustainable investment

For many years, the taxes and royalties paid by Chile's mining sector have been the go-to source of income that its government has used to fund other parts of the economy. Eduardo Valente, lead consulting partner at EY Chile, gave the example of the government mechanism to stabilize fuel prices for the population, which the State intends to fund with revenue attained from the copper industry in 2021. "If you do not create the conditions for investment, there will no longer be revenue to be used in other segments of the economy," stated Valente. "If the Chilean government invests in copper, companies can grow, will pay more taxes, and the government will have more revenue to invest in other sectors."

Indeed, if Chile were to develop its known reserves, even without exploration success, the country could increase its copper production by around 2 million tonnes per year (t/y) and its lithium production by around 1 million t/y. "The revenue from this production would

generate vast wealth for Chile that would dwarf the extra taxes being discussed on current mines, in addition to creating thousands of jobs and indirect benefits for millions of Chileans," reflected Marcelo Awad of Wealth Minerals.

In addition to the major producers already active in Chile, the international investment community is watching what is happening in the country closely. Michael Scherb, founder and CEO of Ap-pian Capital Advisory LLP, discussed his company's view of Chile's political risk: "We view politics very much like we view commodity prices – a pendulum on a clock swinging back and forth, side to side, but rarely in equilibrium down the center."

Scherb commented that if politics moves against foreign investment in the mining sector, investors will simply choose to put their capital in a different country.

Randy Smallwood, president and CEO of Wheaton Precious Metals (WPM), weighed in on the subject: "We are happy to take on geological, metallurgical,

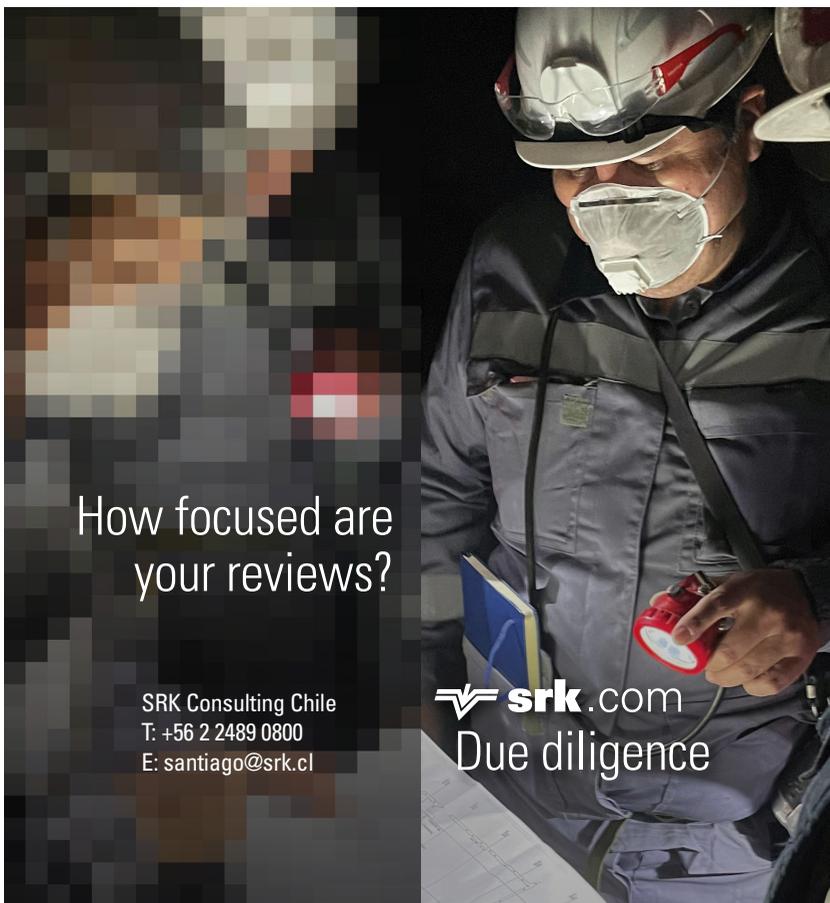
mining, engineering and even community risk to some extent, but we will not take on political risk ourselves."

While foreign investment in mining will go where the best opportunities present themselves, many mining service companies, from contractors to equipment providers, do not have the luxury of setting up shop in another country. Philippe Hemmerdinger, president of the Association of Industrial Mining Suppliers (APRIMIN), emphasized the importance of the US\$120 billion invested into Chilean mining in the last 15 years from the perspective of the country's vast ecosystem of suppliers and those who live from this chain. Underlining the need to foster competitiveness, he said: "We have to think that we live in a global village, and if Chile has a tax level that does not allow the mining sector to be relatively profitable, we will not receive investment."

Analyzing the type of government Boric intends to run, Michael Cullen, managing director Latin America for FTI Consulting, suggested: "Chile's new president will try and implement something along the lines of Scandinavian welfare state politics rather than old-school communism," and noted that the government's ministerial appointments have alleviated market fears, most notably finance minister Mario Marcel, who previously successfully ran the Chilean central bank from a fiscal management point of view.

Gabriel Boric is part of a new generation of leaders that want to make tangible change for a greener, fairer and more inclusive country. To achieve this, he has an enviable natural resource endowment that will not only play a leading role in the energy transition, but also has the potential to fund the initiatives that will enable change. "Governments should be focused on creating long term sustainable value rather than focusing on the short term," concluded Eduardo Valente.

At such a crucial time for the country the hope is that a constitutional framework will be established that can foster mining development for the years to come. As the world transitions away from fossil fuels and if copper really becomes the new oil, the opportunities awaiting Chile can not be understated.



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Due diligence

Industry Thoughts

Chile's Evolving Sociopolitical Landscape

"I believe that attracting sufficient investment for growth and creating more local benefits for Chilean communities go hand in hand – with greater growth, including that fueled by investments, we will be able to give back more to our communities. At the moment in Chile, we are experiencing change with a new government and the ongoing process to write a new constitution. In both cases, we are seeing an emphasis on a more progressive social agenda and potentially higher taxes for the mining industry. I think that mining, and business more broadly, can play a significant part in this new social pact to create a balance that allows businesses to continue to grow and invest in the country."



Iván Arriagada, CEO, Antofagasta plc



"There is a huge opportunity in Chile for continued investment in the mining industry, but it will be dependent on how legal frameworks progress over time. Uncertainty in the last couple of years has caused a number of us to step back and see how this plays out before we make any major decisions on future projects, because you need some degree of fiscal and regulatory certainty in the environment you are operating in. I would say we would probably be moving faster on the El Abra project if we had more clarity. We are hopeful that the process will conclude in a manner that will be beneficial to all parties."

Joshua Olmsted, President and COO – Americas, Freeport-McMoRan

"During the election campaign there was a perception, which was encouraged by Boric's opposition, that his coming to power would be a Chávez type moment for Chile. That was erroneous for a number of reasons, including the strength of Chile's institutions, and the fact that the rhetoric used to energize Boric's left-wing base is very different to the reality of governing a country. The government's ministerial appointments, most notably finance minister Mario Marcel, who very successfully ran the Chilean central bank from a fiscal management point of view, went a long way to alleviate market fears."



Michael Cullen, Managing Director – Latin America, FTI Consulting



"Boric's lack of a majority in congress should ensure a stable administration under the new government. While the social agenda that animated his campaign may entail changes, the economic realities will ultimately sustain the close working relationship between the government and the private sector. The president understands the imperative necessity to continue to attract foreign investment, and the indispensability of mining operations to the lifeblood of the Chilean economy. Moreover, there is a growing cognizance of the private sector's role, from generating tax royalties to funding local community programs, to effectuating any reformist policy."

Cristobal Garcia-Huidobro, CEO & Managing Director, Lithium Power International

"The most important thing is to restore full stability for investors. Just by developing known reserves, even without exploration success, Chile can increase its copper production by around 2 million t/y and its lithium production by around 1 million t/y. There are a number of inactive oxide plants in Chile that could be used to bring new projects into production. The revenue from this production would generate vast wealth for Chile that would dwarf extra taxes being discussed on current mines, in addition to creating thousands of jobs and indirect benefits for millions of Chileans."



Marcelo Awad, Executive Director, Wealth Minerals

Production & Development

Investment and streamlined development is needed to capitalize on a generational opportunity



Photo courtesy of Freeport McMoRan

Is copper the new oil? The red metal has traditionally been a bellwether for the global economy, but in the last two years a combination of dwindling physical stock, medium-term supply deficit, and bullish long-term demand fundamentals have driven copper prices to all-time-highs.

