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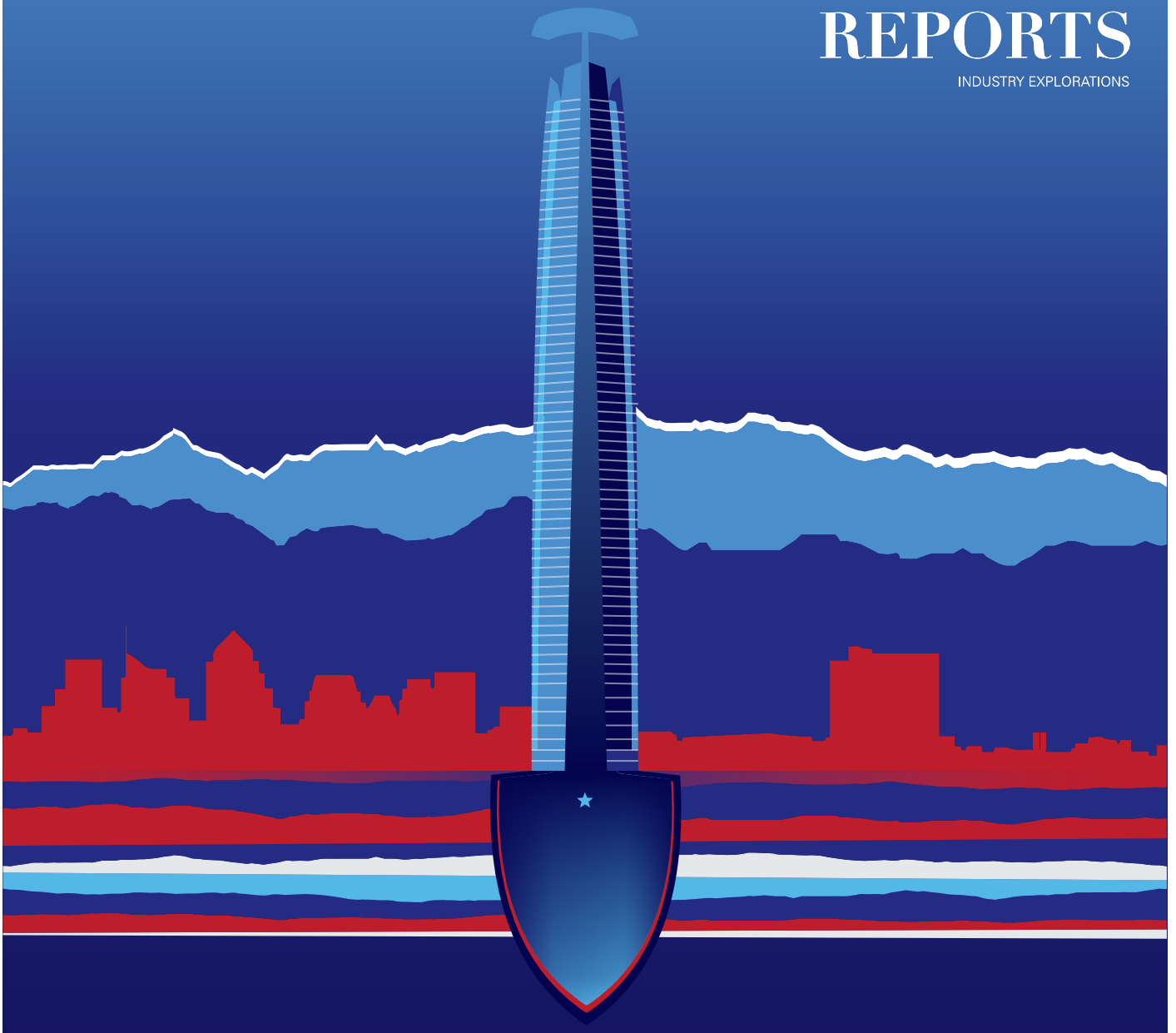

CHILE
MINING
2021

Political Overview - Production - Exploration - ESG
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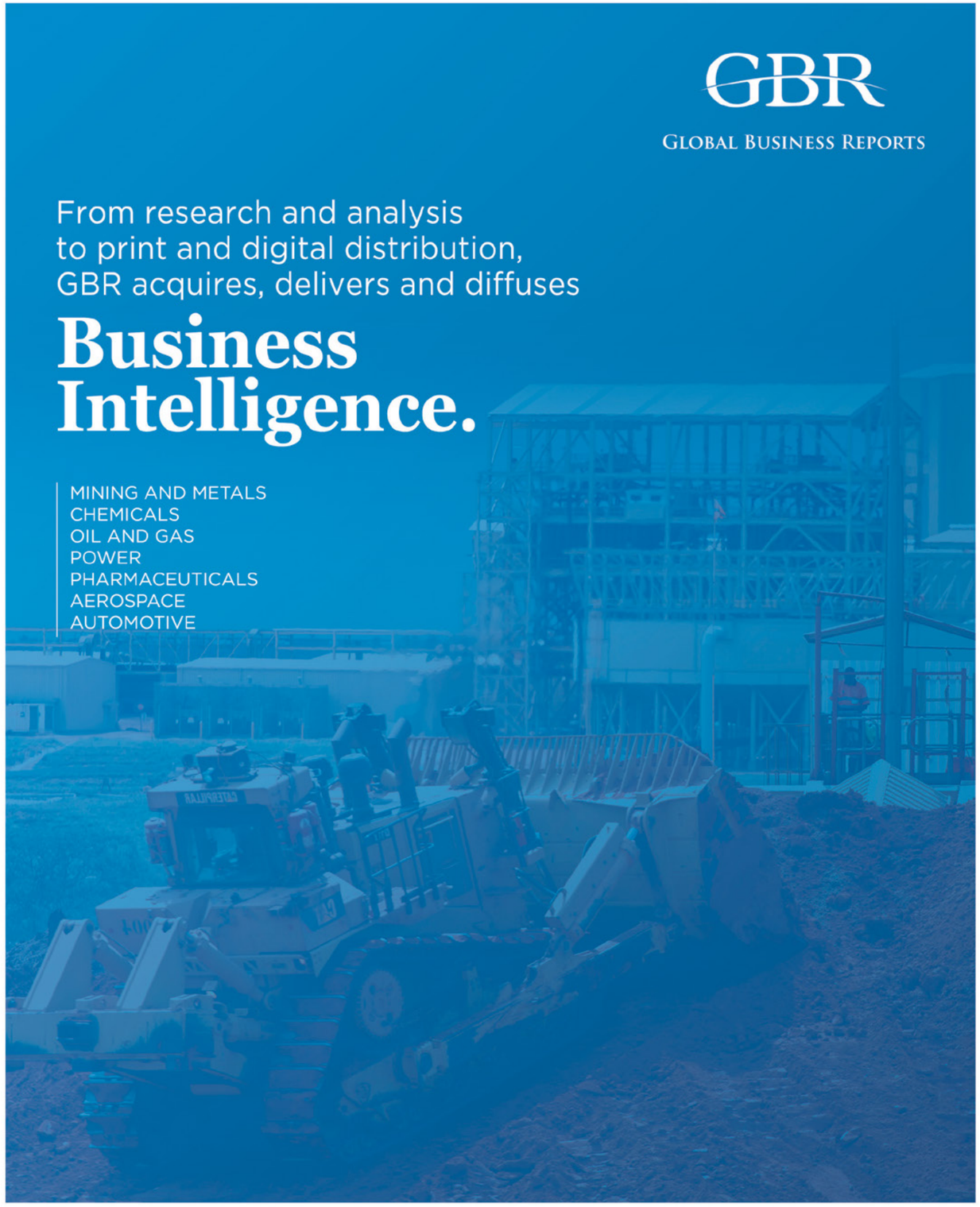

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Dear Reader,

Welcome to our *Chile Mining 2021* publication, where we dive deep into the challenges, opportunities and competitiveness of the Chilean mining industry, as well as ongoing trends and debates on automation, digitalization, the copper cycle, the future of lithium and potential for gold.

Our Chile Mining report of 2020 highlighted the battle the country fought with the social unrest and how the industry was impacted. Chile was hopeful at the beginning of 2020 to start the year on a clean slate. However, the world witnessed the Covid-19 pandemic unravel, plunging global economies into recessions and triggering trillion-dollar stimulus plans.

Fortunately, the Chilean mining industry has shown remarkable resilience and perseverance, as it withstood the external pressures well compared to other leading copper producers. This was facilitated by the industry's early trial at remote work in October 2019 and the boom in commodity prices that pushed base and precious metals to record-highs that gave hope to the global mining sector.

The pandemic has also significantly accelerated technology adoption across the entire supply chain as companies adopted remote working techniques. However, there were challenges as supply chains were disrupted due to lockdowns and social distancing measures.

The pandemic aside, the industry in Chile is fighting some of the same battles we see every year with water scarcity, rising energy costs and decreasing total factor productivity. This year we are witnessing significant investments in R&D by equipment and service providers to address these challenges.

In parallel to these events, the country is undergoing a pivotal process that will dictate its future: rewriting the national constitution. Some investors and analysts remain wary of how this might impact mining investment, although regulators should be aware of the industry's significance and its crucial role in the country's economic growth and development.

This report is the product of over 70 interviews with major mining companies, junior mining companies, service providers, equipment and technology suppliers and government officials, as we try to paint an accurate picture of the present state of the industry and attempt to foresee its future direction.

Thanks for reading!

Alfonso Tejerina
General Manager and Director
GBR

CHILE MINING 2021
Industry Explorations
Global Business Reports

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INTRODUCTION TO CHILE

"The challenges in the Chilean mining industry are entering a new stage as the industry matures. Today the industry is focused on sustaining operations in a complicated environment, characterised by political and economic uncertainty."

- Juan Carlos Guajardo,
Founder and Executive Director,
Plusmining

Image courtesy of Freeport-McMoRan

Chile faces hurdles to maintain leadership position

OVERVIEW OF MINING IN CHILE

The world witnessed unprecedented events in 2020, and Chile, the world's copper powerhouse, was no exception. Traditionally considered a model for political and financial stability in Latin America, the last two years have challenged this reputation. Nevertheless, the country's solid macroeconomic framework has allowed it to withstand the pressures, cushioning the effects of the volatile internal disturbances of 2019 and the pandemic of 2020.

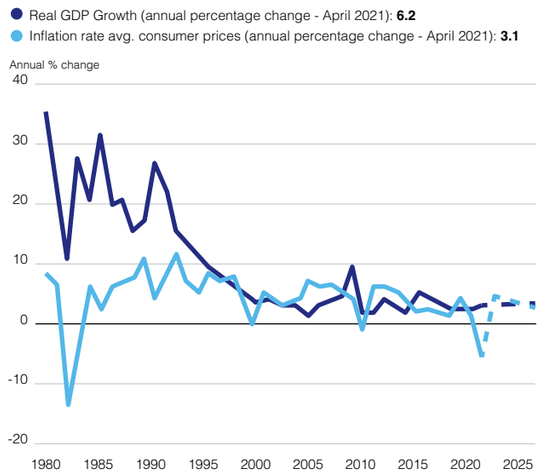
In October 2019, the country experienced social unrest reflecting widespread frustration with persistent inequality. Yet mining investment in the same year recorded its highest level since 2015, standing at US$10.1 billion, while total production in 2019 amounted to 5.79 million tonnes (mt) of copper and 112,600 mt of lithium, according to the Chilean Copper Commission (Cochilco). In 2020, the country was exposed to volatile copper prices and export demand, as well as prolonged Covid-19 containment measures. On 25th October 2020, Chileans held a plebiscite, resulting in a landslide majority voting to draft a new Constitution, potentially adding uncertainty to the future evolution of the regulatory framework. Yet, these factors did not prevent copper output from maintaining stable levels, with 2020 production reaching 5.73 million mt according to Cochilco.

"The pandemic has affected practically every aspect of life in Chile. Curfews, temporary border closures and reduced business hours were implemented to lower infection rates," elaborated Christoff Janse, investment promotion officer at InvestChile. "The mining industry, however, has been resilient. The sector's safety protocols were quickly adapted to minimize contagion risks. Some investments were delayed due to logistical challenges resulting from the lockdowns, most of which are resuming in 2021. "

The copper price was expected to enjoy an upward trajectory in 2020, but the reality was a rollercoaster of price changes. As the Covid-19 outbreak went from a public health emergency in China to a global pandemic, the copper price plunged to a three-year low in March 2020, before peaking to an eight-year high in Q1 of 2021. On the other hand, gold witnessed a bullish run as cases rose, reaching an all-time high in August 2020. Meanwhile, lithium, of which one-third of the supply is in Chile, faced downward pressure as a result of disruptions and uncertainty as electric vehicle (EV) sales decreased. "The pandemic ignited and exacerbated

GDP and Inflation

Source: IMF



2020 has been a year of great uncertainty and, despite variations in companies' production projections, Chile's mining sector has demonstrated remarkable resilience and has overcome these challenges successfully, thanks to the industry's commitment to safety and strict protocols.

- Marco Riveros, Vice President, Cochilco

Juan Carlos Jobet

BI-Minister of Energy and Mining
GOVERNMENT OF CHILE

Chile continues to be the fourth country in the world in terms of exploration investment, with over US$450 million in 2020 alone.

What is the vision of the Piñera administration for the mining industry?
Mining is our biggest industry: It represents over 10% of our GDP, more than 50% of our exports, 25% of total investment received, and a big chunk of fiscal revenues for the country. 2020 presented many challenges, the pandemic being the largest one, and the mining sector showed great resilience and capacity to take care of the health and safety of workers, with contagion rates much lower than the average population. That was complemented with business continuity, as we closed 2020 with a copper output in line with 2019 figures. For comparison, copper production in Peru fell by 30% in 2020, so the industry's performance in Chile was remarkable last year.

Copper has been trading at very high levels in 2021. How can the industry take advantage of this opportunity?
The main opportunity ahead is that projected demand for copper is very big, as global economies progressively migrate from fossil fuels to renewable energies and the usage of electric vehicles continues to increase. In this context, the industry is at the core of global efforts to put a stop to global warming.

To take on this opportunity, the industry in Chile needs to solve several challenges: first, our deposits are quite mature, so mineral grades have been falling, hauling distances have been increasing, and the rock has become harder. In many cases, companies have had to invest significant amounts just to maintain the same levels of production. So, the first challenge is competitiveness and the introduction of new technologies.

The second challenge is sustainability: the industry is already switching from coal power generation to contracts with renewable energy providers, and we expect that more than 60% of the energy used in mining will come from renewables by 2023. Related to this, another issue is water: today, 30% of the water used in the industry is seawater, and that figure should reach 50% by the end of the decade. We also need to improve relationships with the local communities, and optimize our environmental management in terms of tailings, glaciers and other aspects.

The Pascua Lama case has put the spotlight on glacier protection. How can the industry coexist with glaciers?
Glaciers are a key freshwater reserve that regulate water flows in the different basins. Their importance is only going to increase with climate change, so they need to be protected. This said, the mining industry can perfectly develop while protecting glaciers. The overlap of mining activities with glacier areas is extremely low. There is a legislative bill advancing in Congress, and we believe we are reaching a good point of equilibrium between glacier protection and mining industry development.

Chile is considered to be a 'mature' country in terms of exploration. How can the industry continue growing based on new discoveries?
For the last years our production has been stable, but we have not been able to significantly grow our copper output. Chile continues to be the fourth country in the world in terms of exploration investment, with over US$450 million in 2020 alone. However, nearly 85% of that money was spent by majors. As part of our mining policy, we are trying to promote exploration by junior companies, and that involves several aspects, including permitting, access to information, access to funding, and the right framework to incentivize concession holders to really advance their exploration work. If majors are not using their concessions, they should probably bring in partners. However, the mining industry presents a lot of risk so it is important to maintain the rules without abrupt changes.

Do you think the process to rewrite the country's Constitution will damage investment attractiveness?
Investors understand that a country that has grown very rapidly over the last 30 years needs to update its regulatory framework to adapt to new circumstances. Interestingly, it is local investors who appear to be more worried. While the process may bring a certain degree of uncertainty, last year alone there were environmental impact assessment approvals for projects worth US$20 billion. The total project portfolio amounts to US$70 billion this decade, and the high price of copper will incentivize the development of further projects. ■

the upward cycle of commodity prices by triggering one of the most extensive expansionary monetary and fiscal plans in history," highlighted Juan Carlos Guajardo, founder and executive director of Plusmining.

The pandemic and its consequences aside, Chile's mining industry stands at a pivotal crossroads. The industry facilitated the nation's rise and prosperity, but is witnessing lower productivity, dormant greenfield exploration, plus greater social pressure and environmental awareness, all of which are limiting its international competitiveness. The copper giant is aware of these challenges and is forging a new trajectory in exploration and production led primarily by innovation and constant collaboration between the stakeholders in the industry to facilitate its long-term growth.

On the bright side, the pandemic could positively impact the mining industry's future efficiency. Mining companies realized that there is space to increase productivity as they were able to maintain output with less personnel on-site.

- Alejandra Fernández, Mining Director, Fitch Ratings

Fighting the outbreak

The Chilean government has fought to strike a balance between containing the virus and shielding the economy. Unlike in Peru, mining was declared essential to prevent closures to mine sites, since the industry contributes 15% to the nation's GDP and represents half of its export income. However, as the outbreak expanded in Chile, some major operating mines did close in Q2 of 2020, namely Codelco's Chuquicamata, after worrying levels of infection among staff members. The pandemic strained relationships between mining companies and workers' unions, as companies were accused of not taking adequate measures to reduce the risk of infection, whilst taking advantage of the crisis to reduce jobs. According to mining association Sonami (Sociedad Nacional de Minería), by July 2020, 35,000 jobs had been lost as a result of pandemic-related lay-offs. However, despite reductions in personnel, production did not suffer to a large extent. From January to May, copper production hit 2.37 million mt, an increase of 3.5% from 2.29 million mt in the same period of 2019. Only Anglo American reported a steep fall in output due to water shortages at Los Bronces.

Critical to the miners' pandemic response was minimizing physical presence at mine sites. Chile, as a hub for mining innovation, was well equipped to take this on and maintain production levels with half of the staff on-site. According to Philippe Hemmerdinger, president of the Asociación de Proveedores Industriales de la Minería (Aprimin), the mining suppliers' association: "Chile's experience with the social unrest in October of 2019 gave it a trial run at remote work, so companies were to some extent prepared for the Covid-19 outbreak. Operations were smooth as measures ensuring employees were trained and equipped for working at home were fortunately already in place."

This smooth transition and implementation of remote control and autonomous mining techniques during 2020 allowed production volumes to be maintained. "The Chilean mining industry was already leading the way to develop more autonomous mining before the pandemic," highlighted Dale Clayton, managing director of Liebherr in Chile.

While the health crisis did not impact production to a large extent, it resulted in the delay of mining projects worth billions, since 23 projects were postponed, according to Cristián Cifuentes, strategies and policies coordinator at Cochilco. Codelco, which is in the midst of an ambitious 10-year, multi-billion dollar investment drive to open new projects and overhaul older mines, reduced its investment portfolio by US$650 million. However, it bounced back rapidly, re-

Marco Riveros

Vice President
CHILEAN COPPER COMMISSION (COCHILCO)

Why do you think Chile has been so resilient to the challenges posed by Covid-19?

2020 has been a year of great uncertainty, and despite variations in companies' production projections, Chile's mining sector has demonstrated remarkable resilience and has been able to overcome these challenges successfully. The industry's commitment to safety and the implementation of strict protocols, together with the hard work of everyone involved in the sector, kept operations going and maintained productivity.

During the pandemic, Cochilco played a fundamental role in Chile, acting as a government adviser in everything related to copper and its by-products. This organization is directed by a council consisting of government ministers of mining and finance, relevant individuals from the central bank, and people appointed by the President of the Republic from the private sector. Our activities are carried according to the council's decisions, which is how we manage to operate with great objectivity and have been a highly valued institution. Cochilco safeguards the public interest of the state-owned mining companies Codelco and Enami by auditing corporate processes and operations and compliance with the applicable laws. The Commission also evaluates the associated risks and their impact on operations.

What are Cochilco's investment predictions for Chile's mining industry for this decade?

Before the pandemic, Cochilco projected an investment of US$74 million in Chile's mining industry for the 2020-2029 period. Despite the effects of the pandemic and the uncertainty generated by it, we maintain this estimation since the factors that allow us to calculate investment have not been altered. This is also due to the fact that mining projects have long-term horizons.

Can you elaborate on the current state of mining exploration?

Exploration is a very significant aspect of Chile's mining industry, but one of the consequences of the pandemic has been a decrease in investment in this activity. The country is currently experiencing the challenge of declining grades of mature mines, so increasing exploration is the perfect remedy for this.

What is the potential for the gold mining industry in Chile?

Chile's prominent role as a copper producer often causes other metals to be overlooked. While gold production is typically associated with countries such as Mexico and Peru, Chile also has significant gold reserves. In fact, US$3 billion in investments have been recently announced in gold and silver projects for 2020-2029. Currently, there are also substantial development prospects for the lithium industry.

Will lithium regulation be addressed in the following years?

Lithium is becoming highly relevant in sectors such as electromobility and the condensation of clean energies. According to Chile's legislation, lithium is a non-concessionary element. This means that its exploitation can be undertaken in public properties, which can be rented through special agreements, or it can also be done in collaboration with private companies. Taking into account that lithium is often found in water solutions under the surface, it is likely that its legislation will have to adapt to prevent its extraction from altering the aquifer basins significantly.

What is your view regarding the debate on whether we are witnessing a new commodity "supercycle"?

The price of copper responds to the laws of supply and demand. A supercycle involves a long boom in demand that drives up prices until they get so high that demand collapses, pulling prices back down. Currently, we are not seeing a difference between the supply and demand of copper big enough to constitute a supercycle. It is important to be cautious; during 2020, and especially in the last months, we have seen other factors besides supply and demand that have affected the increase in copper prices, such as the increase in money supply in economies like the US.

Do you have a final message for our international readers?

Chile's mining industry will manage to overcome the economic challenges after the pandemic and will continue to be a world leader, making great efforts to direct its activities towards sustainability and environmental protection. We want to transmit our confidence to mining investors in Chile that mining rules will be respected and will keep progressing despite the constitutional reform, always in compliance with international treaties. The formula against uncertainty in the mining industry involves confidence and hard work. ■

Philippe Hemmerdinger

President
ASSOCIATION OF INDUSTRIAL MINING SUPPLIERS (APRIMIN)

How did Aprimin's members maintain supply chain continuity in 2020?
Chile's experience with the social unrest in October of 2019 gave it a trial run at remote work, so companies were to some extent prepared for the Covid-19 outbreak and operations were smooth as measures ensuring employees were trained and equipped for working at home were already in place.
Operational continuity was a priority for mining companies and service providers abd they adapted to following strict Covid-19 safety protocols. Another priority was ensuring a clear communicative channel between all the stakeholders to ensure no delays and quick decision-making. Digital practices played a significant role in the industry's survival during the pandemic.

What are Aprimin's initiatives for 2021 under your leadership?
We defined five axes of productivity for 2021: operational continuity of the mining sector amid Covid; continue supporting our members to work remotely efficiently and effectively; an emphasis on automation in processes, to allow remote control and the importance of incorporating technology such as artificial intelligence (AI); smart contracts and improving time on tool; and the social license to operate, as we are promoting the use of green energy sources such as green hydrogen, solar power, wind, desalinated and seawater. Another initiative we are leading is ensuring the industry is diverse and inclusive since women make up only 12-13% of the workforce for the mining suppliers in Chile.
The increase in the copper price and its promising future is exciting for the industry, which is expected to contribute an additional over budget of US$1.5 – 2.5 billion in taxes and mining royalties this year. This would help reduce the national debt or generate savings and new resources in case of need.

Can you elaborate on the membership requirements for Aprimin and the benefits it provides?
Aprimin currently has 109 members who hold a majority market share in Chile's mining supplier market. Local service providers make up 57 of our members, and the remaining 52 are multinational corporations. To qualify for our association, the mining service provider must have annual revenue of at least US$4 million and agree with Aprimin's vision for the industry as well as health and safety protocols. Aprimin was created to negotiate with mining companies on behalf of the industry's suppliers and protect their interests. Today we cooperate with multiple associations to ensure our members' best interest and promote innovation and sustainability.

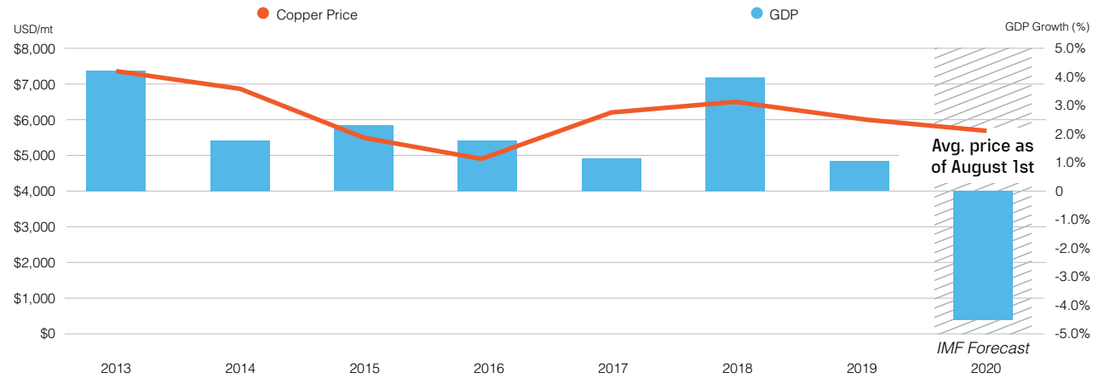
What are some of the barriers to innovation in the sector today?
Covid-19 reduced the barriers to innovation in Chile, but one barrier in Chile is that mining companies refuse to incorporate unproven products and services into their operations as it risks their volume or continued operation. There are not many places to pilot technology on an industrial scale. Approximately one-third of Chilean mining suppliers do not allocate resources to innovation. Canada and Australia are ahead of Chile in mining technology development and implementation. On the other hand, financing is not a significant barrier to innovation in the sector and some government agencies also provide support to innovators in partnership with mining companies. Suppliers also have the option to partner with a mining company.

How will changes to the constitution impact the Chilean mining industry?
We expect that changes will not significantly impact the mining industry, which is a pillar of the Chilean economy. Chile has parties across the political spectrum, however, they tend to meet in the center. This decade we expect investment in the mining industry to amount to US$70 billion, mostly in upgrading existing operations.

Do you have a final message to our international readership?
The growth and transformation momentum in the Chilean mining industry must be maintained and fostered. As ore grades are declining, mines must invest in innovations to ensure higher copper ore grades are extracted and productivity is achieved to remain competitive. The industry will continue relying on automation, but it must incorporate other initiatives to ensure diversity and inclusion. Finally, we are sure the market will bring good news to the copper industry and its suppliers, because the copper demand will be higher than the offer for a long period of time. ■

Growth in Chile: Independent of Copper Prices?

Source: John Hopkins school of international studies' elaboration of data from the World Bank and Market Insider



starting operations at full capacity and resumed the expansion project at El Teniente by Q4 of 2020, to be completed by 2023. Meanwhile, Vancouver-based Teck Resources delayed the expansion of its Quebrada Blanca Phase 2 by six months in July of 2020. "The mining industry scaled back on investments, reducing maintenance, and sustaining capex following the obligation of limiting personnel on mine sites and cushioning the impact of the outbreak on cash flows. Most companies also reduced dividends," highlighted Alejandra Fernández, mining director of Fitch Ratings in Chile.
Other crucial projects that were delayed include seven desalination projects, one of which was planned for BHP's Spence copper mine in Antofagasta, the others were to be developed by Antofagasta Plc, Mantos Copper, Codelco, Capstone Mining, Teck Resources and Freeport McMoran. According to Cochilco, desalination and seawater use will likely increase by 230% by 2030, as miners battle water shortages. Anglo American, for example, developed a water reuse system at Los Bronces allowing recycling of more than 70% of available water. Meanwhile, lithium giant SQM is reducing freshwater consumption across all operations by 40% by 2030.

Sustainability trends

The mining industry is aggressively asserting and promoting sustainability across the entire value chain. Mining operators across Latin America are altering their community engagement strategies from mere transactional handouts to proactive engagement and long-term strategies that are inclusive of the local, national and broader communities. In the case of Chile, conflict with local communities is mostly a result of environmental issues. To obtain a social license to operate, companies must invest in the use of renewable energy sources, reduce freshwater use and eliminate toxic waste.
Investment in renewable energy sources is set to swell. BHP, for example, is switching to green power for its Chilean operations, thus reducing costs by 20% at the Escondida and Spence operations. Likewise, Iván Arriagada, CEO of Antofagasta PLC, explained: "Antofagasta has set a goal to reduce its forecast greenhouse gas emissions by 300,000 mt by 2022, supported by a series of initiatives including the transition of all our mining operations' energy supply to renewables by 2022".
According to data from Cochilco, renewable energy use in the copper industry is expected to grow to 49% of power used by 2023. "I am confident that, in the upcoming years, the industry will undergo revolutionary changes that aggressively promote the use of clean energy sources and the reduction of carbon footprints. I foresee an industry that is carbon-negative in the future, and one that produces net zero emissions over the next decade," commented Eduardo Valente, lead consulting partner at Ernst & Young in Chile. "The ability to sell minerals in the future will likely depend on the extent of greenhouse gases used in the process, which will only push mining companies more towards ensuring sustainability, increasing the popularity of green copper," he concluded.
Meanwhile, sustainability in the equipment space is driving innovation, as providers are replacing diesel engines by battery-driven electric machinery for underground and open-pit operations.
The road to recovery from the outbreak of the virus has begun in Chile, as the Chilean government moved decisively and rapidly to secure enough doses to vaccinate its population twice. By February 2021, Chile was able to vaccinate 16% of the population within just 21 days, which testifies to its organisation and resolve to move past the outbreak. After two consecutive years of uncertainty, 2021 presents an exciting year for mining in Chile amid bullish commodity prices and a recovery from the Covid-19 outbreak. Chile is forecast to produce 5.99 million mt of copper in 2021 according to Cochilco, and is welcoming major expansion projects such as BHP's Spence, Codelco's El Teniente, Teck Resources' Quebrada Blanca Phase 2 and the construction of Gold Fields' Salares Norte, as well as a more active junior segment, mid-tier operators and a revived exploration sector. ■

Image courtesy of Wesdome Gold Mines

Political and Economic Overview

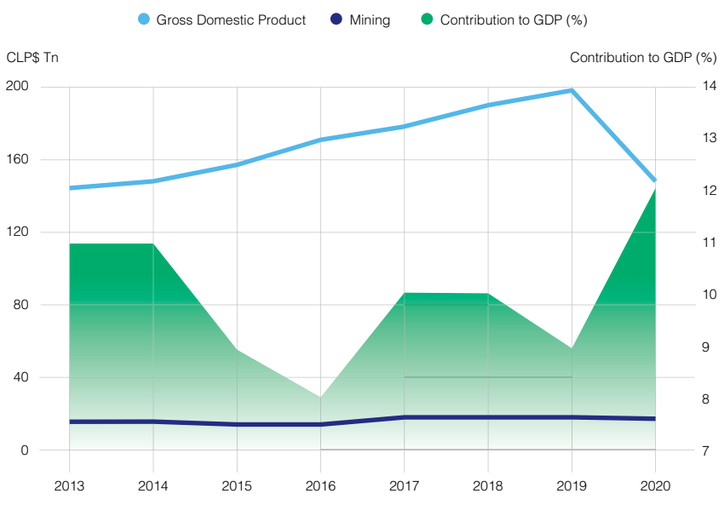
2021 IS ANOTHER PIVOTAL YEAR FOR CHILEAN MINING WITH A NEW CONSTITUTION AND GENERAL ELECTIONS TO NAVIGATE

As the first Latin American country to become a member of the Organisation for Economic Co-operation and Development (OECD), Chile is the commercial and economic success story of the continent. Since free market reforms began in 1975, Chile has consistently outperformed its neighbours in multiple indices of economic development, freedom and democracy. From 1980 to 2019, GDP per capita quintupled, enabling the country to dramatically reduce the share of the population living in poverty from 30% in 2000 to 3.7% in 2017, according to the World Bank, and to create a large middle class. The opening up of the economy encouraged foreign direct investment (FDI) into the country since the 1990s, facilitating the growth of capital-intensive activities such as mining, which today accounts for 10.1% of GDP, according to Chile's Central Bank and Cochilco.

Chile's dependence on copper has allowed for significant development, but leaves the country exposed to price fluctuations and demand from China. Furthermore, productivity is slowing down as a result of decreasing ore grades. Throughout 2020, however, the copper industry remained a bright spot in Chile's otherwise exhausted economy, which contracted by 14% in April 2020 year-on-year, according to Chile's

Mining Industry's Contribution to GDP (%)

Source: GBR's elaboration of data from Cochilco



Democracy Index, Chile

Source: EIU

167 countries scored from 0 to 10 based on 60 indicators

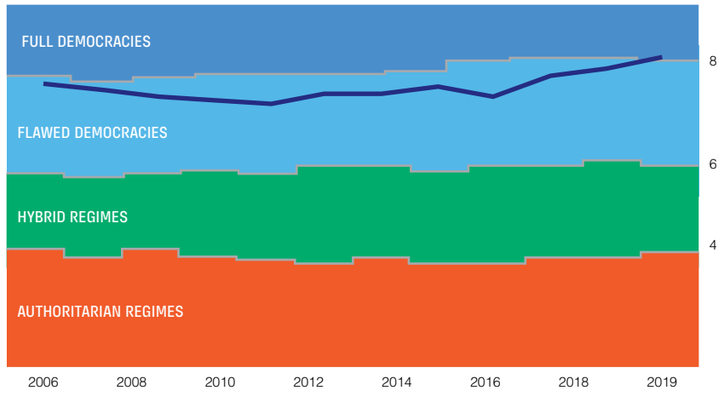


Image courtesy of Image courtesy of Freeport-McMoRan

The new constitution will strengthen the industry. Chile's path is in many ways similar to that of other developed countries. I believe the outcome depends on how we respond to the challenge and I am very optimistic as this is the way forward for Chile.

- Tomás Fischer Ballerini, General Manager, Edyce

Central Bank, as Covid-19 ravaged the economy in the midst of tensions over socioeconomic inequality.

According to the IMF, throughout 2020, Chile underwent a deep recession that saw national income decrease between 4.5% and 5.5%. To attempt to mitigate the impact of the outbreak, the government injected stimulus into the healthcare system, used tax measures to provide support to SMEs, and the central bank decreased fiscal policy interest rates to 0.5% while relaxing regulatory credit requirements.

Fortunately, sovereign debt risk remains minimal due to sound regulations, while the banking sector has proven its resilience. Fiscal and monetary policy measures and the gradual opening of the economy should underpin growth in 2021 as vaccination rates increase. Real GDP growth for 2021 and 2022 is expected at 5.3% and 3.2%, respectively, according to the IMF. This, however, is conditional on the political fate of the nation –Chile is to elect a new government this year whilst undergoing a process of constitutional reform– and on the possible resurgence of new virus strains.

Drafting a new future

In the near term, Chile's political climate will be defined by the forging of a new constitution. "The government's swift response to allow a referendum to rewrite the constitution, and the subsequent results of the referendum, are a testament to Chile's maturity and stability," highlighted Timothy Beale, director of CSE-listed Pampa Metals, a junior mining company with interests in Chile. "The country appears to be on a peaceful and positive democratic path that has not affected the ability of the country in general, and businesses in particular, to continue and progress," he added.

Nonetheless, as Chilean citizens voted overwhelmingly to rewrite the constitution, they set the stage for a dramatic reassessment of the country's relationship with the environment, public healthcare and national security. Diego Hernández, president of Sonami (Chile's National Mining Society), told Reuters: "Hardly any project of a very large magnitude will be carried out in the next two years until there is clarity around the new constitution."

Analysts foresee investment lagging until the new constitution is approved by late 2022. The process may also defer capex, already constrained due to Covid-19 restrictions, until investors see more clarity. According to Juan Carlos Guajardo, founder and executive director of Plusmining, a mining intelligence provider in Chile: "The new constitution will mainly tackle the role of the state in the economy and is likely to reshape it to a welfare state."

"There is no indication that basic property rights will be altered," highlighted Christoff Janse, investment promotion officer at InvestChile, a government agency. "The country's fiscal strength and its low level of debt as a percentage of GDP provide a financial buffer with which the government can address social demands without risking its credit rating in the short and medium-term or affecting the long-entrenched favorable base conditions for investing."

Presidential and legislative elections scheduled for November of 2021 add to the uncertainty. If the left-wing Frente Amplio wins the election, it could significantly increase the role of the state and may promote the nationalization

Legal definitions will be essential; the definition of concepts such as glaciers are imperative to determine if projects will be allowed to develop or if they will face restrictions.

- Fernanda Santoro, Environmental Engineer, Montt Group

of natural resources. The risk for radical changes decreases and interests of the private sector are protected if Chile Vamos, the ruling coalition, wins.

Glaciers, water and taxes

The new constitution is unlikely to introduce radical changes regarding mining due to the immense negative impact this would have on investment into an industry that is vital to Chile. However, the questions concern how the new constitution will pronounce itself regarding issues such as environmental regulation, strategic metals, indigenous and collective bargaining rights, and worker benefits.

Under environmental regulation, the new constitution is likely to address changes to the water code and glacier protection. The debated glacier protection law has been stuck in Congress since October 2019, and calls for a better definitions of glaciers. If approved, it will prohibit mining in glacial areas, hindering the construction of large mining projects by Codelco's El Teniente and Andina. The lack of a clear definition of glaciers already resulted in the controversy of Pascua Lama, an open-pit gold, silver and copper project advanced by Barrick on the Chilean-Argentine border that was forced to halt activities in 2013 following a Chilean court order.

Water rights are also likely to be considered. "The government is drafting policies regarding water to consider giving water rights a temporary character and restricting some uses, which will affect mining operators if implemented," highlighted Iván Rayo, general manager of JRI Ingeniería, a local multidisciplinary engineering consultancy.

In addition to water rights and glaciers, the constitutional process will tackle lithium, currently labelled a strategic metal since 1979. The subject overlaps with water rights since lithium is found in brine pools and requires extensive amounts of water to extract. Advocates are promoting the classification of brine as water so as to grant local communities more authority over the resources, since indigenous people own water.

Another likely topic to be considered is mining royalties and how to guarantee financial benefits for the populations in mining regions. "It is difficult to conclude whether the impact of rewriting the constitution will be positive or negative. The process is complicated because it carries very high expectations that it must meet," commented Guajardo of Plusmining. "Mining is a complex activity with multiple stakeholders and of a particular nature when it comes to capex, risk, taxation and impact. It must, therefore, be approached sensitively when addressed under the new constitution."

Radical changes to the constitution that will result in negative consequences on mining investments are unlikely. "The country is no stranger to democracy and its processes, therefore I am confident it will be a smooth transition of power," elaborated Eduardo Valente, lead consulting partner at EY Chile. "Mining companies should participate in discussions with the government to ensure their interests are taken into account in the new constitution." ■

Juan Carlos Guajardo

Founder and Executive Director
PLUSMINING

How will the upcoming constitutional changes impact the Chilean mining industry?
The process is pivotal to the future of the nation and its stability. The process is complicated because it carries very high expectations that it must meet. Mining is a complex activity, with multiple stakeholders and a particular nature regarding capex, risk, taxation and impact. Therefore, it must be approached sensitively when addressed under the new constitution. The election in April of 2021 will give us a more concrete idea of what to expect. The new constitution will mainly tackle the role of the State in the economy and is likely to reshape it into a welfare state. Environmental regulation and indigenous issues will also be addressed. Changing the constitution is symbolic but with profound economic and political consequences. There is a risk that social unrest erupts again if the population's expectations are not met.

As the industry recovers, what are some of the most significant investments being made in 2021?
The installed capacity of mining in Chile is one of the largest in the world. An immense production capacity is coupled with tremendous challenges. The investments being made in 2021 are to maintain this capacity by expanding mines, some of which are heading underground. Most of the investment is targeted towards brownfield projects. Meanwhile, the greenfield projects under development are Quebrada Blanca and Salares Norte. The industry should be concerned about the lack of greenfield projects being undertaken.

Where do you see future growth potential for Plusmining?
The challenges in the Chilean mining industry are entering a new stage as the industry matures. Today the industry is focused on sustaining operations in a complicated environment, characterised by political and economic uncertainty. Plusmining's role is to support clients through this uncertainty by providing guidance and consulting. Increasing use of copper is opening more opportunities around the world, so we will also focus on growing our business development service. ■

Christoff Janse

Investment Promotion Officer
INVESTCHILE

What was Chile's experience with the pandemic, and how has it impacted the economy?
Preliminary forecasts show a GDP contraction in 2020 of 6 to 8%. The mining industry, however, has been resilient. The sector´s safety protocols were quickly adapted to minimize contagion risks. Production was generally stable or only marginally lower. Some investments were delayed due to logistical challenges resulting from the lockdowns, most of which are resuming in 2021.

How did the permitting process in Chile become more streamlined?
One initiative already implemented is the creation of an agency known as the Sustainable Project Management office (GPS), specifically to support and streamline the environmental permitting process of large projects. The ministry is also developing the National Mining Policy for 2050 in collaboration with the private sector, to be completed in June, to guide the mining industry's development in the short, medium and long term as an engine for sustainable growth. Various administrative and legal initiatives that favor investment are being considered.

How are foreign investors in Chile protected from changes in the constitution?
Chile has been in the fortunate position of still attracting healthy foreign direct investment (FDI) since the social upheaval of 2019 and the onset of the pandemic. While FDI flow globally has declined 42% according to UNCTAD, the indicators for Chile show a more moderate decline of 21%. This highlights the confidence that foreign investors still have when it comes to long-term investing in the country.
Regarding possible constitutional changes, there is no indication that basic property rights will be altered. Most companies also recognize that the country's fiscal strength and its low level of debt provide a financial buffer with which the government can address social demands without risking its credit rating in the short and medium-term or affecting the long-entrenched favorable base conditions for investing. ■

Eduardo Valente

Leading Partner of Consulting
EY CHILE

What are some of EY's most recent developments since we last spoke?
EY acquired a company in Chile specialised in digital data and artificial intelligence, allowing us to better analyse and use the data from our mining clients to increase productivity and lower costs. We have been working closely with major mining companies in Chile, helping them with their digital transformation programs, which has become a priority in the industry as a whole as it increases efficiency but also enhances safety by reducing operational risks. We see increasing use of digital data analytics, integrated remote operation centres and autonomous mining machinery such as trucks.

What other industry trends have you come across?
Another issue we witness is regarding the risk associated with the license to operate (LTO). An LTO incorporates the management of relationships with governments, communities, associations and suppliers, to integrate production and reduce carbon emissions, as well as optimise water consumption and energy usage. EY is working with clients to not only ensure compliance with local regulations but to design tailored strategies for sustainable operations. The key driver of LTOs is the more environmental aspect.
I foresee an industry that is carbon-negative and one that produces net zero emissions over the next decade. The ability to sell minerals in the future will likely depend on the extent of greenhouse gases used in the process, which will only push mining companies more towards ensuring sustainability.

Is the current political sphere impacting investment in the sector?
As a result of COVID-19, countries' sovereign debt increased, putting pressure on governments to raise revenue which could drive tax and royalty increases. This poses a risk in Chile, as the mining sector could be responsible to pay for the pandemic debt and stimulus.
2021 is an eventful year for Chile, as it rewrites the constitution following the referendum last year, and holds elections in November. The country is no stranger to democracy, therefore I am confident it will be a smooth transition of power. ■

Santiago Montt, Fernanda Santoro & Bernando Aguilera

SM: CEO
FS: Environmental Engineer
BA: Senior Mining Lawyer
MONTT GROUP

SM

FS

BA

Can you introduce Montt Group and its role in the Chilean mining industry?
SM: Montt Group is a 46 year´s old firm, originally a law firm, but since the last 15 years we have transitioned to a consulting group, including professionals such as lawyers, engineers, economists and environmental specialists. We have progressively expanded to almost every Latin American country. Our most important offices are in Chile, Peru and Colombia. We are currently constituting mining divisions in Colombia and Ecuador. The group has extensive experience in mining litigation.

How is the environmental law in Chile pushing towards the construction of desalination plants?
SM: The adoption of environmental resolutions is very slow in Chile, primarily due to the long process of reclamations once a decision is made. Today, carrying out an environmental study takes at least two years, and a declaration of environmental impact at least a year.
Desalination plants can be an excellent solution to the water scarcity that affects the northern and central parts of Chile. An excellent initiative to save resources would be to have an engineering company in charge of the desalination plant and the construction of the pipeline and to share this infrastructure among a cluster of several mining companies, communities and other sectors.
FS: Desalination projects are a very viable solution for both mining and agriculture projects. However, these are large and expensive projects that require coordination between different stakeholders.
BA: Several of the leading mining companies in Chile are moving towards the desalination of ocean water, and this is encouraging the rest of the industry to go in the same direction. However, there needs to be some sort of push from the government to promote these solutions, such as fostering joint initiatives to share desalination plant infrastructures. ■

Chile's constitutional process and royalty reform discussion: Business as usual or a transformative landscape?

Expert Opinion Article by
FRANCISCO ACUÑA,
MINING CONSULTANT AND ENTREPRENEUR SENIOR CONSULTANT,
CRU

On April 11th this year, Chileans will vote for the first time in history for a Constitutional Convention, composed of 155 elected members that will have the responsibility to propose a new constitution for the country. This is the result of months of social distress that started in October 2019 and culminated with a plebiscite one year later. The overwhelming result of which was a decision to write a new constitution.
The Latin America region has been characterized by constitutional changes that often have come in the form of authoritarian governments and have cemented the basis for political instability, lack of rule of law and an overall detrimental scenario for investment, which has a particular impact for capex-intensive and long-term industries such as mining. Chile's constitutional process, howeber, has moved forward within the legal framework set out in the current constitution and therefore maintaining the tradition of transparent electoral processes, well-functioning institutions and rule of law that have characterized the country over the last three decades.
While on the Chilean political spectrum there are those that support radical views that favor the idea that natural resources should only be extracted by state-owned companies and that this constitutional process could be an opportunity to nationalize the resources, this is a very unlikely outcome as the new constitution will require the approval of two thirds of the Convention's members. Furthermore, mining has been a cornerstone of Chile's economy, and the benefit of a booming mining sector has percolated through the different layers of the economy and has not been characterized by major social conflicts.
The Convention will not be an isolated event, and alongside its development there will be other significant political milestones including the upcoming presidential election at the end of this year. The mining sector does not appear to be a central topic for constitutional changes, however, one could predict that it could built momentum in the policy and legislative discussions that will naturally occur in parallel. A very likely outcome is that Chile's fiscal expenditures will see a relevant increase in the upcoming years as social programs including healthcare, education and pensions are central themes to the constitutional process. It is reasonable to expect new programs will be put in place or major reforms will come in effect that will require additional fiscal collection. As the most relevant industrial sector in the country, it is fair to expect that mining will likely be in the center of the discussion and will feel pressure for changing the current mining tax regime or implement a new royalty scheme.
An unexpected catalyst has been the spectacular copper price rally that has peaked at 10-year highs. The positive perspectives for copper demand and prices in the mid- and long-term have exponentially accelerated the political agenda to implement a new royalty regime. In late March 2020, a 3% ad valorem royalty legislative proposal was approved in the lower house and will move forward the legislative process.
The short-term impact for a new royalty or tax will mean that mining operations could lose their competitiveness in terms of economic viability. Valuations for mid-sized projects could be significantly reduced resulting in suspension or nullification of the investment decision.
It is fair to assume that we might see changes in the upcoming year. Endogenous factors, such as the results of the constitutional convention and presidential elections, are the key drivers that could shift the outcome one way or the other. Exogenous factors have also been shown to have a relevant impact (namely the copper price volatility). Finally, the response that the mining sector takes to either oppose or collaborate in this process, and how that is conveyed to the different stakeholders, will likely have an impact too.
This can be a turning point for the industry in Chile, but it could also be the consolidation as a tier one mining jurisdiction that demonstrate how institutionality and rule of law can lead to structural social changes while maintaining the incentives of the mining sector for sustaining Chile's development and growth. ■

Timeline of Constitutional Turning Points in Chile

Source: The Cato Institute, BBC, the Economist, NY times, Reuters, GBR

1971

President Salvador Allende receives congressional approval for a constitutional reform giving the state "absolute, exclusive, inalienable, and imprescriptible" ownership of all mines

1973

Coup led by military junta results in change of government, imposing military rule led by General Augusto Pinochet

1980

The Pinochet constitution is confirmed by plebiscite; 67% of votes in its favour. Access granted to private investors in the mining industry under the Law on Mining Concessions declared by José Piñera, minister of mining

1987

Chilean political opposition challenge the constitutional system created by the military government by initiating a campaign to vote against the extension of Pinochet's rule for another eight years in the 1988 plebiscite

1989

85% of Chilean vote in favour of constitutional reform

2005

Amendments made to the constitution, considered to consolidate democracy in Chile by reducing the political influence of the military

2014

March: Approximately 100,000 people protest in Santiago demanding constitutional reform from president Michelle Bachelet

2015

Bachelet launches a process to draw up a new constitution. The proposal fails to make it to Congress before president Piñera is elected

2019

Social unrest in October known as Estallido Social prompted by high levels of inequality. In November, president Piñera promises a referendum

2020

In October, a referendum is held and Chileans vote by an emphatic margin to approve a constitutional convention and to draft a new constitution

2021

May: elections held to select the representatives of the Constituent Convention to draft the constitution. The Convention has nine months to draft a new constitution, with a one-time option to extend its mandate for three more months. In November, the Chilean general presidential election is held

2022

By mid-2022 a final referendum will be held to approve the proposed constitution, requiring a simple majority to approve

2023

The new constitution becomes effective

Insights from the ground: Will the redrafting of the constitution impact mining investment in Chile?

"For the mining industry, I don't expect Chile to move away from the robust and predictable set of rules we have and which have allowed mining investment to prosper and deliver growth in the sector over the last 40 years."