The downward trend in copper inventories at Comex, Shanghai and LME warehouses since 2018 is threatening supply. Although new production coming online in 2022 from projects such as Teck Resources’ Quebrada Blanca 2 (QB2) in Chile and Anglo American’s Quellaveco in Peru should see 2023 levels increase, a deficit is expected from 2025 onwards.

It is not uncommon to face supply gaps, but what is different now is the challenge the industry is facing to swiftly bring projects into production. Speaking at the 2022 World Copper Conference in Santiago, Erik Heimlich, head of base metals supply at CRU, suggested that the global copper industry needs to spend more than US\$100 billion on new developments in

order to close an annual supply deficit forecast to be 4.7 million tonnes (t) by 2030. In other words, building eight projects the size of BHP’s Escondida in Chile, the world’s largest copper mine, over the next eight years. To say this is unlikely would be generous at best.

On April 7th, a report from Goldman Sachs stated the world is “sleepwalking towards a stockout”, pointing to an extreme fundamental turn for copper, as for the first time in a decade stocks on exchanges declined through March instead of rising during what is the metal’s main seasonal surplus phase.

All of the above, and in particular copper’s integral role in the energy transition, points to higher copper prices. “The world will need twice as much copper in the next 30 years as it has used in the last 30 years,” stated Ragnar Udd, BHP’s president – minerals Americas.

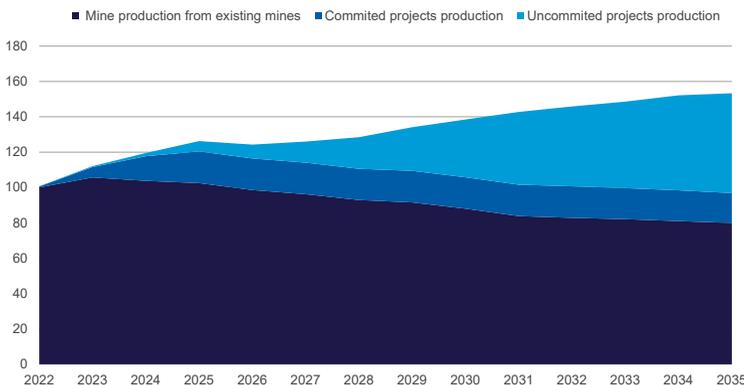
As the world’s biggest producer, Chile has a generational opportunity to leverage its endowment for the benefit of its popula-

Potential mine production - Indexed data provided by



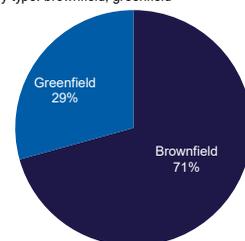
Chile potential mine copper production

100 = mine production from existing mines 2022



Share of potential production uncommitted projects in 2035

% by type: brownfield, greenfield



“QB2 will double our consolidated copper production by 2023 and significantly reweight our portfolio more towards copper at a time when we see significant rising demand fueled by the transition to the low-carbon economy.”

**Don Lindsay,
President & CEO,
Teck Resources Limited**



tion and all stakeholders involved in the country's copper value chain. However, to capitalize on this, vast investment and streamlined development is needed.

Chile, which accounts for over a quarter of global copper output, saw a production decrease of over 7% in both January and February 2022, compared to the corresponding months in 2021, according to the State Chilean Copper Commission (Cochilco). While production is set rise in 2023 on the back of QB2 seeing its first full year of production, a dearth of major near-term projects in Chile's copper pipeline underlines the urgency for action. The inertia brought about by the current discussions surrounding the new constitution, while understandable, is causing delays to investment decisions.

For investments currently underway there is no shortage of capital available. State-run Codelco, the world's largest copper producer, announced pre-tax profits of US\$7.4 billion in 2021 compared to US\$2.1 billion a year earlier. The company produced 1.728 million t of copper in 2021, combining its own production of 1.618 million t with its stake in Freeport's El Abra and Anglo American's Sur. Codelco's current investments include the Rajo Inca expansion, which will extend life at the company's Salvador operations to 2070.

Iván Arriagada, CEO of Antofagasta plc, discussed the Phase 1 expansion of the company's Los Pelambres project, which is due to be completed in 2022: "As mining progresses at Los Pelambres, ore hardness will increase. The Phase 1 expansion is designed to compensate for this, increasing plant throughput from the current capacity of 175,000 t/day of ore to an average of 190,000 t/day."

Arriagada revealed that the expansion

will increase annual copper production by an average of 60,000 t/y over 15 years, helping optimize throughput within the limits of the existing operating, environmental and water extraction permits, and creating up to 2,000 new jobs during construction.

Freeport McMoRan, the world's third largest copper producer behind Codelco and BHP, is working on ramping up production at its El Abra mine in Chile to pre-pandemic levels, which it expects to achieve later in 2022, according to Joshua Olmsted, Freeport's president and COO – Amer-

icas. Olmsted commented that Freeport is in the process of constructing a new leach pad to stack material on at El Abra and aiming for production in the range of 200 million to 250 million lb/y. He added: "The focus of the ramp-up process now is to revert back to a 24/7 way of operating, which is all about planning and scheduling rather than overcoming any technical hurdles."

When asked about the company's strategy for expansion in the Americas, Olmsted emphasized Freeport's focus on organic growth through expansion projects such as an extension of the open pit and the transition to sulfides at El Abra. "El Abra is a world-class resource that we have been drilling for many years to gain a better understanding of the ore body. It is a significant opportunity for us long term on the sulfide side," he added, noting that there has been a lot of work historically on the engineering side, but in 2022, the focus is on being prepared to submit an EIS for the mill sulfide project, as well as ongoing stakeholder engagement.

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“The foundation of every decision is the orebody itself and WPM has a strong technical focus on asset quality. We see Capstone’s Santo Domingo project as very exciting, especially considering the potential scale of the project and variety of metals it contains.”

Randy Smallwood,
President & CEO,
Wheaton Precious Metals



“Fenix Gold is the largest undeveloped gold heap leach project in the Americas, and is now fully financed to production. The project already contains 5 million ounces (Moz), but we believe this could grow through exploration to closer to 10 Moz.”

Alex Black,
President & CEO,
Rio2 Limited



Monetizing an environmental liability

Both the demand for copper and the timeline it takes to move projects from exploration to production are increasing. To meet demand, the traditional means of production are insufficient and innovation is required. Clayton Walker, Rio Tinto’s COO of copper, remarked that 100 million t of copper is estimated to be trapped in tailings deposits globally, which represents an opportunity for incremental production through reprocessing.

This is an opportunity that Amerigo Resources (TSX: ARG), through its Chilean subsidiary Minera Valle Central (MVC), has been working on since 2003. “We used to produce around 25 million lb/y Cu, but have grown this figure to 63 million lb Cu in 2021.

This was achieved by investing US\$300 million into the facility, doubling the capacity of our concentrator plant, and incorporating the rights to process historical tailings,” explained Aurora Davidson, Amerigo’s president and CEO.

Amerigo gets its material through a contractual relationship with Codelco’s El Teniente division, the largest underground mining operation in the world, where MVC has the rights to process fresh tailings and a series of historical tailings deposits. “Essentially, Amerigo works with an environmental liability – tailings – and extracts further economic value from that by producing copper concentrates,” said Davidson, noting that MVC is by no means a small operation, as a tremendous amount of material has to be processed given the low grade that by

definition is contained in tailings. “In many ways, we are more of a copper factory than a mining operation.”

Under the leadership of Davidson, Amerigo has focused on improving margins and has overcome critical water supply issues through investments such as thickeners that increase water circulation efficiencies. In February 2022, the company announced record revenue, which poses the question of what potential there is to replicate this business model at other mines in Chile?

“I think that when the decision makers at mining companies start adjudicating the potential value of their existing tailings and see them as an opportunity to top up production, rather than just a liability, there could be tremendous opportunities for Amerigo given its existing operational experience,” said Davidson.

Chile’s development pipeline

The importance of large mining development projects goes beyond production figures. Interviewing companies throughout the whole value chain for this report, the opportunities that projects such as Teck Resources’ Quebrada Blanca Phase 2 (QB2) or Antofagasta’s INCO development represent to Chile’s vast ecosystem of suppliers and the thousands of families that live from this income cannot be understated.

QB2, one of the world’s largest undeveloped copper resources, is currently under construction and set to start production in the second half of 2022, according to Don Lindsay, Teck’s president and CEO, who described the project as the first step in Teck’s copper growth strategy that will be transformational for the company. “Once in production, QB2 will double our consolidated copper production by 2023 and significantly



Photo courtesy of Teck Resources Limited

“Amerigo works with an environmental liability – tailings – and extracts further economic value from that by producing copper concentrates. In many ways, we are more of a copper factory than a mining operation.”