- Iván Arriagada, CEO, Antofagasta Plc

"Any transformation will be smooth and non-disruptive to the mining sector. There is a great centuries-old mining culture in Chile. Change is a feature of Latin American politics, fortunately, in the case of Chile, change has been often progressive in nature."

- Alastair McIntyre, CEO, Altiplano Metals

"I am confident in Chile's ability to redraft the constitution without altering the investor sentiment that it has maintained for decades and that has allowed its rise as the top copper producer."

- Tony Harwood, President & CEO, Montero Mining

"I believe that moving forward the way we do business is going to be different as it has to evolve with society and meet society's expectations. Society will demand that business operations are in harmony with the environment and individuals' livelihoods."

- Tomás Fischer, General Manager, Edyce

"The process creates opportunities for mining companies to serve in the interests of the environment, local communities and the country in which they operate and to attempt to write the wrongs of the industry's past mistakes."

- Brian Miller, Managing Director, Astra Exploration

"We expect changes that will not significantly impact the mining industry, which is a pillar of the Chilean economy. Chile has parties across the political spectrum, however, they tend to meet in the center."

- Philippe Hemmerdinger, President, Association of Industrial Mining Suppliers (Aprimin)

"In Chile, there are clear legal limits to what can be changed in the process of constitutional reform. There are several international treaties in force that guaranty the protection of investments."

- Santiago Montt, CEO, Montt Group

PRODUCTION, DEVELOPMENT AND EXPLORATION

"Among the key drivers that allowed the copper price to rebound have been the sizeable Chinese government's stimulus to boost their economy post pandemic and China's extremely high copper inventory build-up of refined copper in 2020, followed by other factors such as US stimulus."

-Alejandra Fernández,
Mining Director,
Fitch Ratings

Image courtesy of Freeport-McMoRan

Copper

ROBUST PRODUCTION AMID THE PANDEMIC AND RESUMING EXPLORATION

Copper's anti-viral properties seem to have rubbed off on the Chilean mining industry, which managed to successfully navigate the pandemic disruptions that heavily impacted Peru, Mexico and Australia, resulting in a decrease in global copper supply by 1.2% in 2020, according to Cochilco, the Chilean copper commission.

"The mining sector showed great resilience and capacity to take care of the health and safety of workers, with contagion rates much lower than the average population," highlighted Juan Carlos Jobet, Bi-Minister of Energy and Mining. "That was complemented with business continuity, as we closed 2020 with a copper output in line with 2019 figures. For comparison, copper production in Peru fell by 30% in 2020, so the industry's performance in Chile was remarkable last year."

Global supply disruptions decreased inventories, exacerbating the copper demand and supply gap, which has been in deficit since 2015, and improving the metal's price outlook. According to Goldman Sachs, the copper price will climb to an average of US$9,175 per mt (US$4.16/lb) by 2022, fuelled by optimism over vaccinations worldwide and strong economic revivals.

In the long-term, analysts foresee demand for copper increase by 28% over the next decade, especially as electric vehicles (EV) use up to three and a half times more copper than an internal combustion engine vehicle, according to Wood Mackenzie, global research and consultancy group, who also anticipates over 20 million EV charging points to be deployed globally by 2030, consuming over 250% more copper than 2019.

Alastair McIntyre, CEO of Canada-based Altiplano Metals, a mineral exploration company focused on acquiring projects with short-term potential for rapid advancement and production, sees the Chinese fiscal stimulus packages fuelling the current record growth in copper demand. He is also optimistic about the future of copper: "The green energy movement requires copper to rebuild infrastructure. The supply shortages as a result of the pandemic and the forecasted increase in demand for copper will drive a bullish market for the metal," he explained.

Of the top 10 copper mines in the world, three are in Chile, namely BHP's Escondida, Anglo American's Collahuasi and Codelco's El Teniente. Major players and an upcoming mid-tier mining scene dominate copper production in Chile. According to Consejo Minero, the Chilean mining association for large scale operators, mining activity in Chile witnessed consistent growth in production until a decade ago, where it stabilized at 6 million mt/y, representing approximately 27% of the world's copper supply. In 2019, production stood at 5.6 million mt, a decrease of 44,000 mt relative to 2018, primarily due to falling ore grades at the country's biggest and oldest mines such as Escondida, the world's largest copper mine and Codelco's Chuquicamata and Andina.

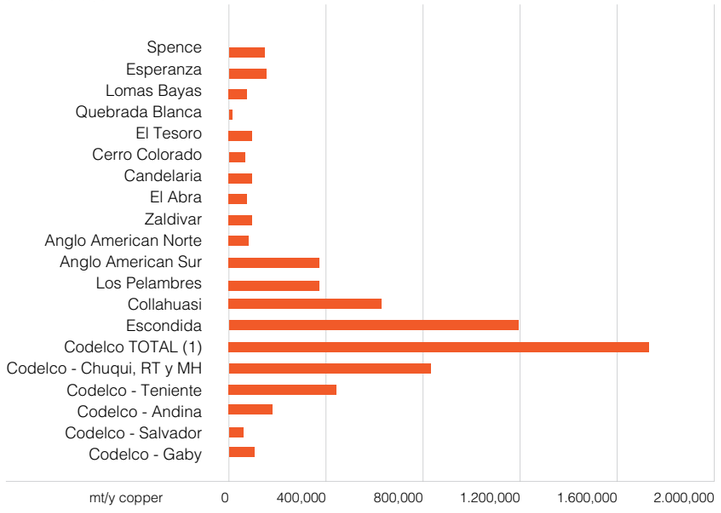
2020 was an eventful year for producers in Chile, who were able to sustain production even as drastic measures were implemented. From January to May 2020, production increased by 3.5% from 2019. However, despite strong performances from El Teniente, Collahuasi and El Tesoro, overall production in 2020 stood at 5.73 million mt, signifying a 1% decrease from 2019 according to Cochilco, which is remarkable, considering that Peru and Mexico saw their copper production decrease by 14.5% and 4.5%, respectively. Jorge Cantallops, director of studies at Cochilco, credits the country's ability to sustain production to the rise in labour productivity, which increased by 24.9% year-on-year.

Cochilco's report on copper production in Chile from 2020 – 2031 forecasts a 23.8% increase in output by 2031, reaching 7.095 million mt, after peaking in 2028 at 7.35 million mt, as a result of the development projects under construction today. This implies an average annual growth of 1.96%. Between 2020 and 2029, Chile is to witness investment in its mining sector amounting to US$74 billion, including 49 projects mainly copper-related. 68% of these projects are brownfield, 34% are in the execution stage, and 64% are in the feasibility stage.

It also highlights a significant change in the country's production profile, shifting from hydrometallurgical copper production towards concentrates production, which will represent 54.9% of the total copper output by 2031. Optimism about a balanced copper market for Chile this year is reinforced as major Chilean projects such as Codelco's El Teniente and Rajo Inca, BHP's Spence and Teck Resources' Quebrada Blanca II enter the commissioning phase, coupled with the development of Antofagasta Plc' Los Pelambres and Capstone Mining's Santos Domingo project.

Copper Production per Mine in 2020

Source: Cochilco, GBR



Iván Arriagada

CEO
ANTOFAGASTA PLC

Even though mine development and maintenance activities were initially restricted, operations have adjusted to the new working conditions and resumed. These measures enabled us to continue operating during the past year, allowing us to achieve our full year production guidance for 2020 and lower cash costs than in 2019.

How did Antofagasta overcome the challenges posed by the health crisis?
The safety and health of our workers and local communities has always been our first priority and never has this been more important than in the past year. We rapidly shifted our office-based workforce to working from home and introduced a range of new protocols to protect people. We have also been operating with approximately two-thirds of personnel at our key operations, with the rest either working from home or in quarantine.
Throughout, we have been working in coordination with government authorities to ensure a consistent approach and also established a US$6 million fund to provide equipment, supplies and financial support to the communities near our operations.
Even though mine development and maintenance activities were initially restricted, operations have adjusted to the new working conditions and resumed. These measures enabled us to continue operating during the past year, allowing us to achieve our full year production guidance for 2020 and lower cash costs than in 2019.

Could you provide an overview of 2020 production and costs, and indicate your guidance for 2021?
Full year copper production was 733,900 tonnes (mt) and cash costs were US$1.14/lb. This reflects our resilience and flexibility over the past year.
We expect another solid performance in 2021, with copper production of 730-760,000 mt at a net cash cost of US$1.25/lb as ore grades increase at Centinela and operating efficiency at our mines remains high. This guidance assumes our COVID-19 measures will remain in place for all of 2021.

What is the status of the Los Pelambres expansion? How is Chile increasingly using seawater for mining operations?
The construction of the Los Pelambres expansion project restarted in August alongside a detailed review of the project schedule and costs, including any COVID-19 restrictions. We now expect the project to complete in early H2 2022.
Some mines in Chile are located in arid areas, where continental water availability is decreasing. Care for this precious resource is a crucial part of our approach and we are currently making the investments to use about 90% sea or recycled water from 2025 onwards. At the moment, we use raw seawater at Centinela and Antucoya, and we are also building a desalination plant at Los Pelambres to release continental water for agricultural and other purposes in the Choapa valley. The usage of seawater is becoming increasingly common in Chile and no new mining projects of any size will be permitted to operate using continental water in the future.

Antofagasta has made a decided move towards renewables: What is timeline for transition and its impact on the group's CO2 emissions?
Antofagasta has set a goal to reduce its forecast greenhouse gas emissions by 300,000 mt by 2022, supported by a series of initiatives including the transition of all our mining operations' energy supply to renewables by 2022.

While we consume a lot of energy as a sector, we are convinced that copper mining is a key component in the move to a more sustainable world given its energy efficiency benefits, with multiple applications in battery technology, zero emission transportation and renewable power generation technologies.

Analysts foresee a lag in mining investment in Chile as it rewrites a constitution. Do you see this impacting investment?
I believe it is an opportunity for us to address the social issues in our country and positively affect people's wellbeing. For the mining industry, I don't expect Chile to move away from the robust and predictable set of rules we have and which have allowed mining investment to prosper and deliver growth in the sector over the last 40 years. People recognize that Chile's prosperity depends on having a strong mining industry and investment and growth are required to fund the social reforms currently under discussion.

What is your view of copper fundamentals and the key drivers?
Following 2020 and the impact of the pandemic, we now have a tight market and expectations are that there will be major stimulus to the global economy. We believe that copper demand growth will continue as the world seeks to find cleaner solutions for modern life.
It also will play a key part in sustainable urban development and a post-pandemic world, given its antimicrobial qualities. ■

Aaron Puna

CEO
ANGLO AMERICAN CHILE

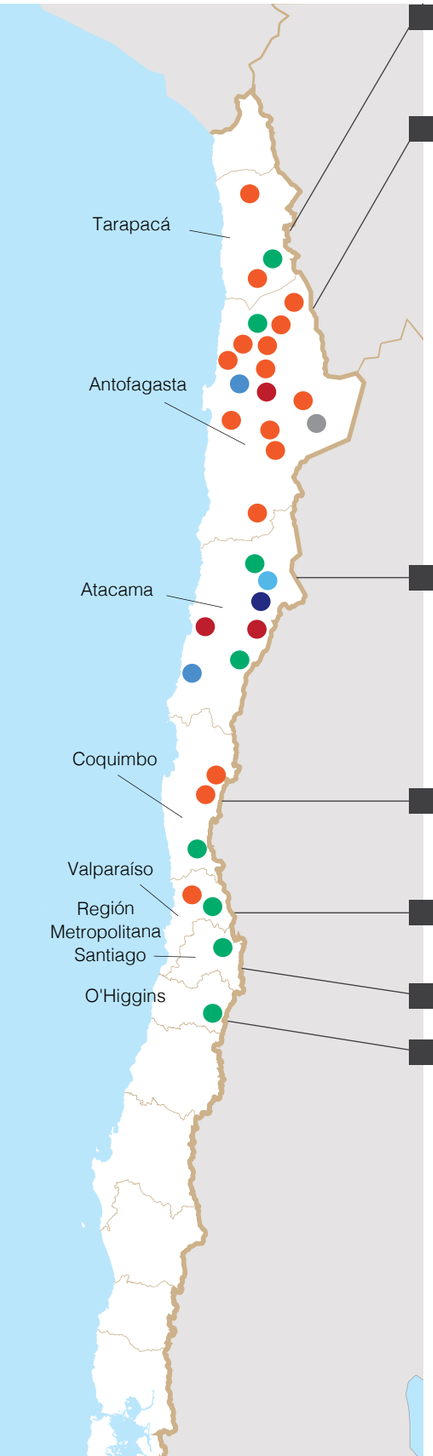
This year, all our operations in Chile will rely on 100% renewable electricity supply, including Collahuasi. We are also promoting electromobility in our operations and recently implemented a fleet of 17 electric buses to transport our workers.

How are you actively reducing your environmental footprint while integrating more automated mining techniques?
We set a global goal of achieving carbon neutrality by 2040, including eight carbon neutral operations by 2030. Therefore, we put innovation at the centre of everything we do through our FutureSmart Mining approach, and we already have several concrete actions underway. This year, all our operations in Chile rely on 100% renewable electricity supply, including Collahuasi. We are also promoting electromobility in our operations and recently implemented a fleet of 17 electric buses to transport our workers. Anglo American also started the pilot of the first photovoltaic plant built on a tailings deposit in the world, with a floating island on the Las Tórtolas deposit. We are developing the world's first green hydrogen mining truck.
We look for ways to develop more modern and intelligent mining techniques to reduce our environmental footprint. The Los Bronces Integrated Remote Operation Center (IROC) is Anglo American's first remote control room. The IROC will allow Los Bronces to operate in real-time and in an integrated manner from Santiago and become the digital operation's brain, where the integration of all digitalization and remote operation technology projects is materialized. It will incorporate artificial intelligence applications, augmented reality, remote operation technology, and other integrated technologies.
With the implementation of the IROC, it will not be necessary to transfer workers to Los Bronces, which means reducing exposure to risk of working at high altitudes and harsh winters. Additionally, this centre will make it possible for a significant number of operators to work remotely, radically improving the workforce's quality of life.
Another similar initiative is our Digital Twin, which is a virtual simulator that allows us to visualize what is happening at Los Bronces mine in real-time. It uses a portable technology that provides workers with a control centre on their cell phone, tablet or computer. Also, since it reduces the need for the transfer of workers, it is beneficial to reduce the number of workers on-site amid the pandemic.

What are your initiatives to contribute to the local development of the regions in which you operate?
We are taking a purposeful approach and questioning our previous manners of operation to ensure we mine in a conscious and environmentally focused manner. Therefore, we developed a roadmap with concrete actions and goals. With this plan, we seek to continue contributing to the development of the country and neighbouring communities by using less water, reducing our carbon footprint and protecting the glaciers that are near our operations. Within the framework of our sustainable mining plan, we promote a series of initiatives to foster local development and environmental awareness, which have emerged from permanent dialogue with the community. Some powerful examples are our Pioneer Model in education, which seeks to provide students with the tools to become agents of change in their territories and in Chile by helping them develop their talents interactively using new learning methodologies. Today the Pioneer Model is being implemented in 17 establishments, positively impacting the lives of more than 2,000 students and their communities.
Meanwhile, to improve the water supply in areas where we operate, we created the Rural Water Program in alliance with WeTech, which is a system to strengthen Rural Drinking Water Systems (APR) using automation and online monitoring. For example, it implements a software that allows the APR operator to control and automate their system remotely. It has been implemented in 52 APRs in the Metropolitan and Valparaíso regions, benefiting more than 120,000 individuals through savings in energy, a reduction in the breakage of matrices and greater availability of water for human consumption.
To strengthen local capacities, we support and promote the School of Social Leaders, which provides training to representatives of social organizations in negotiation and design and application for competitive funds.
Finally, to promote local economic development, we have several programs. The most important and oldest is Emerge. Through this initiative, we have supported 3,200 businesses in neighbouring communities, which have received essential knowledge, tools and advice that allowed them to improve the administration and management of their businesses and significantly increase their sales. ■

Production Map & Directory

Source: Consejo Minero



Tarapacá Region	Products	Company
Cerro Colorado	C	BHP Billiton
Collahuasi	C M	Anglo American/Glencore
Quebrada Blanca	C	Teck Resources
Antofagasta Region	**Products**	**Company**
Antucoya	C	Antofagasta Minerals
El Abra	C	Freeport McMoRan/CODELCO
Radomiro Tomic	C	CODELCO
Chuquicamata	C M	CODELCO
Ministro Hales	C	CODELCO
Michilla	C	Antofagasta Minerals
Spence	C	BHP Billiton
Sierra Gorda	C G M	KGHM
Centinela	C G	Antofagasta Minerals
Gabriela Mistral	C	CODELCO
Salar de Atacama	L	SQM
Lomas Bayas	C	Glencore
Zaldívar	C	Antofagasta Minerals/Barrick Gold
Escondida	C	BHP Billiton
Franke	C	KGHM
Atacama Region	**Products**	**Company**
Salvador	C M	CODELCO
NuevaUnion (development)	C G M	Teck Resources/Goldcorp
La Coipa	G S	Kinross
Maricunga	G	Kinross
Ojos del Salado	C G	Lundin Mining
Candelaria	C G	Lundin Mining
Caserones	C M	Lumina Copper
Coquimbo Region	**Products**	**Company**
Carmen de Andacollo	C	Teck Resources
Altos de Punitaqui	C	Glencore
Los Pelambres	C M	Antofagasta Minerals
Valparaíso Region	**Products**	**Company**
El Soldado	C	Anglo American
Andina	C M	CODELCO
Santiago Metropolitan Region	**Products**	**Company**
Los Bronces	C M	Anglo American
O'Higgins Region	**Products**	**Company**
El Teniente	C M	CODELCO

COMMODITY

- Copper
- Copper-Gold
- Copper - Molybdenum
- Copper - Gold - Molybdenum
- Gold
- Gold - Silver
- Lithium

C = Copper
M = Molybdenum
L = Lithium
S = Silver
G = Gold

Majors' production and brownfield expansion updates

Production rose in some mines in Chile over the course of 2020, while Anglo American reported a steep fall in production of 17.9% year-on-year in the first five months of 2020 as a result of water shortages at Los Bronces. Across its Los Bronces, El Soldado and Collahuasi joint venture, Anglo American produced 647,400 mt in 2020, which is a 1% increase compared to 2019.

On the other hand, Lundin Mining's Candelaria saw production fall 14.9% to 126,702 mt amid conflicts with trade unions that forced it to suspend operations in October of 2020 until both parties reached an agreement by the end of November. However, Candelaria's production is expected to rebound to 172,000 – 182,000 mt for 2021. Many major mining companies struggled to maintain smooth relationships with their workforce, and this issue was identified as the seventh risk facing mining companies globally in EY's Global mining and metals top 10 business risks and opportunities report for this year. While companies moved rapidly to protect their workforce from the outbreak, labour unions criticized them for taking advantage of the crisis to reduce jobs.

To cope with the pandemic, Iván Arriagada, CEO of Antofagasta Plc, explained that the company shifted to working from home and operated with two-thirds of personnel on key sites. "Even though mine development and maintenance activities were initially restricted, operations have adjusted to the new working conditions and resumed. These measures enabled us to continue operating during the past year, allowing us to achieve our full year production guidance for 2020 and lower cash costs than in 2019," he commented.

The British multinational's total production in Chile in 2020 stood at 733,900 mt. "We expect a solid performance in 2021, with copper production of 730-760,000 tonnes at a net cash cost of US$1.25/lb as ore grades increase at Centinela and operating efficiency at our mines remains high," highlighted Arriagada.

Output at Zaldívar, the 50/50 joint venture between Antofagasta Plc and Barrick Gold, decreased 16.9% to 96,500 mt.

Meanwhile, the expansion of Los Pelambres, which accounts for half of the company's copper output, is one of the projects to keep an eye on in 2021. Due to the pandemic, the US$1.3 billion expansion project was suspended for 120 days starting in April, but resumed in August of 2020 and should be complete in H2 2022. It will increase capacity by 60,000 mt/y and includes a US$500 million desalination plant. Using desalinated water and renewable energy, the company aims to extend the mine life to 2050 as opposed to 2035. The company is also investing in expanding Centinela, with plans to

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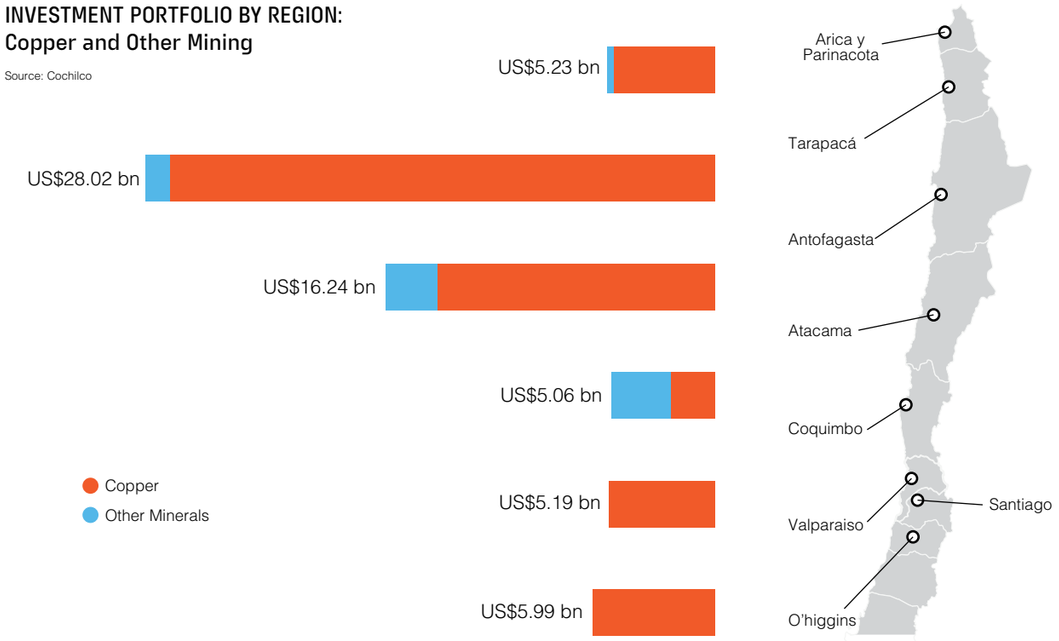
INVESTMENT PORTFOLIO BY REGION:
Copper and Other Mining

Source: Cochilco



construct a second US$2.7 billion concentrator in early 2022. Another major expansion project that was temporarily put on hold as a result of Covid-19 restrictions is Teck Resources' Quebrada Blanca Phase II (QB2), of which 40% was complete by February of 2021. This project will contribute 316,000 mt/y of copper for the first five years to Teck's annual production of 276,000 mt, with an initial mine life of 28 years, using only 25% of the total reserves and with significant expansion potential. The company aims to become carbon-neutral by 2050. To enable this transition, 118 MW for QB2 will be sourced from AES Gener's renewable portfolio of wind, solar and hydroelectric energy. In total, more than 50% of QB2's total operating power needs are expected to be from renewable sources.

Teck Resources also operates Quebrada Blanca, Carmen de Andacollo and Nueva Unión, a 50/50 joint venture with Newmont that is said to be one of the largest underdeveloped copper-gold-molybdenum projects in the Americas. It is awaiting the submission of the Environmental Impact Assessment (EIA) to begin the drilling campaign. Meanwhile, 350 km north of Santiago lies Carmen de Andacollo, an open-pit copper mine with a life of mine expected to continue until 2035 and annual production of approximately 60,000 mt.

One of the most anticipated expansion projects is the Spence mine, BHP's second-largest deposit in Chile after Escondida, for which production increased by 4% in 2020. BHP's wholly-owned Pampa Norte operation, in the Atacama Desert of northern Chile, consists of the Spence and Cerro Colorado mines, which collectively produced 243,000 mt in 2020, a 2% year-on-year decrease, primarily due to a 14% decline in stacked ore grade. These are targeting a production of 243,000-270,000 mt in 2021.

The US$2.5 billion Spence expansion project was delayed in April of 2020, as Covid-19 disrupted operations. However, construction was ramped up by Q4 of 2020 to ensure production by Q1 of 2021. According to the Australian giant, Escondida and Spence will rely on 100% renewable energy and eliminate water usage from aquifers by the mid-2020s and 2030, respectively.

Freeport-McMoRan's open-pit El Abra operation, the joint venture with Codelco, is also working to increase the percentage of renewable energy usage. The operation was awarded a Silver Seal Energy Efficiency Award from the Chilean Ministry of Energy. The Phoenix-based company is evaluating a large-scale expansion at El Abra, as their focus in Chile is on brownfield expansions. "Pre-COVID-19, we were in the process of doing baseline studies for the significant sulfide resource but were forced to stop that work," commented Joshua Olmsted, president and chief operating officer-Americas of the company. "This year, we plan to restart those baseline studies and consolidate all our previous efforts on pre-feasibility studies to determine whether we want to take the project to the next step."

Meanwhile, Europe's second-largest copper producer: KGHM Polska Miedź, reported record Q2 earnings from its joint venture with Japan's Sumitomo Metal Mining Co, Sierra Gorda, an open-pit copper and molybdenum mine commissioned in 2014. The mine produced 709,000 mt of copper in 2020, recording a 1% annual increase in production. KGHM was granted environmental approval in 2018 for a US$2 billion expansion, which would extend the mine's life by 21 years. The plans include an increase to the capacity of the facility's mill from 190,000 mt to 230,000 mt per day, according to Chilean newspaper *Estrategia*.

Joshua Olmsted

President and Chief Operating Officer-Americas
FREEPORT-MCMORAN

Could you provide an overview of 2020 production amid the pandemic, and indicate your guidance for 2021?
We had to modify our operating plans as a result of the impacts of COVID-19 on the global economy and the copper market. I'm extremely proud of how well the Freeport-McMoRan team responded to the challenges of the pandemic, specifically safeguarding our people, communities and assets as we executed and delivered on our revised operating plans.
As stated in our recent earnings call, copper sales for 2021 are projected to increase 20% over 2020, and our unit net cash cost of production is expected to decline. Consolidated sales volumes for the year 2021 are expected to approximate 3.8 billion pounds of copper, 1.3 million ounces of gold and 85 million pounds of molybdenum.

What are the status and details of El Abra's expansion? How will it expand your operational capacity?
El Abra, our mine in Chile, has been a part of our asset portfolio for many years and is similar to several other of our operations that are focused on leach production. During the last decade, our brownfield exploration has identified a significant sulfide resource opportunity at El Abra. We've been exploring to determine if and when a transition from a leaching operation into a sulfide operation is economically feasible. As we look into the future, there are opportunities for growth at El Abra. Studies are currently underway but no decisions have been made at this point.
We're taking the operation back to pre-COVID-19 levels during the next 12 months or so. Pre-COVID-19, we were in the process of doing baseline studies for the significant sulfide resource, but were forced to stop that work. This year, we plan to restart those baseline studies and consolidate all our previous efforts on pre-feasibility studies to determine whether we want to take the project to the next step.

How are you addressing the water scarcity challenges of operating in Chile?
At El Abra, we source new water needed for our operations from groundwater and storm water. Globally, Freeport-McMoRan prioritizes maximizing our recycled/reused water across all our operations. El Abra is no exception, especially given it is in an arid region near the Atacama Desert. Our water use efficiency (water reused/recycled) at El Abra averages around 94% annually.
In addition to managing our own water risks, we also are dedicated to supporting our local communities in securing water. El Abra has been supplying drinking water to the indigenous community in Ascotán since 2009.

What is your view of copper fundamentals and its key drivers?
If you look at both supply and demand, the market seems to be tight. The global inventories are as low as they've been in at least a decade. From a fundamental perspective, the market continues to be strong, the challenges are around the uncertainties associated with a global recovery and China. Recently, prices have risen significantly in recognition of copper's favorable demand trends and the limited ability of the industry to increase supply.
With 70% of the world's copper supply used to deliver electricity, the intensity of copper use will increase as clean energy initiatives are implemented. Copper utilization in electric vehicles and in the generation of renewable power is more than four times greater per unit than that of traditional vehicles and power generation. In a relatively short timeframe, global demand just from these green initiatives could approximate the size of today's US copper market. As demand accelerates, copper supply will continue to struggle to keep up, and this supports the favorable near-term and long-term outlook for copper.

Can you elaborate on Freeport's growth strategy in Chile in the upcoming years?
Similar to our overall growth strategy for Freeport, in Chile we're focused on brownfield expansions. The potential sulphide resource and possible El Abra expansion project are very much in alignment with that.
As for acquiring assets in other metals, Freeport is foremost in copper. Our portfolio of assets is large and high quality. We are a well-established industry leader and operate mines that are among the largest in the world. Our assets have long lives and are durable, with embedded options, reserves and resource growth. In short, we're a reliable supplier to the global copper industry. ■

The rise of mid-tier mining

"A current trend we have noted is the increase in mid-tier mining companies interested in Chile. Large-scale operators are expanding, but there are also several promising mid-sized projects for which we are developing studies," highlighted Claudio Lesch, president of Ausenco in South America, the leading Australian EPCM company operating globally. "We believe there is a strong potential for these projects to be developed in the future. Canadian and Australian junior companies are also increasingly active in Chile, especially in the gold space."

Chile is known for its major mines, which produce 90% of its output. However, recently the country is witnessing the rapid growth of small to mid-tier mining producers such as Minera Tres Valles (MTV), Mantos Copper, Los Andes Copper, Altiplano Metals, Pucobre, and Capstone Mining. Capstone Mining's copper-iron-gold project, Santo Domingo, is Chile's only fully permitted, greenfield project and is expected to start construction in 2021. "2021 is a pivotal year for Capstone Mining as we are putting together all the pieces to finance Santo Domingo, which is fully permitted," commented Jerrold Annett, senior vice president of strategy and capital markets for Capstone. "We are expecting to begin construction by the end of 2021 and be in production by 2024. This will more than double the company's entire production."

On the other hand, MTV ramped up production at its Don Gabriel mine following the completion of its expansion project in early 2020. The company is using block-caving to extract the ore. "This method has a very low unit cost compared to the other potential methods. The initial capital cost has been financed through our strategic partners," commented CEO Luis Vega, who added: "We rely on a sophisticated monitoring system to control the caving. This is vital to achieving a uniform decrease in the columns of ore over the extraction points, so technology is key to the operation's success."

Meanwhile, Canada-based Los Andes Copper is working on the pre-feasibility study for its Vizcachitas copper-molybdenum project, 150 km north of Santiago. Eduardo Covarrubias, director of Los Andes Copper, explained that the project has significant geological potential: "The current mineralization is open in most directions. We optimized the project on an operational scale at a starting rate of roughly 110,000 mt/d. With a large land package such as Vizcachitas, there are so many alterations that one can spend the next 15 years drilling and finding more resources," he said.

Another project with scope for expansion is Mantos Copper's Mantoverde brownfield operation in the Atacama region, for which it secured US$846.6 million in February of 2021 to fund the development of Mantoverde's Sulphide Development Project (MVDP). The project includes building a concentrator to process ore from the sulphide deposit and expanding the oxide operation, extending the life of Mantoverde to 2041 and increasing production to approximately 110,000 mt of copper annually and 33,000 oz of gold from 2023 to 2030. ■

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Darren Pylot, Albert Garcia III & Jerrold Annett

DP: President, CEO and Director
AG: Vice President of Projects
JA: Senior Vice President of Strategy and Capital Markets
CAPSTONE MINING CORP.


DP


AG


JA

Can you give an introduction to Capstone?

DP: Capstone Mining is a Vancouver-based base metals mining company focused on copper. We have two operating assets, the first-quartile low-cost Cozamin operation in Mexico and the Pinto Valley mine in Arizona. We also have a large-scale transformational growth project in the Atacama Desert in Chile called Santo Domingo, a top quartile copper-iron-gold project that has a large cobalt deposit.

JA: 2021 is a pivotal year for Capstone Mining as we are putting together all the pieces to finance Santo Domingo, which is fully permitted. We are expecting to begin construction by the end of 2021 and be in production by 2024.

Can you elaborate on Santo Domingo's timeline and the type of partner you are looking for to advance the project?

DP: Capstone Mining has recently repurchased the minority interest of the project and is again 100% owners. We were also able to bring down the capital cost estimate of the project by completing a US$290 million gold stream agreement with Wheaton Precious Metals. We have also reached an agreement with Puerto Ventanas to build and operate the port. The initial cost estimate of Santo Domingo was approximately US$1.5 billion, but where we stand today, we only need to finance about US$800 million. We would like to bring in a partner on a 30% - 50% ownership level. ■

Fernando Porcile & Eduardo Covarrubias

FP: Executive Chairman
EC: Director
LOS ANDES COPPER


FP


EC

Can you give us an update on Los Andes' most recent developments?

FP: We published a Preliminary Economic Assessment (PEA) in June 2019, and we have been working on a pre-feasibility study (PFS), including a drill programme, which we expect to commence by May 2021 following authorization from the government. Los Andes is also currently preparing to develop an environmental impact study.

How are you addressing the issue of power to the mine and to what extent are you relying on renewable energy sources?

EC: Currently, we are still sizing the power requirements of the project. We own hydroelectric water rights in the Rocin River, allowing us to put together a small hydropower project. We are thinking about where power generation dynamics are going over the next 30 years and want to make sure that we include a significant portion of energy as renewable energy.

What is your vision for Los Andes Copper?

EC: We operate one of the most attractive new copper projects. When you compare Vizcachitas with greenfield or extension projects, the fundamentals are very compelling in favour of Vizcachitas. We are focused on ensuring that our project's configuration is sound, reliable and favorable from an environmental and social perspective to continue advancing the project. ■

Alastair McIntyre

CEO
ALTIPLANO METALS

Can you tell us more about the expansion plans of Farellon and its timeline?

Altiplano began extension of the Hugo Decline at Farellon in early 2020 to access additional copper-gold mineralized material at depth within the iron oxide copper gold vein system. To date, we have accessed the 376 m level underground. We are expanding also to the southwest where we have observed good grades.

How will Altiplano's new processing facility increase recovery and capacity?

Our new mill is designed to recover copper and gold and reduce the current processing and trucking costs by 33% and 75%, respectively. We have also designed a magnetic iron recovery circuit which will allow us to capture high value iron concentrate and reduce tailings output by 45%. The facility will also include a de-watering system that will reduce freshwater consumption by 75% and produce dry tailings, ensuring our operations minimize our footprint.

What makes Chile an attractive mining investment destination?

I understand there is some concern regarding the change of the constitution, however, I am confident that any transformation will be smooth and non-disruptive to the mining sector; its citizens and politicians will recognize the importance of mining and the contribution it brings to the country. Change is a feature of Latin American politics, fortunately, in the case of Chile, change has been often progressive in nature. ■

Codelco: Going Underground

THE FIGHT AGAINST DECLINING ORE GRADES

Chile faces a structural issue regarding productivity growth, as the country's total factor productivity (TFP) has plateaued since the 1990s and decreased by 4.7% on average every year from 1993 to 2015 as a result of declining copper ore grades, according to the OECD. "Mines must invest in innovations to ensure higher copper ore grades are extracted and productivity is achieved to remain competitive," confirmed Philippe Hemmerdinger, president of the Association of Industrial Mining Suppliers (Aprimin).

Chile is home to the world's largest copper producer, Codelco, which accounts for 10% of the world's known proven reserves and 11% of global annual production. Codelco also operates some of the oldest mines in the world, such as Chuquicamata, the company's second-largest operation by size. The company's total production amounted to 1.71 million mt in 2019 and increased by 1% in 2020. The company did however, face challenges to maintain production amid the pandemic. Codelco has a plan to invest US$40 billion on its core assets to extend their life, expand and overhaul operations over the next decade.

Chuquicamata's life is to be extended by another 40 years at least, as approximately US$5.6 billion is being spent on the century-old mine to transition it from one of the world's largest open-pit mines (by excavated volume) to an underground operation to maintain Codelco's production rates amid the declining grades. The three levels deep underground expansion is to be implemented using conventional drill and blast drifting techniques. By 2026, it is expected to produce 320,000 mt/y of fine copper and 15,000 mt/y of molybdenum.

Chuquicamata accounts for a quarter of Codelco's total production, however 1,700 km to the south lies the company's largest operation, El Teniente, the world's largest underground copper mine. First mined in the early 1900s, El Teniente developed through the years and today includes 3,000 km of underground tunnels. Its US$3.4 billion expansion, to be completed by 2023, will introduce a new section called Recursos Norte, to contribute 20% of the ore fed daily to the mine's processing facilities. Next comes the Diamante and Andesita phases, currently under construction. Overall, the expansion will extend the productive life of the mine by 50 years, boosting production to more than 500,000 mt/y compared to 459,744 mt/y it produced in 2019.

Earlier in 2021, Codelco also approved a US$1.38 billion development project for Rajo Inca, part of its Salvador division, which has been operating since 1959 with three small open pit mines and an underground mine. The expansion will increase the mine's output by 50%, peaking at 95,000 mt/y of fine copper. Meanwhile, its Andina operation is to be altered under a US$250 million plan following criticism from environmentalists to protect glaciers in the region.

With great production capacity comes great challenges for Codelco, which faces attacks from environmentalists across multiple operations, tensions with labour unions and high costs and debt to finance structural projects. Nonetheless, the company has embarked on a journey of innovation and is increasing the use of mining technology to reduce its carbon footprint, minimize costs and increase productivity by applying automation and robotics to efficiently extract high grade copper at its deep mines. The current high cycle of copper prices should only help the company's positioning for the coming years. ■

Copper Exploration

RECOVERING COMMODITY PRICES RENEW INTEREST IN EXPLORATION ACTIVITIES

Investors are wary of a copper supply shortage as demand for the metal is projected to grow by 1.7 million mt/y by 2027, according to the Copper Development Association. The worldwide increase in demand for cleaner energy, coupled with bets on economic recovery pushing metal prices to unprecedented highs, will drive increasing demand for copper. Resulting higher metal prices could cause a 15% to 20% increase in mineral exploration budgets, according to S&P Global.

In 2020, Chile registered an exploration budget of US$458 million – the fourth highest in the world and equivalent to 5.5% of the global exploration budget for nonferrous metals, according to S&P and Cochilco. However, this figure decreased by 30% in 2020 as the pandemic pushed companies to slash capex activities such as mine development, exploration and maintenance for a few months. Globally, in 2020, exploration budgets decreased 10% to US$ 8.7 billion compared to US$ 9.2 billion in 2019, with copper being the most affected with a drop of US$560 million, of which the drop for Chile was US$ 196 million.

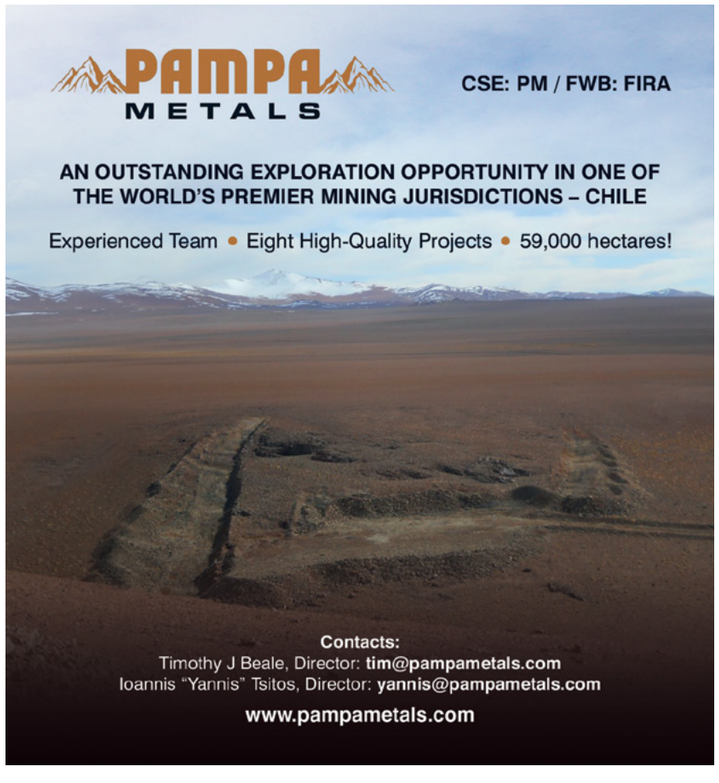
According to Cochilco, out of the 101 companies with exploration projects in Chile, 75 are junior companies, who tend to be headquartered in Canada or Australia. However, even though juniors are active, they represent a smaller portion of the market relative to other mining jurisdictions. Major companies remain the most relevant actors in Chile's exploration segment, representing 85% of the total exploration budget in 2020. Nonetheless, majors tend to focus on updating their resource base and reserves of their current deposits through predominantly brownfield activities, which is worrying considering the need for greenfield projects given the industry's recent decline in productivity due to falling ore grades.

"Shareholder and stakeholder pressure is a factor that prevents greenfield exploration and favours brownfield," commented John Currie, director of prospect generator Excava. "It is false to assume that Chile has no greenfield opportunities and has matured in terms of exploration potential. Also, the past downturn in the commodity cycle has limited access to capital for exploration activities. Another deterrent has been limited access to the prospective ground. We look forward to capturing opportunities with the boom in commodity markets," he continued.

Junior exploration updates

A good portion of the copper prospects in Chile currently undergoing exploration are porphyry-type deposits, followed by iron-oxide-copper-gold (IOCG) deposits. Torq Resources acquired the promising Margarita IOCG project in March 2021, with an exploration target of approximately 20-35 million mt of copper at 0.2-0.5% Cu.

Pampa Metals controls a 100% interest in eight exploration projects in northern Chile. "Five of the eight projects' geology is obscured by young sedimentary sequences, so geophysical exploration is our current priority combined with geological mapping, a program that has already been started at Arrieros," stated Timothy Beale, director of Pampa Metals. "Pampa Me-



Timothy Beale

Director
PAMPA METALS CORP.

What was your strategic motivation behind the creation of Pampa Metals?
The idea to create Pampa Metals was seeded at the end of 2019 when Revelo Resources was looking at opportunities to progress its business and create a separately financed company that did not rely on the prospect generator model as Revelo did, and which was able to invest in its own direct exploration. Eight of Revelo's copper-focused projects were subsequently sold to a private company to create a new vehicle that now falls under the Pampa Metals Corporation name and that is listed on the Canadian Securities Exchange (CSE) with the ticker symbol of "PM". For various reasons, the new company decided it would list on the CSE as opposed to the TSX, as the requirements for listing are a little easier. Pampa Metals is also listed on the Frankfurt Exchange, to appeal to European investors.
The company had successfully raised a contractually required minimum amount of CAD$ 4 million prior to listing, and immediately after the start of trading of its stock in December 2020, was able to start investing the money raised on the exploration of those eight projects.

Which of the eight assets is Pampa Metals' main focus at the moment?
We have great faith in all the projects in our portfolio and their geological prospectivity as they are located along the highly prospective and prime mineral belts in northern Chile. Five of the eight projects' geology is obscured by young sedimentary sequences, so geophysical exploration is our current priority combined with geological mapping, a program that has already been started at Arrieros. Pampa Metals' primary focus is on copper, however three of our projects also have good evidence for potential gold and silver mineralization.

How do you market Chile as a mining jurisdiction to prospective investors?
We have always ranked Chile very highly as a mining jurisdiction. Chile wears the crown of the top copper producer globally comfortably. It is also in the spotlight for its lithium resources and has long attracted attention for precious metals. Mining is the backbone of the Chilean economy and the country offers a sound legal, fiscal and financial framework for investors.

To what extent has Chile's stability been compromised following the protests in 2019 and the upcoming constitutional reform?
I do not believe the demonstrations altered the long-term stability Chile has witnessed over the last decades. The government's swift response to allow a referendum to rewrite the constitution, and the subsequent results of the referendum, are a testament to Chile's maturity and stability as the country appears to be on a peaceful and positive democratic path that has not affected the ability of the country in general, and businesses, to continue and progress. The Chilean government is also to be praised for the manner with which it is handling the health crisis and the fact that mining production has largely been maintained.

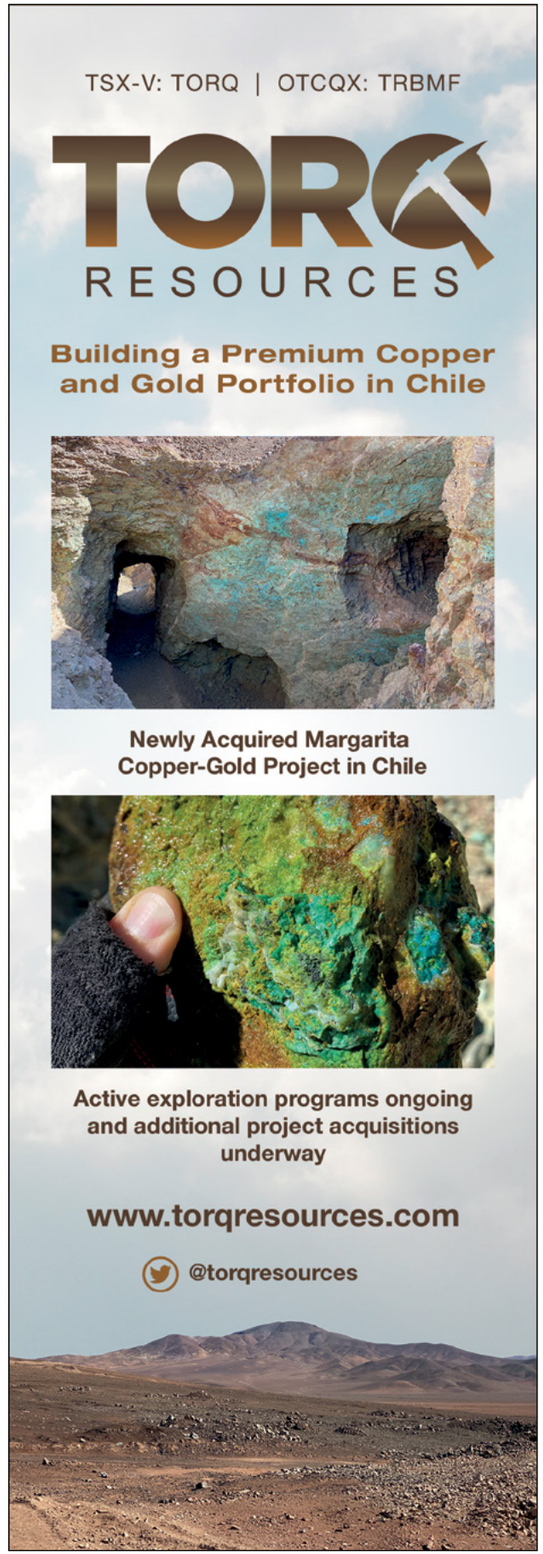
Do you believe Chile's declining copper grades are likely to pose a bigger challenge to mining in the future?
The scale of some of the mining operations in Chile is immense with world-class operations for 100 years. The scalability of these large deposits is incredible. Whilst grades overall have declined over time, the overall production of copper in Chile has been maintained and even increased over the last decade. There is a global challenge to find new mineral deposits to provide important minerals to society, and we are now finding deposits deeper and in more complex geological environments, which makes the challenges even more critical. Pampa Metals believes it is well placed to meet those challenges.

Where do you see the highest growth potential for Pampa Metals in Chile?
Chile is a mature market but in a positive way. Most of the mining activity occurs in the northern desert, where population density is low. Large portions of northern Chile are either underexplored or unexplored, so while it may be a mature mining market, it has not yet reached maturity in terms of its exploration potential. Pampa Metals' efforts will be directed towards exploration, by relying on improved geological models than those used 20 or 30 years ago, allowing us to revisit areas historically explored with fresh eyes and technology, as well as investigating totally new areas. ■

tals' primary focus is on copper, however, three of our projects also have good evidence for potential gold and silver mineralization."
Recent arrivals to Chile's junior segment include Tesoro Resources, Orestone Mining Corp, Solaris Resources and Helix Resources, while Austrin Resources, Cornerstone Capital Resources, Josemaria Resources, MGX Minerals and Santana Minerals, discontinued exploration activities in Chile.
Orestone Mining Corp commenced a 1,200m drilling program on its Resguardo project, showing typical porphyry characteristics and a similar mineralization to Candelaria. TSXV-listed Solaris Resources is drilling for discovery at its Tamarugo and Ricardo projects.
"Exploration activities undertaken in Chile today are predominantly focused on immediate production and converting existing resources or revisiting historical data. The decline in greenfield exploration is alarming and cause for concern," commented Michael Kosowan, president and CEO of Vancouver-based Torq Resources. "The risk-taking attitude towards exploration needs to be fostered and increased. This dormancy period in exploration affects regions like Chile because grounds are not readily open or are held by groups with low interest in exploration."

Financing

Most registered companies rely on releasing shares to raise capital for their activities. Cochilco's report on exploration activities in 2020 identifies the Toronto Stock Exchange (TSX), the TSX Venture Exchange (TVX) and the Australian Stock Exchange (ASX) as the main markets funding exploration activities in Chile. In 2020, TMX Group (TSX and TVX) funded 34% of projects in Chile, while the ASX funded 28%.
An alternative to stock market financing is private equity, which decreases companies' exposure to the volatility of public financial markets. While most private equity firms financing exploration are foreign, some companies are looking to raise capital locally such as Astra Exploration. "We are exploring many options for financing, such as private investors and local institutions. It is vital for Astra to engage with local investors in Chile," explained managing director Brian Miller.
The medium-sized mining space has been increasingly attracting attention from private equity firms in the last years. For example, Denham Capital has a wide portfolio of mid-tier companies that started off as juniors, such as Santiago Metals, operating the Delirio and Puquios projects. Meanwhile, Mantos Copper is owned by a consortium led by British investment firm Audley Capital and Orion Mine Finance Group, who bought Mantos Copper and Mantoverde from Anglo American. ■



Michael Kosowan

President and CEO
TORQ RESOURCES

Torq Resources fills a void in the market for major companies, as we are equipped and confident in taking the calculated risk associated with exploration.