**Aurora Davidson,
President & CEO,
Amerigo Resources**



reweight our portfolio more towards copper at a time when we see significant rising demand fueled by the transition to the low-carbon economy,” said Lindsay.

Lindsay also provided details of the Quebrada Blanca Mill Expansion (QBME) prefeasibility study and potential for Phase 3 expansion, which would add another 150,000-plus t/y of copper equivalent production as early as 2026—increasing throughput by at least 50% and leveraging existing QB2 project infrastructure to its fullest. “The pre-feasibility study (for QBME) is expected to be complete by the end of this year,” affirmed Lindsay, noting that QB2 only uses around 18% of the 2021 reserve and resource tonnage and the vast, long-life deposit is large enough to support multiple expansions, which we will be looked at moving forward.

On the precious metals side, Kinross announced that on February 1, 2022, its La Coipa processing plant restarted operations. The restart comes after a year of mechanical maintenance, rehabilitation of electrical systems and instrumentation, and restitution of equipment that had been preserved since 2013 after a Partial Temporary Stoppage (PTP) for eight years, according to Rolando Cubillos, vice president and general manager of Kinross Chile.

Cubillos listed the pending items to optimize the Phase 7 mine plan at La Coipa: “Plant renovations are currently focused on the crushing, grinding, leach pads, refinery, filtration and tailings areas, making sure critical components are complete to start first-stage production and move towards full operating capacity by the middle of 2022.”

On March 12, 2022, Kinross announced it had poured its first gold bar at La Coipa, and the company is eyeing expansion at the nearby Lobo-Marte project, located about 50 km from the main pit, after the conclusion of mining at Phase 7.

Located close to La Coipa in the Maricunga region of northern Chile is Rio2 Limited’s Fenix Gold development project, currently under construction and expecting to achieve its first gold pour early 2023, according to president and CEO, Alex Black.

Discussing the timeline for development at Fenix, Black explained that it takes a few months between getting the EIA, which is expected in Q2 2022, and the construction permit, expected in Q3. “In the meantime, we bought an infrastructure site about 20 km from the Fenix mine site, at the turnoff from the main road that goes from Copiapó to Argentina and close to Kinross’ La Coipa camp (...). We can do a lot of fabrication of plant components at the site, so when we receive the construction permit it becomes more of an assembly project.”

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Black mentioned that the characteristics of Fenix are very similar to the two mines that the Rio2 management team built in Peru – La Arena and Shahuindo – under its previous company Rio Alto Mining, which was acquired by Tahoe Resources for C\$1.2 billion in 2015. Fenix lends itself to simple gold heap leach ADR operations where material does not have to be crushed and therefore does not require large capex to build. Black added: “When you talk about inflation, a 10% increase on a US\$120 million build is a lot more manageable than on a US\$1 billion project. From our experience, we know we can move things around to save costs in different areas.”

The attraction of low-capex start-ups was highlighted by Randy Smallwood, president and CEO of Wheaton Precious Metals (WPM), who helped finance the construction of Rio2’s Fenix via a US\$50 million gold streaming agreement. “We have seen so many examples in the mining industry where people are too aggressive in terms of their first buildout, and this is particularly relevant in

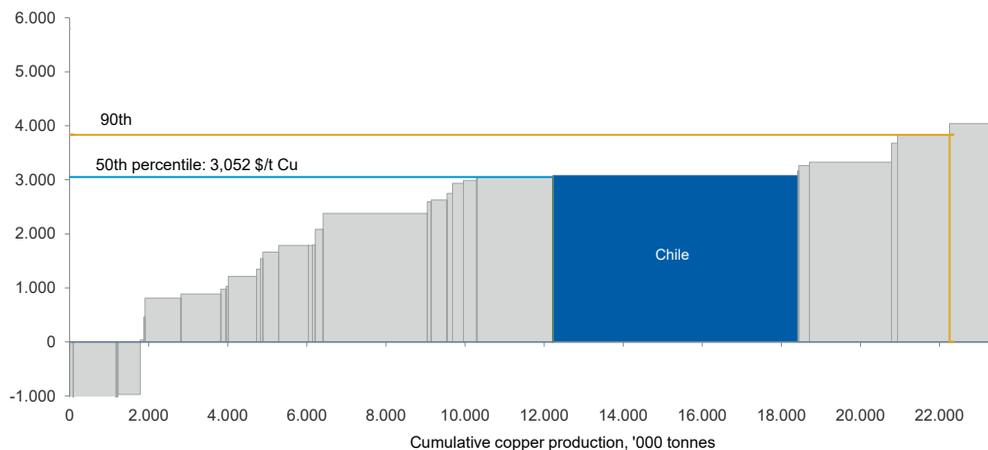
an era of supply chain delays and rising inflation,” observed Smallwood, mentioning that he particularly liked Rio2’s strategy of opting for a staged approach to grow the mine, adding that Alex Black’s track record of delivering high quality projects on time and on budget also influenced WPM’s investment decision.

Another of WPM’s 2021 investments into development projects in Chile is the US\$290 million acquisition of a gold stream at Capstone Copper’s (formerly Capstone Mining) Santo Domingo project. Smallwood spoke of WPM’s long-term relationship with Darren Pylot, having optioned him his first property in 2002/2003 when he started building Capstone, and suggested that the Santo Domingo transition is an example of WPM’s philosophy of maintaining strong relationships with its partners beyond the financing agreement. He concluded: “We were honored to be selected to again work with Capstone and see the Santo Domingo project as very exciting, especially considering the potential scale of the project and variety of metals it contains.”

Cash Costs data provided by

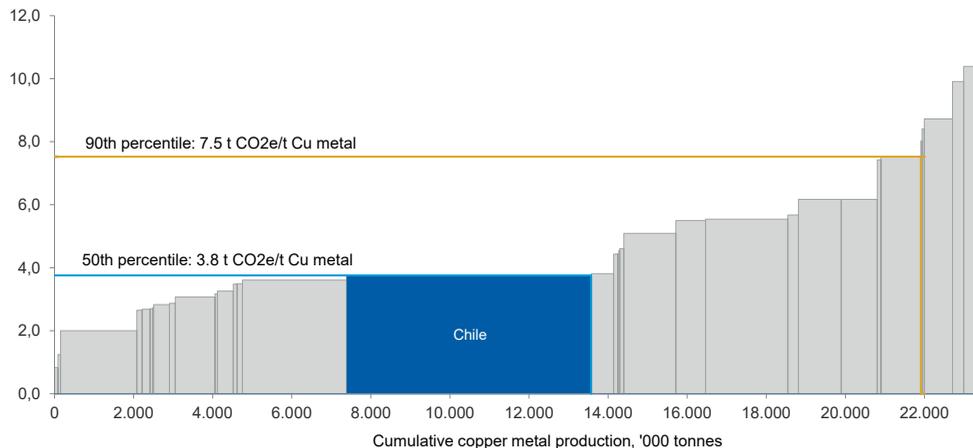


Weighted average CRU value-adjusted cash cost by country, 2022
US\$/t Cu



Emissions

Weighted average CRU Scope 1, 2 & 3 CFR emissions by country, 2022
t CO2e/t Cu metal



Junior Exploration

Hunting for scale and a near-term path to production

The world is hungry for copper and its appetite looks set to increase. A February 2022 report from Bank of America global research analysts forecast that the copper market will flip back to a deficit from 2025 onwards following the completion of the current wave of project buildouts. Vanessa Davidson, head of copper research at CRU, also sees a supply gap from 2025, with the majority of demand set to come from outside China, particularly in Southeast Asia and India, but also North America and Europe as green technologies and the transition to electric vehicles really start to take off.

Even in the near term, sluggish financial markets in China in April 2022 failed to dim copper's shine as the price of the red metal hovered around the US\$4.50/lb mark after reaching record highs in early March. In addition to the expected supply gap and future demand being baked into the price, one of the reasons for copper's performance has been the lack of exploration success in recent years and the timeline to move projects into production.

Two of the three standout junior success stories in the last two years have been South American copper plays. In 2021 Solaris Resources' market cap rose above C\$1.5 billion on the back of sustained, near-surface high-grade drilling results at its Warintza project in Ecuador. In April 2022 Filo Mining's market cap reached C\$2.5 billion as it continued to advance its Filo del Sol high-sulphidation epithermal copper-gold-silver deposit on the border of Argentina's San Juan province and Chile's Maricunga belt.