Can you give us an overview of Torq Resources and the company's transition from Stratton Resources?
Torq Resources is an exploration company focused on establishing a top tier mineral portfolio and the fourth company within our group of exploration juniors. Our management teams have raised US$550 million and monetized successes in two previous exploration companies, delivering high value to shareholders. Following a comprehensive review, focused primarily on the Americas, Torq saw high potential for exploration projects in Chile, a world-renowned mining country.
Chile is attractive due to its stability economically and politically and sound mining code. The silver lining of the pandemic for us has been our ability to find and appoint a highly experienced local technical team to evaluate projects and build a strong portfolio led by Waldo Cuadra, who has over 40 years of experience in the industry. Having this highly skilled team is critical as we look for opportunities in the primary mining regions of Chile.

Do you think we are witnessing the beginning of a new commodities supercycle?
We are witnessing the reflationary efforts of central banks around the world that are injecting stimulus into the world economies at an unprecedented level. This will trigger inflation and a boom in commodity prices. That, coupled with the lack of exploration and production short falls, will place significant upward pressure on the commodity complex. The majors will need to replace their resources as quickly as they can amidst this bullish market backdrop. They are increasingly outsourcing exploration to junior companies to ensure a strong pipeline of quality assets while mitigating geological risk.

How would you describe the junior market dynamic in Chile?
Large-scale mining companies are being challenged on the exploration front at a time when commodity prices are skyrocketing. As margins increase for the producers, they are under increasing pressure to replenish their reserves. The industry, as a whole, therefore needs to invest more in exploration as it is the lifeblood of the mining industry. Our advantage is our ability to raise capital for that much needed exploration. By leveraging our global experience, we can fund and uncover projects that will help fill this void.
Exploration activities undertaken in Chile today are predominantly focused on immediate production and converting existing resources or revisiting historical data. The decline in greenfield exploration is alarming and cause for concern. The risk-taking attitude towards exploration needs to be fostered and increased. This dormancy period in exploration affects regions like Chile because grounds are not readily open or are held by groups with low interest in exploration.

How do investors perceive Torq Resources?
The market perceives our company as having a track record of success, so investors, rightly, have high expectations. Management are also major equity owners, so we are aligned with our shareholders' interests. We are fortunate to have the exploration team that led the discovery at El Morro working with us. Mines are made not just stumbled upon, and it takes a high level of technical expertise to unlock a significant discovery and develop a project that is economically appealing to investors and eventual major buyers. Torq is well positioned to meet this challenge as we combine our capital markets expertise with the team's exceptional talent on the ground.

Where does Torq Resources see the highest growth potential in the near future?
Making a discovery is where we see the company's greatest potential to bring value to our shareholder base. Torq Resources fills a void in the market for major companies, as we are equipped and confident in taking the calculated risk associated with exploration. We look forward to playing a significant part in the exploration succession plan in Chile as we seek out market-impacting copper and gold properties. ■

Insights from the ground: Are We Witnessing the Beginning of a New Commodity Supercycle?

"The price of copper responds to the laws of supply and demand. A supercycle involves a long boom in demand that drives up prices until they get so high that demand collapses, pulling prices down again. Currently, we are not seeing a difference between supply and demand of copper big enough to constitute a supercycle."

- Marco Riveros, Vice President, Cochilco

We are witnessing the reflationary efforts of central banks around the world who are injecting stimulus into the world economies at an unprecedented level. This will trigger inflation and a boom in commodity prices."

- Michael Kosowan, President and CEO, Torq Resources

"We are seeing an upward cycle for commodity prices, which was expected to follow the downward trend that began in 2012. The pandemic ignited and exacerbated the upward cycle by triggering one of the most extensive expansionary monetary and fiscal plans in history."

- Juan Carlos Guajardo, Founder and Executive Director, Plusmining

"If you look at supply and demand, the market seems to be tight. Global inventories are as low as they have been in at least a decade. From a fundamental perspective, the market continues to be strong, the challenges are around the uncertainties associated with a global recovery and China."

- Joshua Olmsted, President and Chief Operating Officer-Americas, Freeport-McMoRan

"Following 2020 and the impact of the pandemic, we now have a tight market and expectations are that there will be major stimulus to the global economy. We believe that copper demand growth will continue as the world seeks to find cleaner solutions for modern life."

- Iván Arriagada, CEO, Antofagasta Plc

"A supercycle is defined as one resulting from a major structural shift in the market. There is uncertainty to the speed at which the transition will happen to EVs and renewable energy which will determine the nature of this structural shift and the extent to which this is a commodity supercycle."

- John Currie, Director, Excava

BEYOND COPPER: GOLD AND LITHIUM POTENTIAL

"Chile's prominent role as a copper producer often causes other metals to be overlooked. While gold production is typically associated with countries such as Mexico and Peru, Chile also has significant gold reserves. US$3 billion in investments have been recently announced in gold and silver projects for 2020-2029. Currently, there are also substantial development prospects for the lithium industry."

- Marco Riveros,
Vice President,
Cochilco

Image courtesy of Barrick

Gold

CHILE'S PRECIOUS METALS

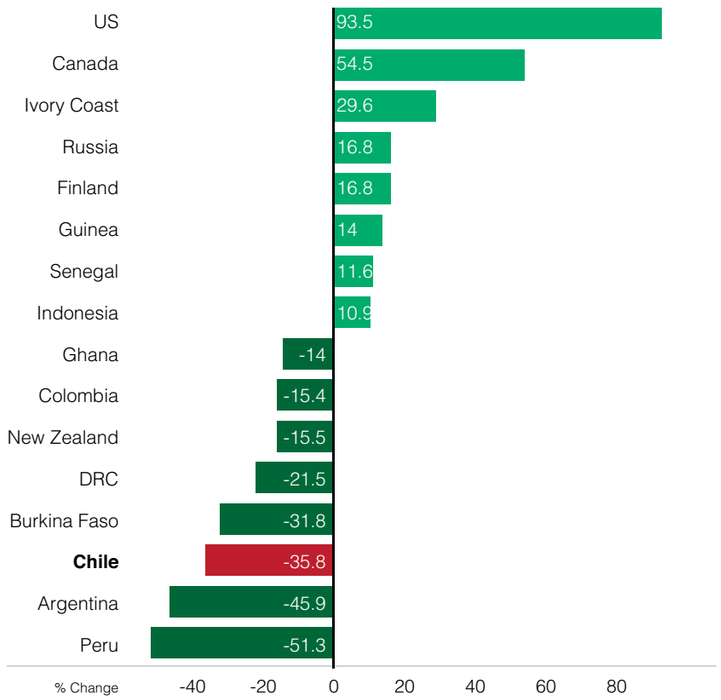
Gold mining in Latin America tends to be associated with Peru, Mexico, Brazil and Argentina. While the industry in Chile is relatively smaller, ranked 25th in the world according to the World Gold Council, it is one that holds great potential and has been recently attracting attention. The country's renowned reputation as a mining jurisdiction coupled with the precious metal's bullish price projections puts the Chilean gold mining industry in the spotlight.

"2020 proved a record-breaking year for the gold price, spurred by low interest rates and government stimulus packages used to mitigate the impact of Covid-19," explained Alastair McIntyre, CEO of Canada-based Altiplano Metals, a junior resource company with interests in near-term production assets in Chile. "Massive amounts of USD stimulus put pressure on the dollar and with gold priced in US$, it has a natural tendency to rise. As economies need to reflate to get back to post COVID-19 employment and GDP levels, I see the outlook on gold remaining positive."

According to Cochilco, Chile produced 1.33 million ounces of gold in 2019, representing a 4.7% year-on-year increase. Gold mining in the country dates back to the end of the sixteenth century, and was encouraged later on with the establishment of the royal mint in Santiago. Gold reserves in Chile can be found in sub-volcanic epithermal deposits and porphyry sporadic deposits, as a by-product of copper and molybdenum. The industry has significant potential and is expected to grow in size by 42% by 2023 according to local newspaper El Mercurio.

Largest Changes in Gold Exploration Budget BY LOCATION 2019-2020

Source: S&P Global



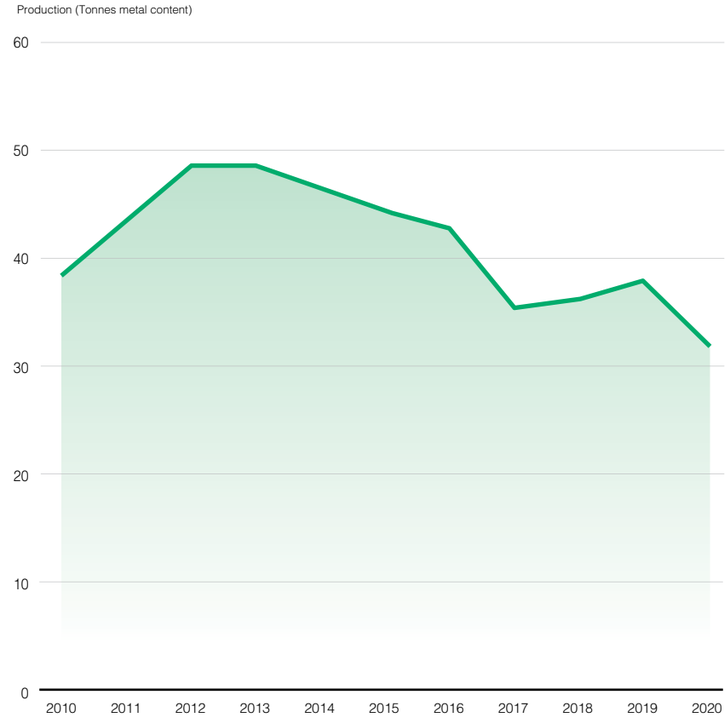
Northern Chile is home to exceptional gold vein deposits by the coast, which is where Gold Fields' open-pit Salares Norte is located. Construction of the project began in February 2021. The US$860 million operation has an initial mine life of 11.5 years and should produce 450,000 ounces of gold annually for the first seven years. "Production is scheduled for early 2023, not considering any significant Covid-related delays, as announced before the outbreak," confirmed Max Combes, country manager of Gold Fields in Chile. "By next winter, we will have 1,400 workers onsite, therefore, if we encounter further logistical delays, the expected production may change."

The northern part of Chile is covered with mining claims controlled mainly by majors, making it difficult for junior companies to compete. Majors can hold on to claims for long periods of time relatively cheaply without the need to conduct a minimum amount of work or expenditure.

- Damien Koerber, COO and Executive Director, Equus Mining

Gold Production in Chile

Source: Cochilco, GBR



The exploration grounds in the known gold regions of Chile are dominated by the majors and mid-tier mining companies. In the south of Chile there are some good underexplored opportunities, although we would consider opportunities in the north, depending on availability.

- Tony Harwood, President and CEO, Montero Mining

Meanwhile, Yamana Gold, one of the biggest gold producers in Chile, operates the underground operations El Peñón and Minera Florida. El Peñón saw its production increase in 2020 to 162,000 ounces of gold, from 159,515 ounces in 2019. After drilling from Q4 2019 to Q1 2020, the Toronto-based company reported significant exploration results in March 2020, supporting further mine life extension at El Peñón. Minera Florida also witnessed a successful drilling campaign that led to discovery in 2020, providing flexibility to the operation, expanding the mineral resource base as well as life of mine.

Another significant gold producer in Chile is Kinross, who announced in February 2020 to move forward with the La Coipa Restart Phase 7 project, which will require a US$225 million investment. In addition to generating 700 jobs, the asset is expected to produce 690,000 oz of gold from 2022 to 2024. Kinross is also proceeding with the feasibility study for the nearby Lobo Marte project in the Marincuga strip, after the pre-feasibility study estimated a total mine production life of approximately 4.5 million oz of gold.

On the other hand, Chile's environmental court ordered the definitive closure of Barrick's Pascua-Lama in September of 2020, over environmental concerns. Located in the Andes mountains on the border with Argentina, the project has been on hold since 2013 and was one of the largest Chilean gold projects, with probable reserves of 17.8 million ounces of gold. "Work is under way to re-evaluate Pascua-Lama's potential through a comprehensive internal review of its technical, economic and social aspects and different approaches to permitting," highlighted Marcelo Álvarez, executive director of Barrick in Chile and Argentina. "As our president and CEO Mark Bristow has pointed out, it appears that combining Lama with Veladero and looking at Pascua separately may make more sense. We are looking closely at this and all other options."

Chile reached its peak of gold production 20 years ago, at 1.74 million ounces. By 2028, the entry of new projects into operation as mentioned above, namely Salares Norte, La Coipa and El Peñón, will add US$1.2 billion in investment into the sector and approximately 900,000 ounces to national production.

Exploration: a gold rush

Given the precious metal's exceptional performance in 2020, global gold exploration budgets were higher than for other commodities. However, S&P Global Market Intelligence reports that the gold exploration budget in Latin America and Chile decreased by 14% and 35.8%, respectively, between 2019 and 2020. Nonetheless, the region

still had the highest budget, totalling US$858 million in 2020 and accounts for the largest share of the global grassroots stage budget.

Over the course of 2020, Cochilco identified 234 exploration projects being undertaken in Chile, of which 28% were gold-related. Gold trumped copper, silver and zinc as the target mineral for last year, as it represented 48% of holes drilled in 2020.

The country is increasingly attracting juniors who are finding access to finance easier than other commodities and focusing on brownfield exploration. According to S&P, fundraising by junior and intermediate companies for gold projects hit a record high from January to September of 2020, amounting to a total of US$4.05 billion.

"The exploration ground in the known gold regions of Chile are dominated by the majors and mid-tier mining companies," explained Tony Harwood, president and CEO of Montero Mining, a new junior player in the Chilean gold mining industry. "In the south of Chile, there are some good underexplored opportunities although we would consider opportunities in the north, depending on availability."

Montero Mining was focused on battery metals in Africa before acquiring the Isabella gold-silver project, for which the drilling program should be complete in 2021. Due to the lack of claims available in northern Chile, new junior companies tend to acquire assets in the south, which is more under the radar of major companies. For example, Australian junior company Equus Mining is to acquire the Cerro Bayo epithermal deposit from Mandalay Resources, where it plans to explore for brownfield and greenfield targets. "We have been exploring throughout the Cerro Bayo mine district for approximately 18 months and have already established an inferred mineral resource of approximately 302,000 ounces of gold equivalent at the Taitao Pit, of which two thirds is potentially open-pitable," commented Equus' COO and executive director Damien Koerber.

Meanwhile, Mirasol Resources, project generator and explorer, resumed exploration at the Inca Gold gold-silver project, on the Paleocene belt, after a brief suspension in 2020. The ongoing 1,500 m diamond drill program should be complete by Q2 2021. If exploration demonstrates significant potential for discovery, Newmont agreed to reimburse Mirasol 70% of their costs and invest in additional exploration.

On the other hand, Astra Exploration is exploring for gold at Pampa Paciencia. Managing director Brian Miller highlighted that the property was first held by B2Gold, who were exploring for copper. "It is located approximately 10 km north of Sierra Gorda and the mineralization consists of outcropping silica caps, quartz veins and sub cropping angular quartz fields that align with east-west to west-northwest lineaments. SQM has a 20% interest in the project and Arena Minerals will also be a major shareholder," he added. ■

Max Combes

Country Manager Chile
GOLD FIELDS

Production is scheduled for early 2023, not considering any significant Covid-related delays, as announced before the outbreak. By next winter we will have 1,400 workers on-site.

Can you elaborate on Gold Fields was able to stick to the construction schedule of Salares Norte amid the pandemic?

Since engineering, procurement and construction plans were finalized in advance and approved in February of 2020, it allowed the project timeline to be ahead of schedule. Therefore, when the outbreak started, we decided to accelerate some of our purchase orders and the construction plan execution. Construction platforms to begin working on temporary facilities started in April, and the earthwork in September. Meanwhile, the construction of the camp was divided into two stages: phase one which started on time, and phase two that was scheduled for October but was instead rescheduled. A decision was also made to add an additional building to increase the number of beds in the camp, to comply with Covid-19 social distancing restrictions.

Production is scheduled for early 2023, not considering any significant Covid-related delays, as announced before the outbreak. By next winter we will have 1,400 workers on-site, therefore, if we encounter further logistical delays, the expected production may change.

How does this project compare to other Gold Fields' assets around the world?

This asset has very unique characteristics compared to other Gold Fields assets. All our gold plants are located in Australia, West Africa and South Africa, which host a very different climate and altitude compared to Chile and we are also using different technology. The geology is also unique due to its gold and silver content. Cerro Corona in Peru is similar in terms of altitude but not in technology since it is a copper mine.

What technology are you relying on to ensure the mine's efficiency through automation?

We have incorporated certain contemporary mining aspects into the design, such as adopting filtered dry stacked tailings in preference to the construction of a conventional tailings dam. By dewatering the tailings prior to placement we will achieve a significant reduction in water consumption, reduction in tailings footprint and improved physical stability of the tailings facility.

We are in the process of deploying a private LTE telecommunications network to support our digitalization strategy and to enhance safety across the site. The LTE network will form the backbone of the mine and plant communications and will allow for the remote operation of certain equipment, e.g. production drill rigs and rock breakers.

The design includes a modern integrated operations control room at Salares Norte which will oversee both mining and processing activities. The process plant is equipped with a high degree of automation implemented over the distributed control system and advanced process control will be implemented once the plant reaches steady production. Site operational data will also be relayed in real-time to a remote monitoring room in Santiago where a team of specialists will analyse the data with the aim to enhance operational performance.

The project will implement a hybrid microgrid to provide electrical energy, with approximately 18% of the energy being supplied from solar power. This level of solar penetration is near the theoretical limit as the system will operate exclusively in island mode. The use of solar energy will decrease our carbon footprint and ensure project sustainability. We will continue to evaluate options to introduce more renewables and other green technologies into our energy matrix going forward.

Considering the bullish appetite for gold, will Gold Fields focus on exploration in the region?

Since the discovery of Salares Norte deposit in 2011, we have never ceased exploration activities in the district and have drilled several near-by exploration targets. As the Salares Norte project was consolidated in 2017, we started to allocate more resources to increase exploration in the surrounding 20 km. Drilling has begun for different targeted plots. However, it is a long-term systematic process that could take years, so it is too early to conclude that there will be another deposit. We are also considering opportunities beyond.

What are Gold Fields' vision and strategy in South America in the upcoming years?

We are looking to consolidate our position around Salares Norte and create a pipeline of projects. We are also open to other opportunities that may be present in the Atacama or other regions.

In Peru, Gold Fields also is looking to make feasible new projects that give continuity or expand our presence in this country. ■

Marcelo Álvarez

Executive Director Chile and Argentina
BARRICK

Could you provide an overview of 2020 production in your Chilean mines amid the pandemic and indicate your guidance for 2021 for your projects?
In 2020, results for Zaldívar (jointly owned by Antofagasta and Barrick, being operated by Antofagasta) were 106 million lb of attributable production of our share at the cost of sales of 2.46 US$/lb and 2.25 US$/lb of all-in sustaining costs. For 2021 the outlook is 90 to 110 million lb of attributable production at the cost of sales of 2.30 – 2.50 US$/lb and 1.90 – 2.10 US$/lb of all-in sustaining costs.
Following the completion of mining through a higher-grade zone for the last two years, we expect grades to decline in 2021. Major maintenance is scheduled for Q2 of 2021.

What is your strategy to reassess the potential of Pascua Lama?
Last year, we prioritized the resolution of several legacy issues. This included drawing a line under a legal process related to the Chilean side of the Pascua-Lama project that started in 2013. The Chilean Environmental Court found that no irreparable environmental damage had been caused, but that Pascua should transition to closure, a ruling that Barrick accepted.
Pascua-Lama remains an important project and a unique gold deposit, and work is underway to re-evaluate its potential.

How are you allocating your US$8 billion exploration budget?
El Indio Belt has been a prolific generator of multiple world-class discoveries. The strategy is to build a critical mass of smaller deposits to create a mining complex capable of meeting Barrick's criteria. Extensions of the belt are underexplored and likely to have a different style of mineralization requiring different search criteria, which is being investigated.
The Alturas – Del Carmen deposit spreads across the Chile and Argentine border and has a resource of over 8 million ounces of gold mineable through a heap leach process. It remains a greenfield with an optionality that holds the potential to advance it to a Tier1 or Tier2 asset.
At Alturas-Del Carmen, drilling has started with the objective of testing shallow, high-grade mineralization that would impact the economics of the project, following up on a comprehensive and improved structural framework completed in 2020.

Can you elaborate on Barrick's growth strategy and investment plan in Chile in the upcoming years?
In the short-term, we have two exciting infrastructure projects. We are working to link Veladero in Argentina to the power grid in Chile, which was temporarily delayed by the pandemic but now resumed and all required permits for the project have been granted. We expect completion of the power transmission project by the end of 2021. Veladero and Pascua-Lama's joint investment in the project amounts to around U$41 million.
Upon completion, the power transmission line will allow Veladero to convert to grid power exported from Chile and cease operating the current high-cost diesel generation power plant. A power purchase price agreement was executed during Q4 of 2019 to supply power from renewable energy that will significantly reduce Veladero's carbon footprint. This is expected to save 32 million litres of fuel per year and reduce CO2 emissions by 83,000 mt/y upon commissioning.
Secondly, the Chloride Leach Project for the Zaldívar mine, with a capital cost of US$189 million, contemplates the construction of a chloride dosing system, an upgrade of the solvent extraction plant, and the construction of additional washing ponds. Upon commissioning in the first half of 2022, the project is expected to increase copper recoveries by more than 10% by adding chlorides to the leach solution and with further potential upside in recoveries possible depending on the type of ore being processed. This process is based on a proprietary technology called CuproChlor® that was developed by Antofagasta at its Michilla operation, which had similar ore types. Once completed, the project is expected to increase production at Zaldívar by approximately 10 - 15 thousand mt/y.
This past year was marked by the establishment of a new exploration and business team for the region. We are confident in our significant organic growth potential, and greenfield exploration teams are hunting for the next world-class discovery across our global holdings, as well as scouting for emerging new targets and projects where the full potential to yield a discovery has not yet been realized. ■

Andrés Guzmán

VP-Country Administrator Chile
YAMANA GOLD

Could you provide an overview of 2020 production at El Peñón and Minera Florida amid the pandemic and indicate your guidance for 2021?
Yamana's operations in Chile were able to continue operating under COVID-19 protocols. El Peñón produced 216,749 gold equivalent ounces in 2020, comprised of 161,000 oz of gold and 4,917,000 oz of silver, while Minera Florida produced 90,000 oz of gold.
For 2021, we are forecasting gold equivalent production of 215,000 – 229,000 oz at El Peñón, including gold production of 155,000 – 165,000 oz and silver production of 4,365,000 – 4,635,000 oz. Minera Florida is expected to produce 84,000 – 90,000 oz of gold.

What techniques are you relying on to minimize fresh water consumption and source power from renewable sources in your operations?
All of our wholly-owned operations, including El Peñón, are zero process water discharge facilities. Yamana also announced a climate action strategy in early 2021, which incorporates two high-level targets: a science-based 2°Celsius scenario compared to pre-industrial levels and an aspirational net-zero 2050 target. Our work in 2021 will identify the greenhouse gas (GHG) emissions baseline and establish the abatement pathway to achieve the 2°Celsius and net-zero 2050 targets.
Our operations made progress in optimizing power requirements in the production process. Several projects are underway, such as optimizations in the grinding system at El Peñón and optimization of the ventilation system of the underground mine. As for renewable energy, our focus is on entering contracts with producers who source their power from largely renewable sources.

What is your view on gold fundamentals and its key drivers?
Many of the factors that positively impacted gold in 2020 were in place before the onset of the global pandemic: geopolitical uncertainty, socioeconomic imbalances, global trade tensions, low real interest rates, and elevated levels of government debt. These issues remain, and some, notably government debt, were exacerbated by the pandemic as governments around the world added double-digit trillions in stimulus spending to combat economic disruption wrought by the pandemic. Debt-to-GDP levels are at unprecedented levels, yet stimulus spending is likely to persist. The US$1.9 trillion stimulus package recently passed in the US is a good example of this. At the same time, as the pandemic subsides, pent-up demand for everything from cars and other luxury items to travel to simply enjoying an evening out again will drive an inflationary cycle in what is almost certain to remain a low-interest-rate environment. Interest rates are likely to remain low because, at current levels, worldwide debt cannot support higher rates; the interest payments on such large debt levels at increased rates would simply be too high. Hence, while we may see the price of gold fluctuate near term, as has occurred in early 2021, we believe the underlying fundamentals support a higher gold price longer term.
Demand for copper is also expected to surge in the coming decade as the green transition gains momentum. Yamana is well-positioned to benefit as it holds a majority stake (56.25%) in one of the lowest capital intensity copper projects in the world: the MARA project. Located in Catamarca Province, Argentina, MARA has proven and probable copper mineral reserves of 11.8 billion pounds and proven and probable gold mineral reserves of 7.4 million oz on a 100% basis. We are continuing to advance the project with the Feasibility Study and Environmental and Social Impact Assessment expected to complete in 2022. While MARA is not located in Chile, it underscores the breadth of our portfolio in Latin America and represents a significant value that will ultimately benefit our stakeholders everywhere we operate.

Can you elaborate on Yamana's growth strategy and investment plan in Chile in the upcoming years?
Chile has long been recognized as a stable jurisdiction for mining with clear and well-established rules. We currently have two operating mines in the country and a significant generative exploration campaign. We have built strong relationships with governments at all levels in Chile as well as our community stakeholders underpinned by mutual trust and respect. We are continually working to grow our business, both organically or through acquisitions. If there is an opportunity to acquire a property in Chile, expand an existing operation, or advance an exploration property to development that makes sense for our business, we will not hesitate. We have operated successfully and responsibly in Chile for nearly 15 years, and we look forward to operating here for many more years to come. ■

Lithium

UNLEASHING CHILE'S POTENTIAL

Some 1500 km north of Santiago lies Atacama, the driest desert in the world and the home to 80% of Chile's lithium reserves. Chile mainly produces lithium carbonate, followed by lithium hydroxide and lithium chloride. Lithium carbonate holds the highest commercial transaction value and can be produced by either hard-rock mining extraction, the technique primarily used in Australia, or by extraction from bine. In Chile, Argentina and Bolivia, also known as the South American 'lithium triangle', lithium is mined through extraction from bine, which is easier and more cost-effective.

There are two types of salars in South America: Andean and pre-Andean, the latter holds a higher concentration of lithium. Chile is home to multiple pre-Andean salars, namely Atacama, Punta Negra, Pedernales and Maricunga. However, the Atacama Salar is the only one hosting significant operations, led by Chile's two lone producers, Santiago-based Sociedad Quimica y Minera de Chile (SQM) and Albemarle.

Even though the lithium industry is smaller compared to copper or gold, its dynamics are exciting in the near future as it is to witness rapid growth as a result of the projected sharp increase in the demand in the upcoming years. The metal's high density and excellent conducting properties make it the number one choice in battery production for electric vehicles (EVs). Demand for the white metal did not grow as expected for 2020 as a result of the global downturn. However, according to a research study by Facts and Factors, the EV market is expected to grow at a compound annual growth rate of 22% between 2019 and 2026. As a result, demand for lithium is projected to increase from 310-315,000 mt/y to 900,000-1 million mt/y by 2025, according to SQM.

"The lithium market is poised to experience growth in the foreseeable future, and we expect it to oscillate around US$10,000 per tonne," explained Marcelo Awad, executive director of TSXV-listed Wealth Minerals, a junior mineral resource exploration company with interests in Chile. "The key drivers of this are the expansion of the global electric vehicles fleet, and the corresponding forecasted increase in lithium-ion battery production."

By 2023, Chilean lithium production will more than double, from 96,000 mt to 230,000 mt of lithium carbonate, according to Reuters. At the 11th Lithium Supply & Markets 2019 conference, then Minister of Mining Baldo Prokurica announced an investment pipeline for lithium projects valued at more than US$1.8 billion. The upcoming projects include Albemarle's US$300 million expansion of La Negra plant phase 3, the US$527 million Blanco project and SQM expansion initiatives.

Gerardo Illanes, chief financial officer of SQM, explained the company's upcoming US$400 million investment plan to expand their production capacity of lithium carbonate, which currently stands at 70,000 mt/y to 120,000 mt/y by the end of 2021. "By 2023, we will expand production in Chile to 180,000 mt/y. On the other hand, lithium hydroxide production will increase from 13,500 mt/y to 30,000 mt/y by 2023," he added.

SQM is set to account for 73% and 74% of the increase in Chile's lithium carbonate and lithium hydroxide production capacity, respectively by 2028.

Meanwhile, Albemarle started the La Negra expansion project, notwithstanding the 15% year-on-year decrease in its sales for 2020. The North-American company's US$300 million expansions in Chile are being carried out in waves, and will result in an increase in Albemarle's lithium carbonate capacity by 42,700 mt/y at a low cost.

Exploration: regulatory bottlenecks

The two main junior actors exploring for lithium in Chile are Vancouver-based Wealth Minerals and Calgary-based Lithium Chile, the latter being the largest landholder of lithium salars outside of the Chilean government.

"Lithium Chile currently has 13 properties in 11 Salars and one Laguna complex, which totals 71,900 acres," commented Steve Cochrane, president and CEO of Lithium Chile. "We are situated in the world's highest-grade lithium district, where over 50% of the world's known lithium reserves are located. Lithium is the energy of the future, and Chile is the Saudi Arabia for lithium."

Both Wealth Minerals and Lithium Chile are advancing their exploration efforts, however, even after discovery they cannot exploit their assets unless regulation regarding lithium sees radical changes.

Chile's policy regarding lithium has been subject to criticism as it does not invite private investment or newcomers into the industry. "Chile was the leading producer of lithium and now is number two, behind Australia," highlighted Ellen Lenny-Pessagno, country manager of US-based Albemarle in Chile.

The lack of attractiveness of its legislation pushed Chile into second place in 2017. The only way lithium is mined at the moment in Chile is if a private company partners with the State through the Chilean Economic Development Agency (CORFO), by obtaining a special permit known as CEOL. This uncertainty regarding further exploitation of Chile's lithium wealth stems from the Augusto Pinochet administration who declared lithium to be a 'strategic resource' in 1976 due to its use in nuclear fission. No mining concessions were granted for exploitation except those already in place prior to this declaration, i.e. those of CORFO.

"Lithium could be addressed under the new constitution, and private actors could be permanently prevented from exploiting it if the constitution enhances state control of natural resources," commented Juan Carlos Guajardo, founder and executive director of Plusmining, a local mining intelligence company.

The country is home to 52% of the global lithium reserves, according to the Chilean Ministry of Mining and the metal is to witness rapid growth in demand. Therefore, exploration is pivotal to take advantage of the upcoming lithium market dynamics. If the regulation surrounding it is addressed in a favourable manner to private investors under the upcoming constitutional changes, the industry could attract billions of dollars in investment that could facilitate Chile's rise as the top lithium producer in the world, especially given the copper giant's history and stability in mining-related activities.

"In 2019, they announced they would launch a change in the regulation soon, allowing private actors in lithium development. The law has been drafted, however, it is yet to be passed. We are optimistic that under Minister Jobet's leadership, given his background in energy, we will see more progress regarding this crucial policy change," elaborated Awad of Wealth Minerals.

Environmental concerns: water

Lithium production through brine extraction requires a considerable amount of water, which South American countries have only recently started measuring. To extract lithium, mining companies must drill in the salt flats, then pump the mineral-rich brine to the surface. The liquid then evaporates in huge pools, raising the concentration of lithium from 1% to 6%.

Even though the process is relatively cheap and effective, it is problematic because it sparks conflict with indigenous communities, especially the farmers and the government, over the allocation of water in one of the driest regions on the planet, since the process can use up to approximately 500,000 gallons of water per tonne of lithium, according to the Institute for Energy Research (IER). There is also potential for air contamination and for the leakage of toxic chemicals from the evaporation pools into the water supply.

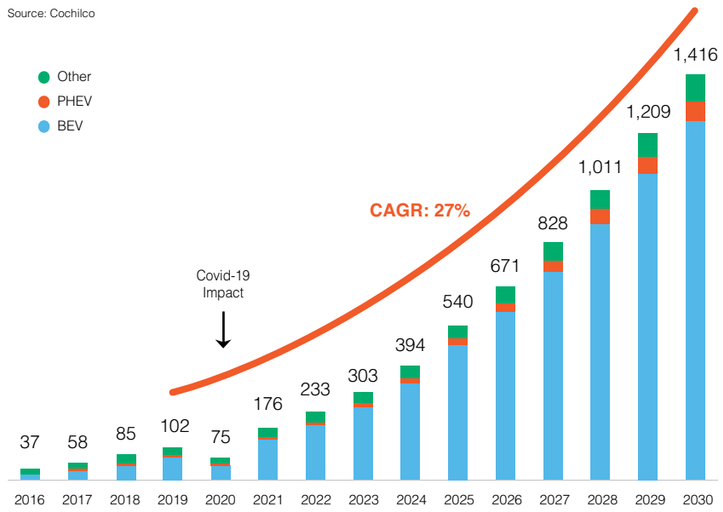
Lithium operators are therefore investing in new more sustainable technologies of lithium brine extraction and setting strict targets to minimize their environmental impact. Illanes of SQM explained: "Our ambitious goal is to reduce our water consumption by 40% by 2030 and 65% by 2040. In the caliche ore operations, we will rely on the use of seawater. SQM will also reduce brine extraction by 50% by 2030 in the Salar de Atacama, which will be a challenge as we plan to quadruple our lithium production."

The lithium industry in Chile shares the same challenges as copper and gold regarding access to water, communities' interests and trying to strike a balance between ensuring sustainable yet profitable operations. However, the industry's unique challenge lies in the lack of clear operational rulebooks. The guidelines of operating in Chile's pre-Andean salars should be revised from an economic and environmental perspective to set the standards for future development.

The Chilean government launched multiple initiatives, showing its awareness of the industry's challenges and potential. For example, the Ministry of Mining and the Nuclear Energy Commission (CCHEN) are working on documents to present their case for lithium commercialization quotas. The Ministry is also working alongside the Inter-American Development Bank (IDB), preparing a study for sustainable lithium brine exploitation in the lithium triangle. ■

Demand of Lithium in Electric Vehicles (LCE kt.)

Source: Cochilco



Gerardo Illanes

CFO
SQM

> We are investing approximately US$400 million to expand our production capacity of lithium carbonate in Chile, which currently stands at 70,000 mt/y, to 120,000 mt/y by the end of 2021.

How have SQM's operations in Chile developed over the last years?
Despite the pandemic, we were able to continue production at all of our plants at a cost equal to or lower than we had budgeted before the pandemic started. However, our operations' logistics and administrative operations were impacted. We had to implement a series of protocols to ensure the safety of our workers, contractors and local communities.
During all of this, we have been working on expanding our lithium production capacity while implementing our ambitious sustainability plan.

Can you elaborate on the sustainability plan phases?
The plan focuses on four initiatives. We plan to reduce our continental water consumption, as we operate in the driest place on earth, so water scarcity is pivotal to the region. Our goal is to reduce our consumption by 40% by 2030 and 65% by 2040. One of the most relevant initiatives we are working on to achieve this is developing a seawater pipeline.
Even though SQM is the lithium player with the lowest carbon footprint, the second initiative addresses carbon emissions. We are aiming for carbon neutrality in our production of lithium, iodine and potassium chloride by 2030 and for all our products by 2040. Thirdly, SQM will reduce brine extraction by 50% by 2030 in the Salar de Atacama, which will be a challenge as we plan to quadruple our lithium production. Our production of lithium was 48,000 mt/y, which we expect to increase to 180,000 mt/y within the next two to three years. Finally, the last initiative includes developing our relationship with surrounding communities by ensuring an ongoing dialogue with them.

What investments is SQM making to increase its production capacity of lithium carbonate and lithium hydroxide?
We are investing approximately US$400 million to expand our production capacity of lithium carbonate in Chile, which currently stands at 70,000 mt/y, to 120,000 mt/y by the end of 2021. By 2023, we will expand production in Chile to 180,000 mt/y. On the other hand, lithium hydroxide production will increase from 13,500 mt/y to 30,000 mt/y by 2023.

Do you see challenges for Chile as a lithium mining destination amid the regulatory uncertainty surrounding the metal?
Chile has a strong mining history. The regulatory framework has always been clear, and that is why so many companies have invested so much over the past several decades to develop the mining industry. On our end, we are making considerable investments in developing not just our lithium operations but also our iodine and nitrates operations in Chile. Rules are enforced, as they should be, to make sure mining activities have minimal to no impact on the environment and local communities. We have a great partnership with CORFO to operate the Salar de Atacama in the most sustainable and efficient manner, and we are working very hard to make this partnership stronger and more beneficial to CORFO, the local communities, the country and our shareholders.

What are some of the critical drivers of the lithium market globally?
In the recent past, the main drivers for the demand growth were traditional applications, such as aluminium alloys, ceramics, lubricants and many others, along with batteries for portable electronic devices and some for electric vehicles (EVs). These days, demand for EVs has grown tremendously as most automakers are switching to this new technology, resulting in more alternatives for end-users, with better performance and at a lower cost, all while taking care of the environment. We see demand growing at a high pace over the following years, resulting in a threefold increase in lithium demand before doubling again in the next five years.

Where does SQM see the highest growth potential?
The obvious answer to this question is lithium, as the market is growing at a very high pace, based on solid fundamentals, and this high growth is expected to continue for many years in the future. But the potassium nitrate business is expected to continue growing at a healthy 5% per year, and SQM is very well positioned to capture part of this growth. The iodine business, on the other hand, continues to be a very attractive business as we are the lowest-cost producer in an attractive market. Finally, the solar salts industry has a huge potential as the world transitions towards greener ways to produce and store energy. ■

Marcelo Awad

Executive Director
WEALTH MINERALS

Can you give us an update of your assets in Chile, namely your asset in Atacama Salar?
Wealth Minerals' focus has been towards the acquisition and development of its world-class lithium assets in Chile. We are witnessing slow progress with our Atacama Salar project in northern Chile as we are waiting for the government to launch a regulatory framework for lithium. The current framework classifies lithium as a strategic metal, not allowing concessions, so only the state or state-owned companies can develop the mineral at the moment.
In 2019, they announced they would launch a change in the regulation soon, allowing private actors in lithium development. We are optimistic that under Minister Jobet's leadership, given his background in energy, we will see more progress regarding this crucial policy change.

What is the potential for the Atacama and Ollague assets?
The Salar de Atacama is home to more than 15% of the world's known lithium reserves. We are certain that the geology of the project is exceptional. Meanwhile, with regards to the Ollague asset, we have reached an agreement with the surrounding communities and are awaiting signatures to move forward. We have witnessed delays across every step of the project.

Can you elaborate on your relationship with Uranium One?
The traditional solar evaporation method used in Chile is outdated and inefficient due to the dry nature of the region, therefore we sought a technology partner in 2019. Uranium One emerged as the most reliable choice since their sorption technology extracts lithium by relying on the reinjection of water, so the total water consumption is just 10% of the amount used by the Evaporation Ponds.

What is the company's strategy moving forward?
Wealth Minerals does not have the financial capabilities to construct the plant and develop the asset fully, so we are seeking a partner to raise the required capital. We also recently acquired a majority stake in two copper concessions in Chile, allowing us to diversify our portfolio. ■

Steve Cochrane

President and CEO
LITHIUM CHILE

Can you elaborate on Lithium Chile's properties and flagship projects?
Lithium Chile currently has 13 properties in 11 Salars and one Laguna complex, which totals 71,900 acres. Salar de Coipasa is one of our flagship properties and is directly accessible from the highway. It is the second-largest Salar in the world, and the property straddles the Bolivian border. Lithium Chile controls approximately 70% on the Chilean side of this prospect, with the Bolivians holding the rest; both properties are under exploration. The Bolivian exploration program yielded encouraging results, which attracted China's Xinjiang TBEA Group who committed to invest up to US$1.3 billion for 49% of the Bolivian side of the Salar de Coipasa. If you apply the same metrics, the Chilean side of the Salar de Coipasa could be valued up to US$500 million. Preliminary exploration shows near-surface samples assaying up to 1410 mg/l lithium. We already have community approval, and drilling is anticipated for Q2 2021.
Another property of focus is Salar de Helados, of which Laguna Blanca is an extension. Near-surface brine samples are assaying up to 1280 mg/l lithium – comparable to what SQM and Albemarle see at their production plants.
Interestingly, Laguna Blanca's cesium value is now more valuable than gold on a gram basis. The reason for the increase in cesium value is that it plays a very intricate role in 5G mobile networks. Initial sample assays at Laguna Blanca define an approximate 4 km square area enriched in cesium ranging from 75 - 690 grams per ton from surface sediment sampling. We will further explore the area of cesium enriched salt deposits identified by the late 2018 reconnaissance geochemical sampling program to establish the grade distribution and tonnage potential. Laguna Blanca also has lithium values ranging from 1035 - 1230 mg/l lithium, and potassium values ranging between 13500 - 15200 mg/l potassium. Laguna Blanca can be set up as a cesium mine, with lithium as a byproduct. ■

ENGINEERING AND CONSTRUCTION

"I do not think we are experiencing the same mining boom we had 8-10 years ago. This said, we see more dynamism in lithium, rare earths and iron ore. It will take 5-7 years to ramp up these new projects, but there is an opportunity there because all these projects require a lot of infrastructure, from transmission lines to ports."

- Sandro Tavonatti,
CEO,
Sigdo Koppers Ingeniería y Construcción (SKIC)

Image courtesy of Echeverría Izquierdo Montajes Industriales

Engineering and Consultants

THE JOURNEY TO GREEN MINING: WATER AND ENERGY

Chile is currently experiencing its worst drought in six decades. The shortage of fresh water in its arid areas, such as the north, where the majority of copper production takes places, has grave economic, social and environmental consequences. Water is a critical component in mining operations, used in hydrometallurgical processes, concentrators, smelter and refinery, as well as other processes.

According to a Mckinsey report, the industry consumes enough water annually to provide for 75% of the Chilean population, and net freshwater consumption by copper mining is between 0.5 and 0.7 cubic meters of freshwater per ton of ore processed, with water held in tailings dams and its eventual evaporation and leakage one of the main reasons for this consumption, reported the Alta Ley Corporation.

As a result of the ongoing water scarcity crisis and the industry's high consumption, the Chilean Congress is discussing amendments to the Water Code to limit freshwater withdrawals. The mining industry is under pressure to decrease its freshwater usage and must seek other solutions such as desalination, reuse and seawater flotation.

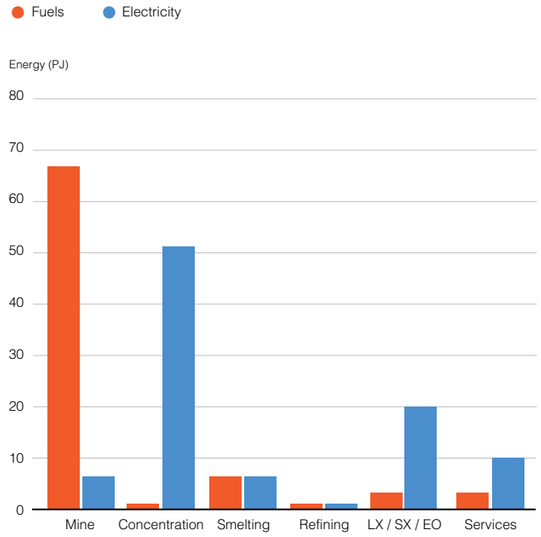
"A primary concern is water scarcity. The country is at a turning point in matters of the environment, especially given the drafting of the national constitution. Projects have to be mindful of these risks and adapt their operations accordingly," commented Iván Rayo, general manager of JRI Ingeniería, a Santiago-based engineering company working on Codelco's Rajo Inca. "The government is drafting policies regarding water to consider giving water rights a temporary character, restricting some uses, which will affect mining operators if implemented."

Miners using continental water sources will be constantly threatened, as the recent case of Anglo's Los Bronces has shown. According to the production report, Los Bronces' copper output decreased by 28% in Q4 of 2019, due to a 44% decline in the plant's processing capacity as a result of lack of water. It eventually came to an agreement with Codelco to use water from the tailings dams of the adjacent Andina mine.

Chilean miners are already concerned with declining ore quality. Now they must consider how to process a larger amount of ore while minimizing their water and energy usage, as the copper production matrix in Chile will change in the upcoming years and rely on the treatment of sulphide minerals which is an even more water-intensive process, according to Cochilco. However, another challenge is transporting water from the coast to high altitudes where most mines are found.

Energy Use in Processes

Source: Alta Ley Corporation, Cochilco



Esteban Hormazabal

General Manager
SRK CONSULTING CHILE

How has SRK evolved since we last spoke in 2017?
SRK in Chile has grown and diversified since its establishment in Chile in 1994 from providing support on just geotechnical and environmental services for local mines, to include most mining disciplines today as SRK covers a project from exploration to mine closure. During the last years, we provided integrated services to the mining industry around the world. Our competitive advantage lies in our ability to work in challenging conditions, whether extreme weather or remote locations. We leverage the skill and expertise of our engineers and consultants globally to ensure the best possible service for our clients.

Which demand trend is SRK witnessing at the moment in Chile?
Most of the projects we are currently studying are focused on mine closure, integrating rock and soil mechanics, hydrogeology, tailings, mining and environmental disciplines. We expect this trend to continue. As the Chilean industry continues towards sustainable mining, we expect to see our mine closure and environmental services grow further.
Evaluating the real economic potential of massive low-grade deposits is challenging, especially early in an underground mine's development. Our global experience gives expert, integrated solutions on every phase of a mining project. We had been involved from scoping studies and conceptual engineering stages to detailed engineering of world-class underground projects and operations. Main examples of this are Chuquicamata underground mine, Los Bronces UG project, Resolution Project (USA) and Oyu Tolgoi (MN).
SRK is a pioneer in applying the geotechnical risk approach to underground mines, formerly applied to open-pit mines. A detailed review can be found in the article submitted to the past MassMin conference, defining the geotechnical risk approach for deeps caving mines. The risk model provides management with the range of consequences of potential failures of mine pillars and other areas and how to quantify it; this is an example of an innovative solution SRK brings to underground mines.

> As the Chilean industry continues towards sustainable mining, we expect to see our mine closure and environmental services grow further.

How is the industry paying attention to climate change and ensuring environmentally sustainable projects?
Climate change is a concern the industry is taking into account. It is becoming a legal requirement to consider extreme hydrological scenarios in studies for new projects. SRK, therefore, supports mining companies by incorporating time-series data analysis and return period up to 10.000 years in the design and solutions for permitting, engineering design, environmental and mine closure plans.
Each project has its unique challenges and environmental considerations. Nonetheless, an issue we see multiple companies facing is that of water supply and scarcity, which also must be addressed under the environmental permit and the social aspect of a project that is increasingly a concern. Companies must strike a balance between the project activity and the surrounding community by ensuring their satisfaction.

Where would you like to see SRK in the next 12 months?
We are experts in technical mining services, bringing value to any project we help develop. Therefore, we will continue consolidating our presence nationally. Over the next year, our goal is to expand our presence in the region, namely in Colombia, Ecuador and Mexico. We also have some projects internationally in Uzbekistan, Kirgizstan, Kazakhstan, Russia, US and Mongolia, which we wish to develop further. SRK has had a great relationship with the majors and mid-tier mining companies in Chile and will continue to provide world-class services. ■

Dave Lawson

President Mining and Minerals
WOOD

How does Wood's growth strategy in Chile differ from Peru?
Our clientele in Chile is relatively mature with operations for decades, such as Codelco, Antofagasta Plc, BHP and Anglo American. Peru is still a developing market compared to Chile that we decided to best approach through mergers and acquisitions. Chile's environment differs significantly from Peru, as mine sites are built in more remote locations with high altitudes.
We are working on the detail design for Codelco's Chuquicamata at the moment under our underground mining division based in Santiago. We are seeing more potential for underground mining growth in Chile at the moment compared to Peru. Wood also works in Australia, North America and Africa. Our focus in Australia is predominantly lithium, as we are working with Albemarle. On the other hand, in Africa we are working on copper, gold and platinum.

What trends are you witnessing for your services in the market this year?
We see an increase in mine development in Chile, as many clients are demanding feasibility studies and pre-feasibility studies. As Wood, we are developing the 'Mine 2050' concept for our clients. The mine of the future would rely on sophisticated technology using artificial intelligence, robotics and automation in mining processes to facilitate a fully automated plant and operation. Covid-19 has pushed the industry further towards the digitalization of processes overall. Mines are now looking to operate from control rooms in remote locations. However, some of our clients prefer task forces on the ground more than remote operations, mainly due to the risks surrounding complete remote operations, such as cybersecurity attacks.

Can you elaborate on Wood's innovation in sustainable solutions for water and tailings management?
In Santiago, our Resilient Environments business is developing creative solutions for water and tailings management in the industry. Most mines in Chile use seawater to become more sustainable, and we are also seeing wind and solar power solutions playing major roles in the provision of electricity to the mining industry. Wood provides mining solutions that utilize applied intelligence to enhance operational and environmental sustainability.
Regarding tailings management, a solution often considered is the use of dry stack tailings as it significantly reduces the environmental footprint. However, the mine's location and size may restrict it from using this method. Also, converting an existing mine's tailings management solution to dry tailings would have financial implications that would require investigation to ensure feasibility. Some of the equipment needed for dry stack tailings has to increase in size to respond to current market trends. We are working with some equipment manufacturers to address this issue.

> We see an increase in mine development in Chile, as many clients are demanding feasibility studies and pre-feasibility studies.

What potential do you see for the incorporation of green hydrogen energy solutions in the industry?
Green hydrogen is an area we expect to see immense growth in over the upcoming years. Wood's track record in the technology, production and the use of hydrogen is decades-long, with a number of successful hydrogen projects delivered for clients around the world.