Speaking at the World Copper Conference in Santiago, Ragnar Udd, BHP's president of minerals – Americas, cited the company's recent C\$100 million investment in Filo Mining as the type of early-stage entry BHP is willing to make to grow its copper pipe-

line. However, the pertinent point about assets such as Filo del Sol and the reason they hold such a premium is their scarcity.

“There is a huge amount of appetite for exposure to copper but the playing field of potential companies for the market to talk to is small. Investors cannot find many projects that have a short timeline to production as well as the ability to be financed without partnering with a major mining company,” reflected Hayden Locke, president and CEO of Marimaca Copper (TSX: MARI).

Marimaca is currently advancing its namesake copper oxide project near Antofagasta with a heap leach SX/EW approach that means it does not need to desalinate water and will be able to process a refined grade A copper cathode, lowering project capex and putting Marimaca in the first quartile of global copper mine site emissions intensity. Due to the company's exploration success in 2021, management has had to adapt timelines to what it believes is likely a materially larger deposit, according to Locke. “The original depth of the Marimaca oxide deposit (MOD) was approximately 250 m to 300 m, but the MAMIX drilling has potentially more than doubled the depth of the project, with leachable material at the bottom of the open pit,” detailed Locke, adding that it is an obvious focus to get into a resource that the company can then use in the DFS, which is expected in the second half of 2022. “This will allow us to both increase the scale of the project in terms of copper production and also the life of mine.”

Another of Chile's more advanced juniors is Hot Chili Limited (TSXV: HCH), which reported a resource upgrade for its Costa Fuego copper-gold project headlined by a 67% increase in the total indicated resource and a 53% increase in the high grade indicated resource. Costa Fuego comprises the Cortadera, Productora and San Antonio deposits, all of which have updated mineral



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resource estimates and are close to one another at low-altitude elevations, 600 km north of Santiago. The updated resource totals 927 million tonnes @0.45 Cu Eq., and the company intends to deliver a combined PFS in Q3 2022.

Project financing is expected to kick off in Q1 2023, and to that end, Hot Chili appointed Nicole Adshead-Bell to its board of directors in March 2022. Adshead-Bell brings over 25 years of capital markets experience, including time at Haywood and Dundee Securities, and is currently a non-executive director of base metals royalty and streaming firm Altius Minerals Corp.

Christian Easterday, Hot Chili's managing director, spoke of how new meaningful copper supply is "fast becoming a mirage," adding: "Hot Chili is well positioned to deliver into the forecast supply gap and contribute to the decarbonization super cycle, particularly due to Costa Fuego's lower economic hurdle resulting from its low elevation location and proximity to existing infrastructure, including abundant grid power with high renewables contributions."

One of the newer study-stage juniors active in Chile is World Copper (TSXV: WCU), which listed in January 2021 and owns the Escalones and Cristal projects in Chile, as well as the Zonia project in Arizona. The company released a PEA for Escalones in February 2022 showing a US\$1.5 billion post-tax NPV and a 46.2% IRR at a US\$3.60/lb copper price, with a payback of 2.18 years. Escalones is an SX-EW oxide heap leach operation, located 97 km southeast of Santiago and 35 km east of El Teniente, with an estimated US\$438.4 million capex from construction decision.

Nolan Peterson, World Copper's CEO, remarked that the resource included in the PEA for Escalones is only half of what the company believes to be the overall resource. He elaborated: "The other half has seen no historical drilling, but geologically it is clear that it is an extension of the main resource. There is also deep sulphide potential as well as three other copper porphyry skarn targets to the northeast that have never been drilled."

Marcelo Awad, World Copper's executive director, explained that most of the companies that held Escalones in the past were drilling very deep in search of a sulfide deposit, without paying sufficient attention to the oxide layer. He discussed the company's exploration targets for 2022: "We also discovered an area of yellow color, our primary target called Mancha Amarilla, which we believe to be part of the main oxide deposit that has tremendous potential."

Early-stage copper gold porphyry opportunities

For investors with a bigger risk tolerance and those hunting for the elusive multi-baggers, the early-stage end of the junior market is where the best returns can be found. These companies are also the lifeblood of an industry in dire need of new discoveries, particularly after a period where majors have preferred to extend brownfield operations rather than allocate budget for greenfield exploration.

"The biggest value-add moment for investors is the transition from exploration to discovery," stated Timothy Beale, direc-

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Industry Thoughts

Chile's Junior Mining Community

"There is a huge appetite for exposure to copper but the playing field of potential companies for the market to talk to is small. Investors cannot find many projects that have a short timeline to production as well as the ability to be financed without partnering with a major mining company. Marimaca offers a unique opportunity in this regard."



Hayden Locke,
President & CEO,
Marimaca Copper

"Copper prices are increasing and new meaningful copper supply is fast becoming a mirage. Hot Chili is well positioned to deliver into this forecast supply gap and contribute to the decarbonization super cycle, particularly due to Costa Fuego's lower economic hurdle resulting from its low elevation location and proximity to existing infrastructure."



Christian Easterday,
Managing Director,
Hot Chili Limited

"Escalones has significant upside exploration potential. The resource we put in the PEA is only what we believe to be half of the overall resource. The other half has seen no historical drilling, but geologically it is clear that it is an extension of the main resource."



Nolan Peterson,
CEO,
World Copper Limited

"Although the HSE gold deposit at our Valeriano project is an interesting resource, we decided we were more interested in the copper porphyry at depth and built a conceptual model of what the project could look like, followed by a C\$8.5 million financing round to further drill the deposit."



Raymond Jannas,
President & CEO,
ATEX Resources

"As a junior, it pays to put money into real exploration work as soon as possible, because all other overhead costs persist, so those who explore slowly get fewer dollars, percentage-wise, into the ground. With this in mind, Torq Resources intends to explore aggressively in 2022."



Shawn Wallace,
Executive Chair,
Torq Resources

"Pampa Metals' main objective is to make discoveries. There are not many junior companies like us currently doing grassroots exploration, and the biggest value-add moment for investors is the transition from exploration to discovery."



Timothy Beale,
Director,
Pampa Metals

"Unlike most juniors, our focus on cashflow is to enhance understanding of our assets to catalyze further growth and this is a model that investors like. Furthermore, we focus on assets that are less difficult to mine and do not require large capex to expand underground, establish reserves or build significant infrastructure around."



Alastair McIntyre, President & CEO, Altiplano Metals

"The two structures we are going after at the Mostazal project are an interesting feature of the company. The big porphyry target is the grand prize, but we also have a near-surface historic resource that has already seen drilling, which I believe we can advance on to build something significant."



Jason Cubitt, President & CEO, Solis Minerals

tor of Pampa Metals (CSE: PM), the Canadian junior with a portfolio of eight projects in northern Chile, with a focus on porphyry copper gold targets. “There are not many junior companies like us currently doing grassroots exploration,” he added.

Austral Gold (TSXV: AGLD), Pampa’s JV partner at its Morros Blancos and Cerro Blanco projects, started its first drill test at Morros Blancos in January 2022 and is drilling five diamond core holes totaling 2,000 m at the Rosario del Alto high-sulphidation gold-silver target. Pampa Metals will be drilling its Cerro Buenos Aires project later in 2022 and has been trenching to expose more of the porphyry intrusion and quartz-veinlet stockwork at its Block 4 project, which Beale suggested could be a significant drill target in the near future. Pampa’s Block 3 project, like Block 4, lies along the Domeyko Cordillera copper belt – host to three of the world’s top five copper mining districts, and is currently undergoing early-stage exploration work.

When asked about the future of the gold industry, Tom Palmer, president and CEO of Newmont, pointed to the importance of deposits that contain both copper and gold: “When it comes to decarbonization, as gold operations are developed you will see more copper-gold mines coming online, such as Yanacocha.”

High-sulphidation oxide gold deposits with a large copper porphyry layer underneath are a feature of Andean geology and can host the scale to attract major companies. ATEX Resources (TSXV: ATX) was formed in 2019 and immediately acquired its flagship Valeriano copper gold project, which is located in a new emerging belt, the Link Belt, between the famous Maricunga and El Indio districts. Raymond Jannas, president and CEO, explained that from historic results, ATEX’s exploration work and complete relogging of all the drill holes, the company believes that Valeriano has many similarities to Filo Mining’s Filo del Sol project. He elaborated: “Both have high sulphidation copper mineralization progressing in

depth into hypogene porphyry mineralization hosted in Permo-Triassic rhyolites as the host rock.”

The company also has significant backing. Craig Nelson, ATEX’s chairman, previously established Metallica Resources with Pierre Lassonde, who was the lead investor in a private placement that raised C\$8.5 million for ATEX in December 2021. ATEX’s share price rose from C\$0.10 in October 2021 to over C\$0.75 in April 2022 as the market anticipates results from three holes being drilled into extensions of the known high-grade mineralization zone. Looking to the year ahead, Nelsen summarized: “We hope to have successfully hit on our three exploration holes and will be able to demonstrate the makings of a significant deposit.”

Shawn Wallace, executive chair of Torq Resources (TSXV: TORQ), revealed that the company acquired its Margarita IOCG and Andrea copper porphyry assets as entry projects into Chile, but the main reason they came to the country was for the acquisition of the Santa Cecilia proj-



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ect, which was completed in November 2021 and is expected to become Torq's flagship asset.

Santa Cecilia is located approximately 100 km east of Copiapó, in the southern region of the Maricunga belt, immediately adjacent to the Norte Abierto project which comprises of the Caspiche and Cerro Casale gold-copper porphyry deposits, collectively containing proven and probable reserves of 23.2 million oz Au and 5.8 billion lbs of copper. "Results from two historical drill holes and additional surface and geophysical work support the logic that the project has a similar mineral system to Norte Abierto, and we believe we can make a discovery that will be attractive to a major mining company," said Wallace.

The real potential that Torq is trying to unearth is whether Santa Cecilia, sandwiched between two major projects that are currently suspended, can tip the economic scale for the entire complex. "There are technical attributes to the project which suggest this could be the case," stated Wallace, explaining that on top of the porphyry system discovered through the two historic drill holes there is an oxide gold cap that was uncovered through a small drill program by a major mining company in the late eighties. He added: "Our next steps are to drill off the porphyry to establish economic viability, while also outlining the potential of the gold system on top. We also believe there is another potential porphyry on the boundary between Caspiche and Santa Cecilia, and will identify targets to make this discovery."

Another copper-focused junior active in northern Chile is Solis Minerals (TSXV: SLMN), which has undergone a restructuring over the past 12 months to focus on Latin America, disposing of some non-core assets in Canada and Mexico and rebuilding the team around a focus on exploration and development projects in Chile and Peru, according to Jason Cubitt, president and CEO.

Solis has a 100% option on the Mostazal copper project, which hosts an undrilled classic copper porphyry target along with significant high-grade copper-silver mineralization at surface. "We see great opportunity to develop both of these tar-

"It is better to launch at a realistic valuation so that your shareholders who are in early have strong positions, and immediately see some upside potential, rather than overpricing it simply because of transient market conditions."

Brian Miller,
CEO,
Astra Exploration



gets and plan to prioritize the interpreted porphyry target, but will also advance the identified stratabound mantos-style mineralization, which is reported as a historical drill-indicated resource," detailed Cubitt.

In February 2022 the company reported widespread copper sulfides logged in the first two holes of its maiden drill program at Mostazal from its initial phase of the campaign comprising four holes for an estimated 2,000 m of drilling.

Astra Exploration (TSXV: ASTR) was formed in August 2020 and listed in

January 2022, and predicated on the exploration opportunity and potential for discovery of precious metals deposits in northern Chile: "a region synonymous with copper exploration, but much less so for precious metals," commented Brian Miller, CEO.

Discussing Astra's Pampa Paciencia project, Miller suggested that based on exploration results, the company believes there to be a large epithermal system just under cover, and drew the comparison of notable low sulphidation systems such as in El Peñón, located 175 km to the south.



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Engineering, Construction & Consultancies

From conception to closure: Solutions for the full mining lifecycle

Chile's evolving regulatory framework and increasingly stringent environmental regulations mean that the engineering firms and consultancies active in the mining space have their hands full. The question of whether new legislation will stunt project development remains to be seen, but with no radical overhaul expected, and considering that inevitable changes will be generated from the impending reforms, the outlook in this segment of the industry looks robust for the years ahead.

One of the themes that have been gaining traction in recent years is mine closure; a perpetual challenge for mining companies for centuries, but one which is subject to ever-more scrutiny. Although the issue of mine closure is not new, the industry has traditionally struggled with it due to changing legislative scenarios, commercial pressures, ESG-related challenges and poorly planned costs.

In 2020, Turner & Townsend collaborated on the 'Planning for successful rehabilitation' report, underscoring the case for early planning for closures and financing such closures. "It also highlighted some

"Mine closure is a matter that must be approached from a multidisciplinary and integrated perspective, from the design, construction, operation of a mining project to its implementation."

Esteban Hormazabal,
Managing Director – Chile,
SRK Consulting



of the challenges in closure and confirmed the need to find alternative options for a rehabilitated mine," revealed Mark Wainwright, Turner & Townsend's managing director – mining, giving the examples of site greening, renewable power sources and job creation schemes related to eco-tourism as options.

"We think the study helped deepen industry awareness of the environmental impact and socio-economic benefits of sound mine closures. With the growing calls for a decarbonized mining industry, this is one of the levers that can be used to enhance the reputation of the sector,"

reflected Wainwright, adding that the necessity to rehabilitate properly is not only a statutory duty but impacts on the future of the business – 'the social license to operate' – as a part of corporate ESG responsibilities which shareholders are watching carefully.

Iván Rayo, general manager of Chilean engineering firm JRI, spoke of the benefits of being involved in mining projects throughout their lifecycle, and on that note, was pleased to report that in 2021, unlike the previous year, there was more value engineering work in Chile such as conceptual studies, optimization projects

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Dominique Viera,
Vice President of
Operations, Metaproject



Dave Lawson,
President – Mining &
Metals, Wood

and concentrate process debottlenecks. “A large part of these value engineering projects are transformed into long-term investment projects,” explained Rayo, suggesting that better metals prices are stimulating this demand, as well as a favorable outlook for metals in the future. JRI celebrates its 40th anniversary in 2022, and has been involved in one of the most emblematic long-term projects in Chilean mining – Codelco’s Rajo Inca development, which will extend mine life at the State-run company’s Salvador division until 2065. JRI has developed all of the engineering studies for the Rajo Inca project since 2016, starting with the value engineering and conceptual studies with an integrated scope (mine, plants, tailing dumps and infrastructure), then the feasibility study, and currently the detailed engineering. “We support the contracts of the operational teams and, as the only engineering company that has interacted with Codelco in this project, our participation is fundamental,” stated Rayo, noting that JRI has developed the project with modern work methodologies such as Lean Full Design, BIM 4D and Advance Work Package (AWP).

Another Chilean engineering firm to celebrate a landmark anniversary is Metaproject, which turns 30 in 2022, and also works with Codelco – taking charge of the tender and asset contract management of all the company’s divisions. Dominique Viera, Metaproject’s vice president of operations, discussed some of the common mistakes made during the lifecycle of a project from an engineering standpoint: “Nowadays projects get delayed because there is a siloed chain from the engineering conception to the

different stages throughout a project,” she said, explaining that there can be discrepancies because these stages are often tendered between more than one engineering company, and an excessive part of the budget is given to the construction companies in very early stages, resulting in the following tenders being given to the cheapest bidder. “However, if you buy cheap, you often end up paying twice. In the end, the client has to do contractual modifications resulting in a more expensive and longer project.”

Viera went on to elaborate on the main benefit of the multidisciplinary engineering approach that Metaproject adopts: “A holistic view and clear project management comes from being involved in the design stages with the client, where both parties have a vested interest because they will be involved throughout the life of the project.”

Tackling water scarcity

Undoubtedly one of the focus areas for all businesses in Chile is water supply. In northern Chile, and in particular the Atacama (the driest desert on earth), the issue has been polemic for years. At Exponor 2019 in Antofagasta protestors stormed the conference with a sign stating ‘We will not be a sacrificial zone’, in reference to the water consumed by mining producers in the region. This was before the riots in October 2019, before the vote for the new constitution, and before Chile elected a president who has environmental concerns at the top of his agenda.

Central Chile has experienced a drought for the last 12 years, prompting Antofagasta Minerals (AMSA) to build a seawater desalination plant for its Los Pelambres

mine in the Choapa Valley, via its INCO project, the first stage of which is due to start operation in the second half of 2022 with an output of 400 liters per second. “Our target is for raw or desalinated seawater and reused or recycled water to supply 90% of the operational water use at all our mining operations by 2025,” revealed Iván Arriagada, CEO, Antofagasta plc.

Desalination plants mean more capex for mining companies, and water scarcity also significantly drives up costs. In 2021, AMSA’s net cash cost to produce a tonne of copper was US\$1.20/lb, and Arriagada acknowledged that the 2022 guidance of US\$1.55/lb net cash cost was partly due to the expected impact of drought this year at Los Pelambres, in addition to declining grades at Centinela Concentrates.