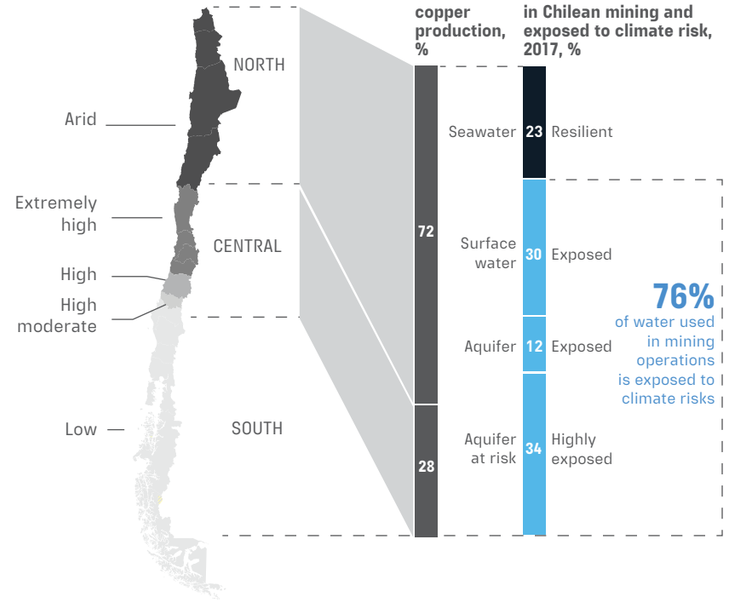
Where is Wood's focus in the upcoming years to facilitate growth?
We successfully completed the Spence project for BHP, where our teams were hired as the integration contractors for the last four years. In the near future, we hope to leverage our expertise and offer the same service to our clients, which we think will be well received. ■

Are desalination plants the answer?

Chile opened its first desalination plant in 2003, in Antofagasta for human use. The leading mining operator in desalination in Chile is by far BHP with its Escondida Water Supply (EWS) project, the largest desalination plant in the Americas. By 2028, there will be a total of 27 desalination plants in Chile and, by 2031, 47% of the water used in mining will be extracted from the sea, according to Cochilco. The Antofagasta region will have the highest number of desalination plants, supplying 66% of the copper industry's water consumption, followed by regions of the Atacama, Tarapacá and Coquimbo. The 15 desalination plant projects include INCO's complementary infrastructure project by Antofagasta Plc, being also executed by Bechtel. This expansion project obtained Chile's first certified green loan for its construction, due to its focus on water efficiency.
Another upcoming desalination project, expected to be the second-largest in the country, is Codelco's US$1 billion desalination project to supply Radmiro Tomic, Chuquicamata and Ministro Hales mines, in addition to its facilities in Calama. The tender for the project was reactivated by the end of 2020 when Codelco decided to reformulate the project.
Other plants under development include Collahuasi's desalination plant, which will have an initial capacity of 525 l/s, and Teck Resources' QB2, with a capacity to treat 1,300 l/s, being executed by a leading water treatment EPCM solutions provider IDE Technologies.
Desalination plants in northern Chile are built along the coast and water is transported using a complex pipeline system that requires non-corrosive piping. Jorge Donoso, the general manager of Techint Engineering and Construction who is working on the Collahuasi plant, explained that the company is witnessing an aroused interest in their pipeline services as a result of the industry's move towards desalination solutions. "We also see a trend towards sharing infrastructure among mining companies. For example, in the northern district of Codelco, there are three mines operating in the same area, and all three customers have agreed to invest in the same infrastructure to distribute water to all the mines. We believe that this is an excellent long-term and sustainable solution in terms of environmental impact and cost," he elaborated.
A by-product of desalination is brine, which is released back into the sea. According to José María Guzmán, country manager of CDM Smith in Chile, desalination is part of the solution, another part is water recycling: "The environmental impact of desalination has been a focus for our firm in Chile, and our experience indicates that the impacts of desalination can be controlled and mitigated. For example, the correct discharge of salt using diffusers increases dilution rates and reduces the threat to marine biodiversity."
When it comes to minimizing water use in drilling, Tomás Buttazzoni, general manager of Technosteel highlighted: "Every drilling rig uses a significant amount of water a day. The use of a mud plant addresses this issue as it ensures additives are not polluting the soil and allows for water recovery, decreasing water use by 30%." 61 >>

Water Stress in Chile, 2020

Source: Aqueduct Water Risk Atlas; Cochilco; Water Atlas; MineSpans by McKinsey

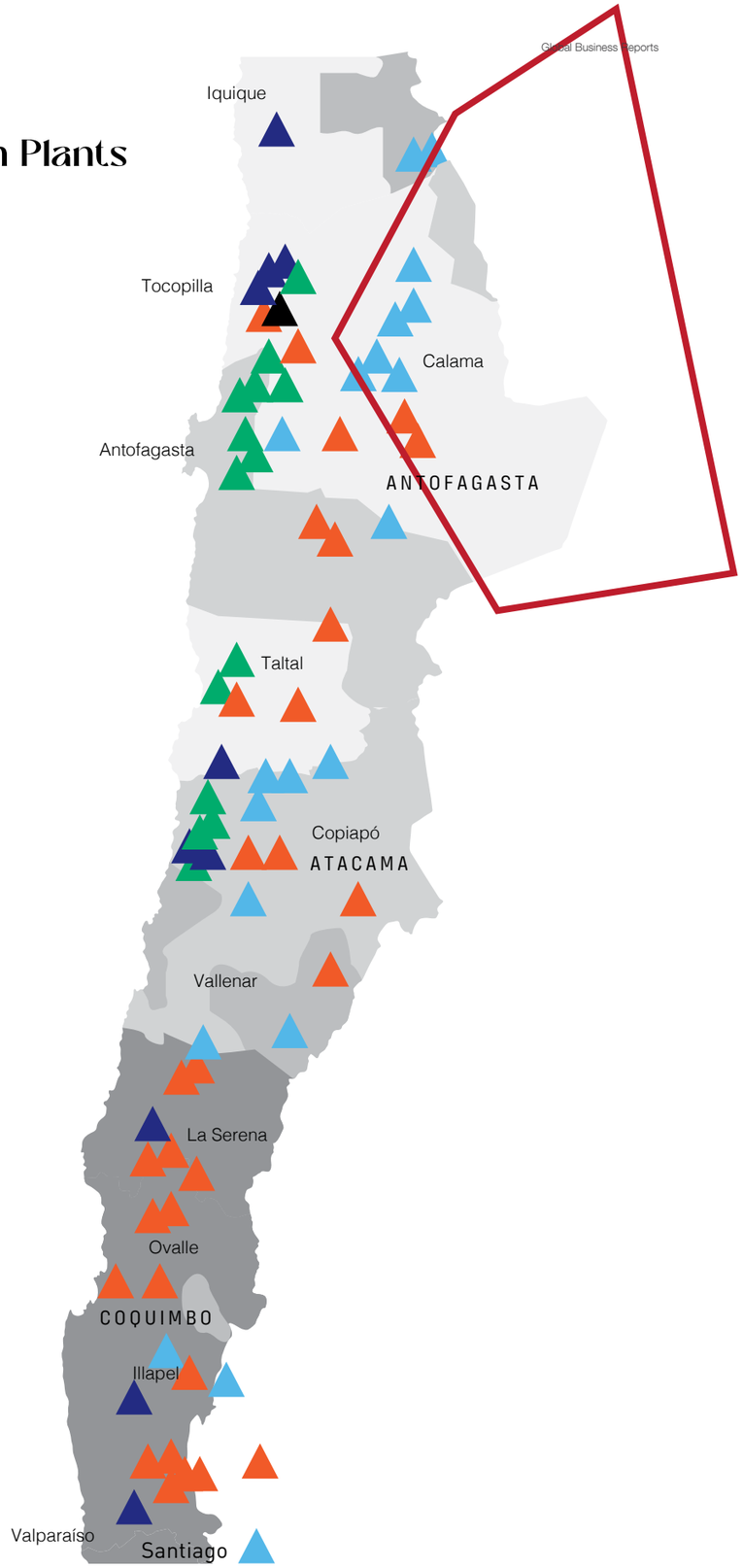


> *Water scarcity is an ever-growing challenge in Chile's mining regions. Every drilling rig uses significant amount of water a day. The use of a mud plant addresses this issue as it ensures additives are not polluting the soil and allows for water recovery, decreasing water use by 30%.*

- Tomás Buttazzoni, General Manager, Technosteel

Projected Desalination Plants AND MINING PROJECTS OPERATIONAL IN 2029

Alta Ley Corpotation (2019), Open Mining, Sernageomin, ODEPA



Iván Rayo

General Manager
JRI INGENIERÍA

In commemoration of the company's 39th anniversary, what have been the most significant milestones for JRI?
JRI is a company that has never stopped growing and expanding its portfolio of service offerings. This year we are expanding our research center, which was created in 2008, by adding a new building and strengthening our focus on highly technical studies. JRI is home to more than 400 engineering professionals and we are investing during a period of economic downturn, which is testament to the company's growth-led mind-set and determination.
Since 2017, the Chilean market for engineering services has been highly competitive because mining activity in the country saw a slight decrease. With the pandemic, the market has tightened even further. We expect the renewal of mining operations in 2021 to increase demand for mining services.

What is JRI's current portfolio of projects?
Since 2019, JRI has been a partner of Rajo Inca, one of Codelco's landmark copper projects. JRI designed the conceptual and basic engineering of the mine and is currently involved in operational engineering as well. Due to its age, the mine has a very challenging geotechnical profile. Our work has allowed the mine to increase its capacity and ensure mining conditions are up to modern standards. JRI is in charge of all the project's engineering needs, which has an investment value of $US1.38 billion.

How do you incorporate technological advancements and software in your operations?
In 2019, the company incorporated Building Information Modelling (BIM) in its operations. This system represents the digitalization of mining, where dimensions are calculated and mapped on a monitor. This technology was ground breaking for mining, an industry that until recently had not been able to apply such processes due to the complexity of its engineering. JRI decided to utilize BIM in all its projects to better integrate the engineering, construction and operation stages. This way, we offer clients a long-term tool for their operations.
JRI is specialized in underground mining design. This focus has been of tremendous importance at a national level; we are in charge of the most important Chilean underground mining operations. JRI's underground mining engineering incorporates automation from the onset; we are permanently liaising with equipment providers to integrate technology directly. Increasing the number of tasks that can be controlled from the operation control room reduces risk and increases efficiency.

How important is sustainable management of mining processes?
Chile is facing important environmental challenges due to climate change. A primary concern is water scarcity amid the ongoing drought. The country is at a turning point in matters of environment, especially given the drafting of the national constitution. Projects have to be mindful of these risks and adapt their operations accordingly. The government is drafting policies regarding water to consider giving water rights a temporary character, restricting some uses, which will affect mining operators if implemented.

How would you characterize the health of the Chilean mining industry?
The Chilean mining industry is facing challenges, many of which are due to the depth of mines. The depth of underground mines creates a risk of geotechnical failure. Climate change has increased precipitation in Chile's mountainous regions which complicates the water management processes at mining sites; water drainage is also an issue for deep mines. Other challenges include electro mobility and ventilation. Finally, the mine's transport systems are a central concern among many operators, especially when vertical extraction processes are necessary. Mines in Chile are getting deeper which is exacerbating the need for sophisticated engineering solutions.

Where do you see the highest growth potential for JRI?
Our plan is to develop detailed engineering solutions for structural projects like Rajo Inca. Participating throughout the different stages of the mine life is also a priority. We want to reinforce our focus on concentrate plants, underground engineering, tailings and pipelines. In terms of expansion abroad, JRI is waiting for the right time. Although we have the capacity to serve Peruvian engineering needs, the mining sector has fluctuated downward due to the pandemic. When investment in Peruvian mining activity resumes, we will be the first to extend our engineering services to the country. ■

Luis Soruco

General Manager
ARCADIS CHILE

What have been Arcadis' greatest milestones in Chile?
One of our key milestones is our integration with Geotechnica Consultants, as we combined the expertise of a global company with the legacy of a local company. Through further acquisitions we developed our process-focused capabilities, such as the concentration and hydrometallurgical beneficiation of minerals. Since Chile is a large producer of copper using both of these technologies, it was a great combination to add to our portfolio and we were able to deliver services to projects in different stages, from profile engineering to EPCM projects.
Arcadis is differentiated in the water management field, but still decided to incorporate another company, GeoHidrología, to complement our full range of capabilities to deliver various water management services for both continental and seawater.

Arcadis is involved in more than 70% of all significant tailings projects in Chile. Can you elaborate on tailings' designs, and which is the most popular in Chile?
Regulation in Chile is strict, especially regarding water. Therefore, many of our designs are focused on leveraging the water in the tailings reservoirs to bring it back into the operation. We are continuously evaluating our processes to enhance efficiency and sustainability with new technologies.

What demand trends is the company currently witnessing for its services?
After the commodity prices recovered, we saw that projects that were delayed due to dormant prices had resumed. We also saw an increase in demand for our services for projects moving to final execution. We are witnessing a trend of moving towards increasing sustainability and digital innovation, at the early stages of the value chain, due to the need for efficiency and social responsibility. The Chilean government will soon pass a new Supreme Decree 248 to encourage the mining industry to move towards more sustainable and digital operations.

How would you say the permitting process has improved in Chile?
Over the years, institutional legislation in Chile has become stricter and the permitting process has been refined so that it is now an excellent process. Each city in the country has certain particulars that need to be adhered to. Thus, mining companies need an experienced team such as Arcadis, as we know what the authorities require and can mitigate risks. However, there are areas in the process that can be improved.
One of the challenges is that engineering and construction usually come after the EIA study but should be done in parallel as the commitments taken at this stage impact profoundly on design and execution. ■

José María Guzmán & Rolando Maluendo

JMG: Chile Country Manager
RM: Mining Project Director
CDM SMITH

JMG

RM

Can you give us an overview of CDM Smith's role in the mining sector?
JMG: We have been involved at BHP's Spence mine in northern Chile as the client decided to outsource its water engineering processes, and CDM Smith has had several roles through the project life and is now assuming an active role during operations. We offer engineering services that encompass water management, remediation, program management and geotechnical services. The company can be involved throughout the entire mine life providing consulting engineering services that ensure operations run smoothly and that the operation's legal requirements and commitments are upheld. Collahuasi, Minera Escondida, Nueva Union and Cerro Colorado are other mines where CDM Smith has been involved.
RM: For CDM, it is important to participate in a mine's entire life cycle. Our experience in project management, for example, allowed us to participate in the expansion of the desalination plant at BHP's Minera Escondida – a mega project which concluded in February 2020.

How does CDM Smith help companies mitigate drought-related risks?
JMG: CDM Smith monitors water availability in Chile and planning analysis for mining projects to identify water management schemes that are more resource independent. In Chile, due to the long distances between mines and water bodies, long-term planning that is conscious of environmental impact is crucial.
RM: The drought risks that have been forecasted challenge engineers to optimize processes even further and leverage water-reuse technologies. Utilizing water from waste processes and tailings will allow a long-term sustainable development of mining projects in Chile.

Is desalination the primary solution to Chile's water scarcity problems?
JMG: Seawater desalination is not the solution but rather part of the solution. CDM Smith addresses water scarcity by optimizing the mix of water sources near a site and desalination plays a role. We are convinced that some other technologies and solutions can expand and improve water sources, so water reuse is of great interest.

Which areas present high business growth potential for CDM Smith in upcoming years?
JMG: There is a large potential for business related to mine closures. Environmental requirements emphasize correct procedures during the late phases of a mine cycle, and CDM Smith can play a role, given its expertise.
RM: CDM Smith wants to participate in the execution phase of mining operations. The company's project management expertise makes us an interesting option to clients, especially concerning reporting and data tracking. ■

Claudio Losch

President South America
AUSENCO

How has Ausenco grown in Chile in the last few years?
Ausenco is a global company founded in Brisbane, Australia 30 years ago. In 2008, we entered the South and North American markets through a series of acquisitions, including Pipeline Systems Incorporated (PSI) and Vector Engineering, that allowed us to better position ourselves in the Chilean market. Today, the South American market represents 45% of the company's revenue, with Chile and Peru being the largest contributors.
In Chile, we provide consulting, design, and construction services from mine to port, including process plants, tailings, environment, permitting, asset management & optimization, pipelines and transportation & logistics. A safety achievement we are incredibly proud of is surpassing 6 million person-hours Lost Time Injury (LTI) free across our projects in Chile.
We were recently awarded the EPC turnkey contract for Mantos Copper's Mantoverde Development project – a defining moment for us. We will deliver a 30,000 mt/d copper concentrator plant and related infrastructure as well as significant carbon emission-reducing benefits. We are also working with BHP on the commissioning of the Spence Growth Option project, and we have been awarded a similar contract to provide commissioning services at Teck's Quebrada Blanca project, where we are currently providing field engineering services.

What set Ausenco's proposal apart from the competition for the Mantoverde project?
We were chosen because of our excellent track record in delivering similar projects and our capital-efficient and optimized design. We reduced the plant's overall footprint by relocating the primary crusher, redesigning the stockpile reclaim tunnel and optimizing grinding and flotation. This reduced earthworks excavation and concrete requirements.

Can you elaborate on the challenges of developing mining projects unique to Chile?
Water scarcity is an ongoing challenge in Chile. The desalination and the transport of seawater require large amounts of energy and increases operational costs for projects. Comminution is also an energy-intensive process. The industry is moving towards greater incorporation of renewable energy sources to address rising energy costs and sustainability issues.
Another challenge is bureaucracy. This affects how quickly projects are approved and permitted. The industry and government are aware of this issue, and efforts are being made to streamline the process.

How would you characterize the current trends in the Chilean mining industry?
Large-scale operators are expanding, but there are also several promising mid-sized projects for which we are developing studies. We believe there is a strong potential for these projects to be developed in the future. Canadian and Australian junior companies are also increasingly active in Chile, especially in the gold space. ■

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Image courtesy of Antofagasta Plc

Water reuse

Even though desalination plants present a long-term solution, it is also a very costly one. The addition of seawater desalination plants to large-scale projects adds at least US$1 billion to the project's capex, or up to US$3 billion if it is as enormous as Escondida, in addition to high electricity costs to pump the water to high altitudes. Therefore, another way of limiting water usage is through recycling.

"Freeport-McMoRan prioritizes maximizing our recycled/reused water across all our operations. El Abra is no exception, especially given it is in an arid region near the Atacama Desert. Our water use efficiency (water reused/recycled) at El Abra averages around 94% annually," highlighted Joshua Olmsted, Freeport's president and chief operating officer-Americas.

McKinsey reports that in 2018, water recycling in mineral concentration in Chile averaged 85% for high performing mines and 75% for most mines. If recycling rates do not reach 85% at least, then at least four Escondida-sized plants will be required by 2028. Antofagasta Plc is already making investments to use about 90% sea or recycled water from 2025 onwards, and Teck's QB2 includes significant mechanisms for water reuse.

Tailings management

Only a small fraction of the large volumes extracted is the target mineral, which is obtained after processing, leaving behind tailings that consist of other chemical elements such as reagents and ground rock with water. The tailings represent between 97% and 99% of the ore processed and are transported for storage in tailings dams. As mines extract higher volumes to find a high-quality ore, production of tailings is expected to double by 2035 in Chile.

According to the ministry of mining, Chile has 742 tailing dams in 10 regions, of which only 106 are active. Since Chile generates on average 537 million mt of tailings every year, different initiatives are being led by mining companies to find value in tailings, such as Codelco, for example, through its subsidiary Codelco Tech looking to identify traces of chemical elements such as germanium, gallium, tungsten, rare earth and others.

Tailings are also crucial in the reduction of water consumption and reuse, since huge amounts of water are trapped in tailings, so mining companies are investing in large-scale filters to recover the water and remove the impurities. The impurities pose environmental problems to surrounding inhabitants, especially since there is always a risk of tailings dams collapsing due to the broken retaining walls that result in flooding of adjacent land, which has occurred in the past in Brazil, Mexico, Peru and Australia.

As a result, mining companies are investing in sustainable and durable tailings management solutions. For example, Los Andes Copper is using dry tailings in its Vizcachitas project. "The project's footprint will also be reduced as our tailings will be disposed of as a solid and will eliminate the need for a tailings dam," confirmed director of the company, Eduardo Covarrubias.

Even though a dry tailings option seems like the ideal solution, according to Dave Lawson, president of the mining and minerals at Wood, a dry stack tailings option is restricted by the mine's location and size. "Converting an existing mine's tailings management solution to dry tailings would have financial implications that would require investigation to ensure feasibility. Some of the equipment needed for dry stack tailings has to increase in size to respond to current market trends," he added.

Meanwhile, Mathiesen, an international group dedicated to the manufacture, marketing and distribution of specialty chemical products, sees great potential in supplying chemicals that optimize water recovery. “Given the unique chemical properties of mine tailings and the importance of its processing, the company plans to boost investment in water treatment,” commented Humberto Pasten, mining division manager of Mathiesen. “We are searching for new chemical products that are more environmentally friendly and improve the recovery of copper and other secondary elements.”

As Chile advances towards sustainable and green copper mining, it will elevate the tailings transformation sector as tailings management becomes a core focus. “Regulation in Chile is strict, especially regarding water, which is a primary concern when designing tailings dams,” highlighted Luis Soruco, general manager of Arcadis in Chile, one of the leading global design, engineering and management consulting firms. “Therefore, many of our designs are focused on leveraging the water in the tailings reservoirs to bring it back into the operation to minimize the impact on the environment.”

The government is also leading initiatives such as the National Tailings Policy announced in 2018, which considers permanent monitoring of active tailings dams and a comprehensive approach to inactive and abandoned dams.

Energy

Over the next decade, the increased activity of concentration plants, the progressive decrease in mineral grades and an increase in mineral hardness will result in a significant rise in energy consumption for Chile’s mines, which currently represents around 8% of the operating costs. "The desalination and the transport of seawater require large amounts of energy and increase operational costs for projects," highlighted Claudio Lesch, president of Ausenco in South America, an Australia-based multinational EPC firm working with Mantos Copper, BHP and Teck Resources. "Comminution is also an energy-intensive process. The industry is moving towards greater incorporation of renewable energy sources to address rising energy costs and sustainability issues."

Therefore, electricity demand for copper mining is forecasted to grow by 34% over the next decade, from 25 terawatt-hours (TWh) in 2020 to 33.4TWh in 2031, according to Cochilco. To meet this demand, a generation capacity of 1,222 MW is needed. As a result, mining companies are shifting to cheaper and more sustainable alternatives.

BHP is paying US$840 million to terminate its 2008 coal-fired energy contract with AES Corporation in Escondida and Spence. It will replace it with solar and wind power, which will reduce its energy costs by 20%. Meanwhile, Collahuasi signed clean power supply contracts with Enel and independent solar power producer Sonnedix. It entered into a long-term power purchasing agreement with Sonnedix for the delivery of 150 GWh per year, which represents about 12% of the mine's power requirements.

Gold Fields is relying on a hybrid solution for its Salares Norte project, positioned 4500 m above sea level. The project will include a 16 MW diesel generator and a 9.9 MW solar generator, executed by Aggreko, a leading supplier of temporary power generation equipment. The extreme environmental conditions of the project were a deciding factor in the type of hybrid model to rely on, according to Pablo Varela, managing director of Aggreko in LATAM. "Aggreko saw diesel generation as the most reliable solution. We designed specific units for high altitudes to get the ultimate output and incorporated a hybrid solar system to reduce generation costs and emissions," explained Varela.

The Chilean government is also actively engaged in promoting the move towards renewables. The Ministry of Energy, led by the Bi-Minister of Energy and Mining, Juan Carlos Jobet, will prepare a National Energy Efficiency Plan. "The industry is already switching from coal power generation to contracts with renewable energy providers, and we expect that more than 60% of the energy used in mining will come from renewables by 2023," highlighted Minister Jobet.

An appetite for hydrogen

Under its renewable energy initiative, the Chilean government is also keen on elevating the so-called 'fuel of the future'; green hydrogen. The Australian government also announced a National Hydrogen Strategy and mining giants BHP, Anglo American Fortescue formed the Green Hydrogen Consortium to accelerate green hydrogen production and its application.

Green hydrogen is the process of sourcing hydrogen from renewable power sources such as solar or wind power. "The green hydrogen is then compressed and stored at high pressure to generate electricity and power equipment, including trucks and cars," explained Tomás Cruz, piping business line manager at Fast Pack, piping, spools and wear parts provider who is incorporating the use of hydrogen in its production process. "Five to ten years from now, we expect to see a surge in the use of green hydrogen in mining sites."

The fuel can be used to store renewable energy to later generate electricity. Jorge Masias, managing director of Volvo in Chile, argued for hydrogen powered trucks, explaining: "The issue with the use of electric vehicles in mining is that they would require higher autonomy because they need to travel longer distances, so hydrogen vehicles are better suited."

”There has been significant technological advancement towards sustainability over the last years and increasing interest among companies in using hydrogen as a source of fuel or batteries that accumulate energy to operate,” confirmed Alejandro Miranda, general manager of Doosan Bobcat, the leading Korean construction equipment provider. ”Doosan has been working on eliminating diesel engines from vehicles to incorporate solutions related to electricity. However, the pandemic has considerably limited the advancement in this area.”