Cochilco estimates that mining’s use of seawater — either used directly or desalinated — will increase 167% by 2032, while freshwater use will decline 45%, meaning that 68% of water used by the industry will come from the ocean. The breadth of companies featured in this article also illustrates how water encompasses all aspects of the mining business, from engineering and consultancies to construction and technology providers. A multi-stakeholder approach is necessary to confront the issue of water scarcity, which represents opportunities.

“From a broad water perspective, looking at new mines in Chile I would expect that all are going to use sea water of some description – whether it is desalinated water used as potable water or non-desalinated water used in processes,” said Dave Lawson, president – mining and metals at Wood.

Lawson went on to discuss some of the cost benefit analysis considerations re-

lated to using sea water, such as the construction materials having to be different due to salt water being highly corrosive and the need to replace materials on a more frequent basis.

At the moment, desalination projects are the realm of the major miners who can afford the substantial long-term investment necessary. However, a future where public/private joint ventures can guarantee water supply for a wider base would make using desalinated water viable for more stakeholders. Lawson elaborated: “If you can build a desalination plant that serves multiple consumers from various industries, costs can be shared, making more sense from an economy of scale standpoint. If the government can invest in desalination plants and use some of that water to supply cities and towns, it can offset some of the costs for smaller players in various industries.”

Tomas Fischer Ballerini, general manager of Edyce, spoke of how the Edyce-Arrigoni engineering team worked in close collaboration with Antofagasta’s engineering

team to look for efficiencies regarding the steel structures of the INCO project. “It is not the first desalination project in Chile, but it is by far the biggest,” said Ballerini, noting that Chile needs more projects like this if the country wants to continue attracting mining investment.

Andritz has been involved in desalination plants for mining projects by digitalization their engineering, according to Andrés Rojas, Andritz’ automation director – Latin America, mentioning work the company has done in this area for BHP, Teck at QB2, and with AMSA at INCO. “Once in operation our technology makes the use of energy and water consumption more efficient, optimizing its transportation and energy costs through the incorporation of digital sensors,” said Rojas, commenting that there are many pumps pushing water that can be made more efficient with this technology and that Andritz also improves water use through its solid-liquid separation equipment, both in concentrators and tailings management, to recycle the water used in these treatments.

John Crane has been providing products for the mechanical sealing of rotating equipment for decades, but in the last three years, the company has developed more specific products that aim to conserve or reduce water usage. Carlos Ramírez, John Crane’s general manager for Chile and Peru, explained that usually a seal must have water that lubricates it to prevent wear, but today, with the implementation of diamond seal face technology, equipment can withstand extreme temperatures without the need lubrication. “In mining, due to the complexity and harsh environments that rotating equipment are used in, generally we see very short life cycles,” said Ramírez, commenting that John Crane works with pump manufacturers such as Weir Minerals, Metso and FLSmidth to increase the uptime of their equipment through new technology, including mechanical seals, which can last up to 18 months and do not use water.

Companies that have traditionally worked outside the sector are also bringing their technologies to the mining market, such as Carpi Tech, which specializes in the waterproofing of hydraulic structures using synthetic geomembranes and geo-compounds. Pascual Perazzo, Carpi Tech’s business development manager for Latam, recalled how the company entered the mining market eight years ago working at a mine in Iran after a recommendation by tailings specialists, ATC Williams: “There we made our first tailings dam with the CARPI waterproof membrane. Consequently, we have made several hydraulic structures for mining to supply water to operations.”

The renewable energy boom

When speaking with major mining companies around the world, one of the most noticeable themes is the concerted push to use more renewable energy to power operations. At the World Copper Conference in Santiago, March 2022, Codelco, BHP and Rio Tinto all highlighted investments and initiatives in the renewables space, with BHP’s president of minerals Americas Ragnar Udd offering an open invitation to companies willing to help with the elimination of diesel through technology.

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Pablo Varela,
Managing Director – Latin
America, Aggreko

is initially 10 years but will likely be extended. We will start by providing diesel and solar solutions, but have committed to improve the technology as the availability of newer innovations comes to the market.”

Expanding on the type of solutions being evaluated for installing batteries at Salares Norte, Varela revealed that Aggreko is considering installing virtual gas pipelines to the site. “We currently have several small power plants running at different sites and already began construction on the main power plant which will first run on diesel while we are working on the environmental approvals to install the solar PV solution,” he said, adding that ironically it currently takes longer to attain a solar approval than a diesel approval.

With the energy transition in mind, companies are rebranding to better represent the focus and direction their business is heading. In October 2021, Hitachi ABB Power Grids became Hitachi Energy, and Mauricio Mazuela, Hitachi’s general manager for Chile, explained why this is relevant in a Chilean context: “In the coming years about 50% of the power in Chile will come from the sun and the wind, and energy is now being seen from another point of view from the population. That is why we evolve our branding; if the world of energy is evolving, we must evolve.”

Pablo Varela, managing director of Aggreko in Latin America, a company that supplies bespoke energy solutions and storage to power isolated mines, discussed Aggreko’s partnership with Gold Fields at its Salares Norte project, working on Gold Fields’ first hybrid installation and largest photovoltaic solar installation in Chile. “Aggreko has committed to deliver power to the Salares Norte project for the whole life of mine, which

Mazuela remarked that there should be a country-wide commitment to install clean energy, because new lines and plants are needed: “Supplementary systems, like solar farms, as renewable as they might be, will not yield sufficient energy during the night. Therefore, a hybrid mix of different energy sources is necessary.”

Another company to have rebranded in 2021 is OHLA (formerly OHL), signifying the new owners’ focus on sustainable construction and renewable energy projects, such as wind and solar design engineering, including battery system storage, according to Thomas Aldunate Kunstmann, business development manager renewables Latam – industrial division. Kunstmann pointed out that according to the International Renewable Energy Agency (IRENA) Chile and Mexico have the world’s highest levels of sunlight, and OHLA uses bifacial modes to transform this sunlight into energy, as well as using string inverters to enhance operational reliability and efficiency at the plants, which reduces prices. He also echoed Mazuela’s statement that big mining companies utilize a hybrid combination of sources because they require constant energy.

Discussing the themes driving demand for renewables in Chile, Kunstmann mentioned water: “Companies utilize desalination to use water from the sea, which requires an enormous amount of energy. Renewable energy sources can facilitate this process and will gain traction as more desalination projects are built.”

Safety in mining construction

The construction industry has had to withstand multiple challenges in the last two years. In 2020 and 2021, Covid-related work-from-home measures meant many projects had to scale down, and when they restarted, severe supply chain delays and rising logistics costs meant that profit margins and completion dates were compromised.

Despite dealing with such complexities, Darío Barros Izquierdo, general manager of Echeverría Izquierdo Montajes Industriales, mentioned that the company never stopped operating in 2021, with a crew of up to 9,000 workers. He cited the company’s work on the primary crusher, two overland conveyors, a stockpile, the

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Darío Barros Izquierdo,
General Manager,
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reclaim tunnels and a lime plant at Teck’s QB2 project as a particular success, suggesting the years of experience of Echeverría Izquierdo’s collaborators at Collahuasi’s operations meant workers had previous experience in similar conditions.

For the past six years, Echeverría Izquierdo has been recognized by the Chilean Chamber of Construction for workplace health and safety standards, and Barros spoke of the factors which contributed to this recognition: “Our approach is to work with our own people and equipment fleet; we outsource very limited activities, and we work with our own cranes and major lifting equipment. We therefore know their story and maintenance as well as the operator and rigger. We have a centralized rigging department that has an exhaustive review process to ensure the safe performance of hoisting and rigging activities.”

Another company to have worked at QB2 is ULMA Construction, specialists in concrete formwork and scaffolding solutions. Antonio Carlos Machado, ULMA’s commercial director in Chile, highlighted the importance of product diversity: “For many min-

ing operations a single type of product, technologically speaking, would not be able to address the entirety of a project. The combination of the different systems ULMA has makes the entire construction process more productive and safer. The safety aspect is the most important point to highlight, as it is fundamental for mining.”

Machado added that ULMA’s multi-directional scaffolding system, MK, contains a variety of metal profiles that form a kind of large-scale Meccano, well-suited to large-scale mining projects with large load capacities where the project engineering needs a system with resistance characteristics superior to what is traditionally offered.

MJ Gerüst, the multinational German scaffolding manufacturer, also offers multidirectional solutions. Christian Abt, MJ Gerüst’s area sales manager for the Americas, gave an example of how such products are applied to mining settings: “Acid, water and petroleum ponds which mining companies use for storage could be easily solved by our frame and multidirectional solution, which is the Uni-Connect and Combi system, fulfilling the highest safety requirements. Ball Mills, crushers, truck shops and conveyor maintenance are suited to our MJ Combi and MJ Optima solutions.”

Abt went on to say that if the industry is truly seeking to innovate, reduce cost and human exposure, then MJ Gerüst’s Optima system, a hybrid solution that is lighter and can be erected faster, is the type of technology that will significantly improve mining operations.

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Equipment, Innovation & Services

*This rise of
autonomous
mining and
remote operations*



Photo courtesy of Kinross.

Three of the biggest challenges facing the mining sector revolve around decreasing its environmental impact, attracting enough young talent to overcome a growing skills shortage, and accessing new deposits. Long before the pandemic declining ore grades had been the stimulant to develop technology that could lower the cost per pound produced and increase the safety of extracting metal. Covid-related work-from-home restrictions accelerated the adoption of remotely operated equipment and now, in 2022 inflationary pressures and supply chain delays have added further elements to the mix in an industry undergoing transformation to ensure it remains competitive from both a cost and ESG standpoint.

Autonomous mining and remote operation are two of the key themes enabling the sector to address these issues. Teck's Quebrada Blanca 2 (QB2) will be the first of the company's op-

"I believe the era of siloed competition is behind us. Collaboration, not only amongst business partners, but also between competitors, is vital to deliver the solutions that the world needs and our customers need."

John Swift,
Managing Director –
Chile,
Epiroc



erations to incorporate a remote Integrated Operations Centre (IOC), bringing together the resources and data necessary for centralized decision making to help achieve better operational performance. Furthermore, being based in Santiago, the IOC can attract a new generation of mining professionals who may not want to be located at the mine site.

"As QB2 is a greenfield development you can build the autonomous operation as the customer is building the mine. You have the benefit of being able to establish a culture and you can build a team which is centered around this new way of operating," observed Sebastián Guridi, senior VP of mining – South America at Finning.

In 2019, Finning signed a contract with Teck to supply a fleet of Caterpillar 794AC electric drive off-highway trucks and other large mining machines for QB2, as well as Cat's Command for Hauling system and 794AC AHS (Autonomous Haulage Technology) kits. "One of the most valuable things about the QB2 project is that we are demonstrating that we can successfully do autonomous mining in deep, hard rock copper mines at 4,000 m of altitude," said Guridi, adding that autonomous vehicles also help in reaching areas which would otherwise not have been accessible.

Guridi believes that autonomous hauling is a real game changer for the industry, giving the example of Finning's autonomous underground equipment being used at El Teniente: "Everything can be done autonomously with only small sections which require manned operations, allowing you to have one operator for several vehicles."

John Swift, Epiroc's managing director for Chile, highlighted digitalization and the company's automated suite of products as ar-



Sebastián Guridi,
Senior VP of Mining –
South America, Finning



Rodrigo Couto, President –
Latin America, Hexagon’s
Mining Division

...eas of the business that have been in high demand. He gave the example of Epiroc’s involvement at Anglo American’s Los Bronces project where automated Pit Vipers are operated from a distance. On the subject of innovation, Swift revealed that Epiroc is looking at remotely doing tasks not only operating the machines: “For example, cognitive reality, where we can advise technicians from a distance, and micro-adjustments to pumps and motors to keep people away from physically running the machines.” Swift underlined the importance of collaboration between suppliers, such as such as Epiroc’s work with Chilean company, ROCMIN, to create equipment that is customized to suit Chilean conditions: “I believe the era of siloed competition is behind us.

Collaboration, not only amongst business partners but also between competitors, is vital to deliver the solutions that the world needs and our customers need.”

Blasting specialist and technology company Orica has collaborated with Epiroc to create Avatel, the first fully mechanized development charging system. The company is currently trying to implement Avatel at projects in Chile and expects this to materialize in 2022, according to Oscar Castaneda, Orica’s general manager for Chile and Argentina.

“My experience at Codelco and BHP made me see that mining companies are thinking outside of the box because nowadays if you continue producing on deposits in the traditional way you are going to hit a plateau, especially at some of the older mines in Chile,” observed Castaneda, who also emphasized the collaborative nature of innovation, giving the example Fundación Chile, a mechanism of rapprochement between mining companies with technology companies, entrepreneurs and universities to connect and combine capacities. “It is a cultural change that has been taking place in recent years,” he added.

One of the pioneers of remotely operated mining technology is Canadian company HARD-LINE. Brian Larocque, HARD-LINE’s general manager in Chile, explained the transition from line of site control (an operator standing in front of the equipment watching it work from a safe distance) to teleoperation. He gave the example of autonomous blasting at a sublevel stoping operation as an illustration of how productivity can be increased:



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“Autonomous operations allow for much less down time as usually after a blast you will not be able to send anyone into the mine for two hours, but now the autonomous equipment can be operating.”

For the open-put market Larocque discussed HARD-LINE’s partnership with Hexagon to develop autonomous situations such as collision avoidance, GPS and drilling patterns: “We marry Hexagon’s systems with HARD-LINE’s systems and based on the combined technologies the equipment can move from teleoperation to semi-autonomous operation to fully autonomous operation.” Rodrigo Couto, president Latin America for Hexagon’s Mining division, explained how the two companies are combining technologies so that mine workers can be removed from dangerous environments, and he also spoke of Hexagon’s partnership with Liebherr to deliver automation solutions: “The most impactful aspect of this is Hexagon’s autonomous mission management system, which orchestrates fleet and unmanned mine traffic movements throughout the mine for optimized haulage”.

Changing mindsets

As a leading mining jurisdictions Chile is advanced when it comes to the adoption of innovation at mine sites. “The mining boom in the 1990s triggered the growth of mining expertise in Chile and the industry has grown alongside emerging technologies,” explained Eduardo Coloma, CEO of Maptek.

However, Coloma acknowledged that the mining industry on a global level is struggling to attract new, young talent. Fostering a younger generation of mining professionals is not only important to keep up with demand, but will also help from the standpoint of technology adoption.

“The main barrier to adoption is culture, not only in the mining market but across industries, and thus change management is extremely important,” commented Mauricio Gregorio, Siemens’ digitalization manager for Chile and Peru, adding that the mining market has come to understand that digitization will be the main driver of increasing main KPIs such as productivity, safety and reliability.

“Today, all the elements that operate in a mining operation produce data, and the big question is how to handle, manage, protect, and use that data effectively. The issues of cybersecurity, data protection, data management and analysis are all very big opportunities.”

Philippe Hemmerdinger,
President, Association
of Industrial Mining
Suppliers (APRIMIN)



Hexagon’s Rodrigo Couto remarked that Chilean mining is advanced with respect to the adoption of many technologies, but catching up when it comes to collision avoidance systems and fatigue monitoring. Many of Chile’s largest mines have had unionized workforces for decades, which have contributed to better working conditions and fairer pay. However, new technologies can be seen as a threat to a traditional way of doing business. “We have been talking with the unions in Chile to explain that collision avoidance systems and fatigue monitoring technologies are not meant to expose drivers but rather to protect them instead so that they can return home safely,” said Couto. Some of Chile’s most important mining operations are also their oldest. Mining at El Teniente, for example, is reported to have started as early as 1819, before the Chilean government bought a 51% interest in the mine in 1967 from Kennecott Copper Corporation. Introducing technology at operations that have operated in a certain way for many years can be a challenge, but State-run mining company Codelco has invested heavily in modernizing its operations. Speaking at the World Copper Conference, CEO Octavio Aranedo underlined the company’s focus on digital transformation.

A large banner for Hexagon. On the left, the Hexagon logo (a white wireframe cube) is positioned above the word "HEXAGON" in large, white, bold, sans-serif capital letters. Below this, the slogan "The Power of One partner for your mining solutions" is written in white, bold, sans-serif font. The background of the banner is dark blue with a diagonal split. The top right portion features a glowing blue fingerprint graphic. The bottom right portion shows a yellow mining truck in a dark, rocky environment, with several small white icons (a gear, a location pin, and a document) overlaid on the scene.

César Ortega, founder and general manager of Chilean company Telemining, worked at Codelco for 34 years and became director of telecommunications, information and automation technologies for all divisions before founding Telemining in 2011. Telemining provides digital services installations, automatization and access control systems for underground mining settings, and Ortega emphasized the importance of installing the requisite digital infrastructure to support autonomous operations. “Today a 1 GB network is too small; you need at least 10 GB to communicate between camps,” he stated, noting that the demand for communication networks has never been higher. “Broadband communication is a must, because shovels and trucks are now automatic. That is the tendency of the future where mining will become completely automated; all the operations will be driven and managed from control rooms through broadband communication networks.”

Telemining has worked with Rajant at El Teniente, a US-based company focused on enabling wireless communications in real time. Sagar Chandra, vice president business development Americas at Rajant, explained that with underground tunneling comes a myriad of challenges such as space constraints, difficult ground conditions, unmovable underground structures, and work that must be done in an environment where it is difficult to deploy reliable network systems. He described how Rajant’s private wireless network enables tunneling operators to overcome the networking challenges inherent in enabling communi-



José Pablo Domínguez,
General Manager – South
America, ME Elecmetal



Christian Cavagnaro,
Managing Director,
TAKRAF Chile

cations, and improves productivity inside tunnels: “Our Kinetic Mesh network comprises compact, lightweight BreadCrumb nodes that can be flexibly deployed throughout the tunnel, on both fixed infrastructure and moving equipment, to form a robust mesh network underground.”

Another mining tech company founded in 2011 is MC System Chile, representatives of Leica Geosystems. Its Machine Controls (MC) are topographic systems onboard machines (such as excavators) that help the operator work to the desired quota, eliminating over-excavating, markings on the floor, and the need for people controlling the floor or staking pegs. The company has worked at operations including Los Pelambres, Los Bronces and Quebrada Blanca, and Christophe Boinelle, director of MC System Chile, suggested that this technology should be provided by a small company due to the flexibility needed.

“When you start working with these systems the machine will work much faster, but if something goes wrong with the system, such as something getting unconfigured or a wire getting cut, the operator goes blind because there are no markings on the floor like before. We are very fast at fixing it,” explained Boinelle, noting that all the protocols larger companies have to comply with make them less efficient.

Innovation in the valve segment of the mining industry, through smart flow control solutions, is enhancing the sustainability of mining operations. Gonzalo Silva, regional manager of Neles Chile SpA, which is now part of Valmet after the merger of Valmet and Neles was completed on April 1st, 2022, explained how the company’s software helps avoid unnecessary stoppages, reduces waste from the process, reduces the replacement of equipment, and avoiding contamination due to excessive consumption of any product. Silva gave the following example: “To this end, we have solutions called Zero Leakage. These solutions guarantee that everything being controlled by our valves is going to stay within the process and not go out into the atmosphere.”

Ancillary vehicles

Suppliers of ancillary and construction vehicles, such as the trucks and tippers that move ore, dirt and concentrate or the buses that transport mining workforces, have seen rejuvenated demand since the height of the pandemic.

To keep up with demand from mining in the Antofagasta region, Swedish OEM Scania has decided to invest US\$5 million to ex-

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pand its workshop, with construction due to start in September/October 2022, according to Pascal Zappone, managing director of Scania Chile. When asked about the focus of this demand, Zappone pointed to solutions that increase the sustainability of operations, such as fleet managements systems (FMS) that enable customers to utilise data from a connected vehicle, lowering fuel consumption and reducing wear and maintenance needs. Zappone highlighted Scania Super, a new engine platform that will be launched at the end of 2022: “This new powertrain has sustainability at its core and is the most advanced combustion engine we have ever built, promising a reduction in fuel consumption between 8% and 10% and more uptime than ever before. All engines have inherent HVO (hydrotreated vegetable oil) fuel capabilities and two of them can be ordered as FAME biodiesel versions.”

Luis Izquierdo, general manager of Andes Motor, the equipment distributor that represents Maxus, Foton, Karry, Iveco, Agrale and Sany in Chile, spoke of the progress made in electric vehicle adoption for mining passenger transport, which Andes Motor is advancing with SQM and Teck. He detailed that the company’s sales in the EV area increased by 44% in 2021, and revealed the company will be testing electric tractors at mine sites in 2022.

Discussing the challenge of transitioning to electric mobility because of the significant technological change, Izquierdo added: “We created a specific electromobility unit to grant support to customers and help them learn. In the same way we went to factories to learn; we have to transmit that knowledge to advance adoption.”

Tailor-made equipment

During interviews with companies involved in the comminution and material handling space in Chile, one of the common trends has been the importance of tailoring solutions to the needs of the client and the mine environment rather than offering a standardized solution. This is particularly relevant for large-scale projects where incremental improvements to productivity can make a significant difference to mining output, while at the same time reducing waste and increasing the safety of an operation.

José Pablo Domínguez, general manager South America of ME Elecmetal, spoke of the company’s work at INCO and QB2. “We proposed AMSA and Teck to perform an optimization process of the mill liners designed for the specific processes of each operation so new equipment could be installed ready to use,” said Domínguez, stating that he expects both projects will achieve a smooth ramp-up of their mills and equipment because they will start with liners designed specifically for those environments. Discussing ME Elecmetal’s approach, Domínguez added: “When we take on a project, we are not only looking for excellence in the manufacturing of the spare part or the liner, but also on the interaction of that component with the mill, the crusher, the equipment, the way they operate and the impact that will have on the tonnes per hour the mill or the crusher will yield, and/or in the mineral recovery.”

On the topic of equipment customized to a particular project, Christian Cavagnaro, managing director of TAKRAF Chile, gave the example of his company’s work at Codelco’s Chuquicamata underground mine, noting that a project of this scale and complexity requires a lot of work to lower operating costs and reach the deposit.

Cavagnaro revealed that TAKRAF installed a high-power, high-capacity conveyor belt system, introducing gearless drive technology. “Gearless technology is not new, but it has only recently been introduced to conveyor belt systems,” he said, elaborating: “We chose gearless technology because of its energy efficiency – CO2 emissions are reduced by ~66% as compared to diesel truck engines for the same copper production volume – and operational costs are reduced, as they require much less maintenance.”

Considering the size of the conveyor, TAKRAF’s belt technology partner also developed a new tension range belt to transport the material under such an extreme condition. “Since you cannot make a 6 km long belt, you have to do it in parts and splice the joints,” explained Cavagnaro, concluding: “In the case of Chuquicamata this project achieves a number of world firsts, boasting the highest conveyor drive power of 58 MW and the strongest resistance belt in the world.”



“If you continue producing on deposits in the traditional way, you are going to hit a plateau, especially at some of the older mines in Chile.”

**Oscar Castaneda,
General Manager -
Chile & Argentina,
Orica**



Another company working at Chuquicamata is High-Res Tecnología Antidesgaste (High-Res), a Chilean company dedicated to the development and manufacturing of innovation in the area of anti-wear coatings for abrasion, impact or corrosion. Rodrigo Diaz, general manager of High-Res, revealed that initial contact was made with Codelco when they were working on their first production line for crushing, during which time they were having issues with the process, stopping every 15 days to change the coating in the middle conveyor belt. “Stopping a mining operation for eight or nine hours every 15 days is too much, so we proposed a solution – a High-Res design using rubber, plasma and tungsten carbide – which meant operations stopped only once every three months, rather than every 15 days,” said Diaz, adding that High-Res is now working on the entire line of wear products for Chuquicamata, and in certain areas can improve equipment wear from 20 days of durability to over six months.

Drillco is a Chilean company in the drilling equipment space that has been active for over 50 years and today has seven offices worldwide. Javier Varela, CEO, explained that the company differentiates

itself by observing operating conditions and making modifications in collaboration with clients to achieve better performance. He elaborated: “This involved a lot of studies to understand variables such as the rocks, the conditions that the equipment works under, how they operate with compressors, etc.”

Trinidad Carmona, Drillco’s sales and marketing director, gave the example of an automatic replacement system for drilling components that the company developed with one of its mining partners: “The operator, with the press of a button, can go through the entire process of replacing the component, which reduces the replacement time from around 55 minutes to 3 minutes, as well as eliminating the risk to the personnel and energy usage.”

Sustainable chemical solutions

The chemical industry shares a common struggle of public perception with mining – both sectors are necessary for everyday items we take for granted, but neither are generally thought of in a positive light. In reality, responsible chemical use has a multitude of benefits, from increasing crop production to feed a growing global population, to improving metal recovery or treating water in the case of mining.

Ricardo Capanema, global marketing director mining solutions at Solvay, spoke about Solvay’s global plans to grow in the copper business: “Solvay is investing in capacity building to meet increasing demand for flotation equipment and concentrators. This is partly driven by the industry’s decarbonization push.”

Capanema expanded on how sustainability is a driving force in R&D, detailing how Solvay’s solutions can help different areas of the mining business: “Additionally, we have developed solutions to help mining companies treat challenging ores that contain problematic waste. We also help companies address their energy and water conservation, especially during the comminution stage.”



Photo courtesy of Neles Chile SpA (Part of Valmet).

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