Overall, hydrogen fuel can play a role in decarbonizing the mining industry. According to the German-Chilean Chamber of Commerce, the fuel has a 70% chance of replacing fossil fuels within the industry. However, even though hydrogen power generation is receiving more attention, Varela highlighted: "This will only become fruitful in 5 to 10 years, as managing the fuel is still quite complex and very expensive." ■

> *Hydrogen power generation is receiving more attention, but I believe that this will only become fruitful in five to ten years, as managing the fuel is still quite complex and very expensive.*
>
> ***- Pablo Varela, Managing Director LATAM, Aggreko***

Pablo Varela

Managing Director LATAM
AGGREKO

Can you give an overview of Aggreko's operations in Chile?
We expanded into Chile in 2006, focusing mainly on mining. We began to develop all the transactional business units to support the mines in exploration, project planning, site construction, commissioning, production, maintenance, mine closure, as well as providing technical advice and expertise for mine expansion. Our first project was with Codelco during the construction of the Gaby copper mine. We then successfully designed, installed, and commissioned a 60 MW power plant for Escondida to provide a back-up power supply at the Coloso port.

Are hybrid solutions Aggreko's specialty?
Every isolated mine will have a hybrid solution in the near future. Larger mines in more accessible areas will have less of a need for hybrid systems and will probably still rely on transmission lines, but they are increasingly becoming more interested in generating their own power as it is more cost-effective.
Aggreko has invested significantly in integration, allowing us to differentiate ourselves in the market. We have acquired Younicos, a battery and software company, to integrate technologies.

How would you describe the current power trends of the mining industry in Chile?
The decentralization of the generation of power is a huge trend due to the reduction in costs. There is also significant investment in decarbonization. Digitalization is also a global trend and we are now able to operate different technologies on different grids, which was not possible in the past.
In Chile, even though there is a big need to reduce emissions, the amount of electric consumption is increasing. Generating power through renewable sources, mainly solar, has become a focus of the mining industry, which will create disturbances in the grid. Aggreko is working to have different points of generation to compensate for these disturbances, and batteries are also a great solution for this. Hydrogen power generation is also receiving more attention, but I believe that this will only become fruitful in five to ten years, as managing the fuel is still quite complex and very expensive. ■

Jorge Donoso

General Manager
TECHINT ENGINEERING & CONSTRUCTION

How has the company grown over the last year?
Our main projects over the last few years have involved feasibility studies for mining projects requiring alternative water sources and mineral ore transportation systems. We also provide the design and construction of these water transportation systems, frequently stretching all the way from the sea up into the mountains. We have also participated in the construction and maintenance of mineral processing assets for main mining companies. As an EPC company, we deliver complete solutions, encompassing all the stages in the project from the feasibility study to the delivery of water to the mine.

What projects are planned for this year?
This year, Techint has been working in Quebrada Blanca Phase 2 project to transport desalinated water and concentrate and is beginning work on a new contract with Anglo American at Los Bronces to maintain transportation systems for water, pulp, and concentrate.

How are you incorporating digitalization and automation solutions into your operations?
For example, we are currently using drone technology for land, subsoil and progress surveys allowing us to check our pipeline routes and give us a better understanding of the geological conditions affecting construction in a faster, more accurate and effective way. We have incorporated automation in welding activities and robot application for several critical aspects of quality needed in pipelines construction. ■

Chilean leadership: The red metal for a greener world

Expert Opinion Article by
JORGE CANTALLOPTS
DIRECTOR OF STUDIES AND PUBLIC POLICIES, COCHILCO

There is significant evidence that the transformation to a greener economy will involve many changes in infrastructure, especially those related to power generation and transmission, but also transportation, including electric vehicles and supporting infrastructure. A greener and more connected world will require more electronic sensors and devices in smart cities and smart houses. The new society model will also increase the need for climate control devices in households, offices, public transportation, and public buildings.
These new developments involve many raw materials, where copper, the old and well-known red metal, stands out, playing a vital role in a greener world.
According to the World Bank, climate change and the deployment of green technologies (including wind and solar generation and electric vehicles) could increase copper demand between 7.5 and 20 million mt by 2050, depending on the scenario for climate change. Other highly copper-intensive technologies are likely to increase this estimate, such as electric vehicle charging infrastructure, climate change mitigation devices, air conditioners, fans or heaters, intelligent technologies in households and public infrastructures in cities.
Many challenges for the transition to a greener economy come from the supply perspective. Responsible sourcing of raw materials plays a prominent role. Despite efforts toward increasing recycling and implementing a circular economy model, mining will still be a critical aspect of the supply chain in the foreseeable future. If we assume a conservative demand forecast of 15 million copper mt by 2050 (500 thousand mt of new supply each year), the pressure on the copper supply chain will be significant. For example, only two mines in the world produced more than 500 thousand mt of copper. It is not clear where supply will come from.
When we think about the future, there are many images of how we envision a greener world, but there is a lack of understanding of how raw materials will be supplied for this purpose. As a contribution to this matter, Chile is already planning and developing what a greener world will mean for copper mining in terms of water, energy and the relationship with society.
Green copper mining will be efficient in reducing operational water footprints. The Chilean mining industry has already reduced freshwater use by 23% from 2010 to 2019. Cochilco forecasts that only 51% of water consumption will come from underground and surface sources by 2030. In addition, the water recycling rate in copper mining is around 80%, and most new projects will use new water sources, such as seawater and other water-efficient technologies.
Green copper mining will be carbon-free. In Chile, due to the integration of electrical systems in the mining industry, the indirect greenhouse gas emissions were reduced by 20% from 2017 to 2019. Furthermore, the copper mining companies have played a key role in the surprising change in the Chilean energy matrix, which is rapidly shifting to renewables. During the subsequent years, copper mining will be directly or indirectly involved in new renewable capacity in Chile. Renewable sources, mostly photovoltaic, will supply around 58% of the Chilean mining industry requirements by 2023. Additionally, the potential of green hydrogen technology could become an excellent opportunity for sustainable development, not only for Chile but also for the rest of the Latin American region.
Green mining involves much more than water and energy, and this is why there are other initiatives in Chile related to inclusion and increasing the participation of women in mining; increasing acknowledgement and contribution to indigenous people; and local development for surrounding communities and a strong respect for human rights. A new relationship with society requires a new deal with mining. Since 2019, Chile has been developing a long-term participatory strategy as part of the 2050 National Mining Policy. This is an opportunity to put mining in the perspective of a more sustainable future.
The way that we mine falls short of meeting the vision of a green economy, but it is also clear that sustainable mining is the way for the industry to remain as a global critical economic pillar. It is also a challenge for Chile, not only to maintain its production leadership in copper supply, but also to be a leader in responsible sourcing for a greener world. ■

Construction and Contractors

The resilience of the Chilean mining industry throughout the pandemic depended on remote work and enforced social distancing measures. The outbreak came at a time when the mining construction sector in the country was experiencing relatively high growth as mines were investing significantly in development and expansion to increase productivity levels. Engineering and construction companies have to deal with one of the most challenging logistics aspects in the mining industry, therefore, they could not rely on traditional social distancing measures to meet tight deadlines.

Rodrigo Prado, general manager of Tecno Fast, a modular constructions solutions provider, explained that the company set up strict protocols to limit the virus's spread. "Among the techniques we have used were dividing teams into smaller groups, expanding remote work where possible and controlling outbreaks with weekly testing. The pandemic has been a period of high business activity because operators were expanding eateries, housing capacity and office spaces."

Thiess, the world's largest mining service provider, was also able to cushion the impacts of the pandemic by focusing on protecting its workforce. "We have learned the value of being proactive and quickly taking decisions and implementing processes to protect our people and operations. Importantly, we have been able to limit Covid-19 transmission on site by following government protocols and directives, and enacting workforce and recovery plans quickly," confirmed Darrell White, the company's executive general manager for the Americas.

The industry's prospects are generally conceived as favourable. Tomás Fischer Ballerini, general manager of Edyce, one of the leading Chilean engineering, construction and steel fabrication companies, commented: "The economic outlook for the rest of 2021 and 2022 looks promising due to the surprising increase in the value of copper and the government's actions to reboot the economy. It seems very likely that all the investment projects that have been planned will continue."

Chile is home to a competitive EPC and consulting mix, consisting of leading nationals JRI Ingeniería, Echeverría Izquierdo Montajes Industriales, Sigdo Koppers Ingeniería y Construcción (SKIC), in addition to international companies, such as Wood Group, Ausenco, Worley, Stantetc and SRK.

Underground mine design and construction

Chile faces challenges in maintaining and increasing its total factor productivity, which has been decreasing as a result of declining ore grades in the last years. Chilean mines operating for over a century, such as Chuquicamata and El Teniente, have shifted towards large-scale underground operations on the hunt for higher ore grades. Nonetheless, open-pit mining still yields 90% of Chile's copper production.

The shift presents opportunities and challenges to EPC companies and new frontiers for competition. JRI Ingeniería specializes in underground mine design. Iván Rayo, the general manager, explained: "The depth of underground mines creates a risk of geotechnical failure. Other challenges include electromobility and ventilation. Mines in Chile are getting deeper which is exacerbating the need for sophisticated engineering solutions."

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Darío Barros Izquierdo

General Manager
ECHEVERRÍA IZQUIERDO MONTAJES INDUSTRIALES

> **The challenge for the construction sector is to not overreact to any situation and also take a longer-term view, using this time as an opportunity to be creative and innovative, incorporate new technology and be more productive and sustainable.**

How were you able to maintain supply chain continuity amid the pandemic?

Our people's health and safety has always been our top priority and since the pandemic started we have taken the necessary precautions to reduce risks of exposure and keep our staff and sites safe. Covid-19 impacted our business regarding costs and schedule, as we now have to take extra sanitary measures. However, we never stopped production and are still servicing the mining sector and the pulp and paper industry in the north and south of Chile respectively. Echeverria Izquierdo has approximately 8,000 employees in all our countries of operation, and we are fortunate and proud to be still growing during tough times.

Social unrest in the country caused the temporary closure of many offices and forced people to work from home. Therefore, when the pandemic hit, we were better prepared to quickly adapt to a more virtual working environment and minimise disruption on our projects.

Can you highlight some of the projects Echeverria Izquierdo is working on in Chile?

Echeverria Izquierdo is currently working on the primary crusher at Teck's Quebrada Blanca Phase 2 project located in northern Chile, which includes overland conveyors, a stockpile and reclaim tunnels. The pandemic has had some impact on the project schedule, but we still have approximately 1,000 people deployed on site. We are also working on a lithium project in Antofagasta with Albemarle. Our largest project is the MAPA Arauco expansion project for the pulp and paper industry, where we are the main contractor for the new facility.

How is Echeverria Izquierdo incorporating more technological advancements into operations to minimize operational costs?

The construction sector has been slow to incorporate new technologies. Echeverria Izquierdo has an innovation department with a strong focus on the digital transformation of our activities to increase the productivity and thus our competitiveness. We are moving towards digitizing our warehouse and operations to shift everything online. Covid-19 has accelerated our efforts to become more digitally orientated in our business. We are also increasing the use of new and modernized equipment in our operations, especially with regards to semi-automated welding equipment as well as last generation equipment.

Precast is another innovative solution that we are implementing in our operations. A successful example of this is the entire foundation of the QB2 stockpile that will be precast at sea level and then assembled on-site. Our goal is to increase our efficiency and productivity and reduce people on site wherever possible.

What trends are you witnessing across the industry today?

Despite the increase of metal prices and promising demand outlook, we observe moderation in the large mining companies as they do not dramatically change their long-term investment plans based on the current market environment. However, there are some initiatives that could take advantage of the current scenario, opportunities to advance schedules and grow project portfolios over the coming years. The challenge for the construction sector is to not overreact to any situation and also take a longer-term view, using this time as an opportunity to be creative and innovative, incorporate new technology and be more productive and sustainable.

Echeverria Izquierdo is currently focused on Chile and Peru. Does the company have any expansion plans?

We are currently focused on consolidating our operations in Peru and we will gradually expand our operations if the opportunity arises. The Ecuadorian mining industry is starting to attract attention. The company also has substantial experience in the pulp and paper industry, and Paraguay holds significant opportunities for us in this regard.

What is Echeverria Izquierdo strategy to consolidate and grow its market share?

Obtaining the QB2 and MAPA projects has been significant to the company's growth. We are one of the leading players in the Chilean construction and industrial erection space, and we aim to continue growing in both Chile and Peru building long term relations with our clients, grounded on our strong ethical values and committed to sustainable development. ■

Sandro Tavonatti

CEO
SIGDO KOPPERS INGENIERÍA Y CONSTRUCCIÓN (SKIC)

> The challenge for the construction sector is to not overreact to any situation and also take a longer-term view, using this time as an opportunity to be creative and innovative, incorporate new technology and be more productive and sustainable.

Could you provide some background information about SKIC?
The company was established in 1960. We currently operate in Chile, Peru, Brazil and Colombia as a regional EPC player, with an annual turnover around US$600 million and more than 15,000 employees We have always focused on large scale industrial installation projects, mainly in the mining industry. In mining, we can generate many synergies with other companies from the Sigdo Koppers Group, such as Enaex, Godelius, Puerto Ventanas and Magotteaux. We are present across the whole value chain, from the mining infrastructure and production to the minerals' shipping. We have expanded our scope from industrial installation to our current ability to handle EPC and BOP projects throughout the years. Beyond that, we have been present in large energy projects, with our involvement in more than 7,500 km of high voltage transmission lines in the region, as well as the related substations.

Can you give some details on your current work with mining clients?
Codelco is our main client today. We have supported them across most of their projects over the last 60 years. Recently we have started working with Teck on two important projects. We are building the flotation area of Quebrada Blanca 2 and also the port. Teck is a new client for us, and I have no doubt that we will accomplish what we have done with other long-standing clients like BHP and Antofagasta Plc. Gold Fields is also a new client for us in Chile. The Salares Norte project is challenging at over 4,000 meters above sea level, so that is forcing us to take a fresh look at preassembly and modular construction processes. The success of this project will be based on our joint work with Fluor on these aspects.

What trends and opportunities do you see in the mining industry in Chile?
I do not think we are experiencing the same mining boom we had 8-10 years ago. This said, we see more dynamism in lithium, rare earths and iron ore. It will take 5-7 years to ramp up these new projects, but there is an opportunity there because all these projects require a lot of infrastructure, from transmission lines to ports. The energy industry is going to be very relevant over the next years. We are currently participating in Chile in the biggest transmission line project in decades (Kimal-Lo Aguirre HVDC 1,500 km). Also, we will see more desalination projects that are energy-intensive, so this infrastructure will go hand in hand with renewable energy. We have already worked on the Escondida Water Supply (EWS) desalination plant for Escondida (2,500 l/s). We are currently bidding for a 2,400 l/s desalination plant in Peru and we are participating in various water and energy transmission tenders for Collahuasi. Finally, in terms of ports, we have just done the whole renovation of the ship loaders for Collahuasi.

How is the company evolving in terms of processes and new technologies?
A big transformation of SKIC over the last five years has been the migration to EPC projects. This way, we are much closer to the clients, being able to intervene in the early engineering phase, and this translates later into more productivity and a greater level of modularity and pre-assembly. We then wrap up the process with excellent logistics management.
There is a lot of space to continue improving productivity and safety. In this respect, Godelius works with all the companies of the Group in new processes and new technologies. Our Toronto and Sudbury offices have alliances with several universities to innovate in remote operations, artificial intelligence, and robotics.

What are the prospects for the future?
Overall, the success of the company is the result of preserving some core values that cannot be compromised, such as sustainability, the environment, diversity, business ethics, inclusion and respect for local communities. With all that in place, you can progressively strengthen your technical capabilities to continue improving. All this has earned us a great reputation among the major mining transnationals, so we will be very active in mining in the years to come. ■

Tomás Fischer Ballerini

General Manager
EDYCE

Can you give an overview of Edyce and the company's role in the mining industry?
Edyce has a history of over 70 years in Chile and has been involved in all of the big mining developments of the last decades. The mining industry represents approximately 75% of our revenue. Our core business is the fabrication of structural steel for mining and industrial buildings. We have the largest production capacity in Chile and South America of 3,000 tons of structural steel per month, complemented by our other services such as structural steel erection and modularization.

What are some of the main mining sites Edyce is working on?
Currently we are working on Teck Resources' Quebrada Blanca phase 2 project as well as Antofagasta Plc' INCO project at Minera Los Pelambres. Both projects have come into the construction phase over the last two years, and we continue to serve our clients who are trying to recover from delays caused by the pandemic. The economic outlook for the rest of 2021 and 2022 looks promising, and we are confident that the project development pipeline of different mining companies will be executed as planned. Chile has had some difficult years recently, but due to the surprising increase in the value of copper and the government's actions to reboot the economy, it seems very likely that all the investment projects that have been planned will continue and that Edyce will be involved in all of them.

Some issues that were being slowly addressed by the mining industry have now been forced into acceleration due to the pandemic. Edyce was already working towards helping the mining industry to increase productivity and improving in terms of human capital, safety, and environmental issues through initiatives such as modularization and offsite construction. With greater importance now falling on optimization of all these issues, we believe that there is more opportunity than ever for us to further serve the industry.

What technological innovations or processes is Edyce incorporating into its operations?
As we have an industrial plant, we always try to keep up with the latest technology available. It is incredible how many innovations have flourished over the last few years, even more so with the virus' outbreak. We are currently incorporating a new technology that will be part of our production process in mid-April 2021. Edyce will be using IoT technology on every machine where our productivity will be measured by smart devices and have information about the functionality and performance 24/7. There have also been significant advances in robotic welding and we hope to incorporate a new automatic welding line in 2022. New innovations implemented are planned to increase efficiency, productivity, quality, as well as better health and safety conditions for our workers.
All of these innovations finally have many field applications: Prefabrication, Pre-Assembly, Modularization and Off-Site Construction and have the potential to significantly reduce project schedule, improve productivity, reduce labour costs and improve safety and environmental conditions. Our facilities in Talcahuano, with direct access to ports, and our Modularization site at Antofagasta, allow us to offer these strong value proposals to our mining and industrial clients.

How do you see the changes in the Chilean constitution impacting mining investment?
Chile is in a very particular political situation as it is undergoing a pivotal process: rewriting the constitution. This has created more awareness of the importance of improving the work environment and I believe that the role companies play in society will be under review. Society will demand that business operations are in harmony with the environment and individuals' livelihoods.
Many initiatives regarding productivity will now also address the above-mentioned requirements. I am of the opinion that the new constitution will strengthen the industry and I believe that Edyce is in an excellent position to adjust to the requirements. Chile's path is in many ways very similar to the path that other already developed countries followed. There are always voices of concern, especially when it comes to change, but I believe the outcome depends on how we respond to the challenge and I am very optimistic for the way forward for Chile. ■

Gastón Rubio

CEO and Managing Director
PROMET

Can you give us an introduction to Promet and the company's most recent developments?
Promet has a history of 30 years serving the mining industry with a workforce of over 4,000 workers at several projects in Chile and Peru. Last year, the Cintac Group acquired 60% of the company – the Cintac Group is a subsidiary of CAP, a large iron ore producer. This acquisition strengthened the company's market share and its five-year strategy is to increase sales from US$200 million to US$500 million annually in camp-related services, industrial installation and structures for mining. We have built 2 million m2 in Modular Construction, and our vision is to become the leading player in industrial construction— and also modular and pre-fabricated solutions— in Latin America.
Five years ago, we also established Promet Montajes, a company dedicated to industrial installation. Today, in Mantos Blancos, we are working on the expansion of the concentrator for Mantos Copper.

How do you perceive market dynamics in the mining industry in 2021 and beyond?
2020 was a challenging year as we only met 80-90% of our budgeted sales. However, I am very optimistic about the next three years. The outlook for copper is positive, which will trigger the development of new projects and expansions. We anticipate increased demand for hotel infrastructure, and we should achieve an annual growth of 25% between 2021 and 2023.

To what extent is the industry becoming greener and more sustainable?
The pandemic is already promoting innovation and efficiency, so the mining industry in Chile is going to become more competitive. I am also optimistic about the energy sector – we will definitely see new wind and solar projects, and Chile will become the undisputed leader in renewable energies in the region.

Can you elaborate on some of the projects you are working on?
In Chuquicamata, we've developed the emergency refuge as well as the underground maintenance shop with the ventilation system. This is the largest underground shop in Latin America, and one of the world's largest. The refuge is pressurized, in case of emergency, and has a capacity of over 100 people. For this project we were able to bring both our modular and industrial installation capacity together. It's an EPC project valued at approximately US$70 million.
In Mantos Blancos, the expansion of the concentrator for Mantos Copper is valued at around US$70 million. The project includes mills, flotation cells and all the necessary equipment. We also worked on several projects in Quebrada Blanca. These are important projects for us that have allowed us to maintain good levels of activity during the pandemic.
We have significant projects at Pelambres, Centinela, Radomiro Tomic, and Collahuasi mines. Promet also works on gold mining projects, such as Salares Norte with Fenix Gold.

How is Promet incorporating more digital processes into its operations?
Digitalization is our main challenge ahead, so we are investing in higher levels of automation in our manufacturing plant. We are also using augmented reality to control the different projects as well as artificial intelligence and machine learning in order to optimize processes to achieve operational efficiency, breaking all existing paradigms. At the same time, we are now implementing BIM inside our company. In addition, we are aiming to control our water footprint, considering most of our facilities are in the desert. We aim to eliminate paper in all our processes, so everything is digital and installed in the cloud. In the future, companies will compete based on their extent of automation, digitalization and sustainability.

Do you have a final message to our international readership?
Our workforce is our main asset, and our priority as a company is to ensure their satisfaction and safety. Throughout our 30 years of operations, we have never had a fatality. Operations under Promet Montajes have never had an accident since its founding, and Promet Servicios offers excellent safety indicators. To achieve a solid safety performance, we have built a culture that prioritizes safety in our business.
Over the next four to five years, we want to be the leading player in industrial construction, increasing our revenue to US$500 million annually, as well as expand operations to Colombia and Ecuador and consolidate our presence in Chile and Peru. ■

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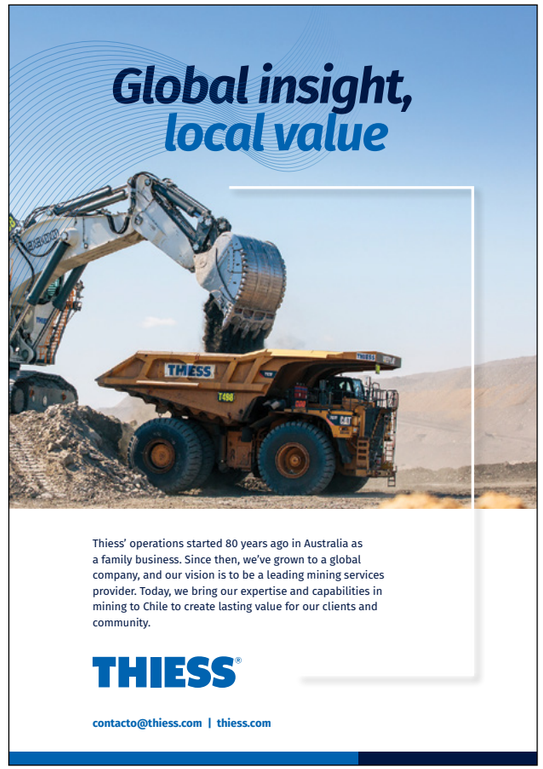
Technology-driven solutions

Chile's miners and their service providers are familiar with the benefits of technology. Patricio Concha, project manager at Plainhill, explained how Building Information Modelling (BIM), an intelligent 3D based process, became a requirement in 2020 for governmental projects. Today, it is being used by 69% of construction, engineering and architectural firms in Chile, compared to 39% in 2013, according to a study by the University of Chile's architecture and design faculty.
"The BIM system is used to integrate information from all different project functions into one single master database. The system is composed of digital 3D models where all relevant information of the project is generated, integrated, administered, controlled and exchanged among the project participants in the course of the whole project life. Further information can be linked such as schedule constraints," elaborated Concha.
Iván Rayo, general manager of JRI Ingeniería, explained that the company incorporated BIM into its operations in 2019 to improve its offer to clients. "This technology was groundbreaking for mining, an industry that until recently had not been able to apply such processes due to the complexity of its engineering."
The trend towards increasing use of BIM allows for the application of artificial intelligence (AI), which will be used to better assess risk, manpower and planning errors. SKIC, a subsidiary of Sigdo Koppers (SK) Group, is working with Godelius, a more tech-focused company of the SK Group, to introduce other innovations beyond BIM to enhance safety and productivity. "Our Toronto and Sudbury offices have alliances with several universities to innovate in remote operations, artificial intelligence and robotics," explained SKIC's CEO, Sandro Tavonatti, who is actively working to reduce the technological gap of the construction industry.
Edyce, who provides steel fabrication solutions for industrial use, is also using robotics in welding. "There have been significant advances in robotic welding and we hope to incorporate a new automatic welding line in 2022. New innovations implemented are planned to increase efficiency, productivity, quality, as well as better health and safety conditions for our workers," commented Fischer.
On the other hand, Techint, a local EPC firm, is using drone technology for rock prospection. "We are currently using drone technology for land, subsoil and progress surveys allowing us to check our pipeline routes and give us a better understanding of the geological conditions affecting construction in a faster, more accurate and effective way," commented Jorge Donoso, general manager.
The application of technological solutions in construction and industrial assembly also enhances safety, considering the labour-intensive nature of the industry. "We incorporated boom trucks with movement sensors to be controlled remotely, so workers are kept at a safe distance. We are also introducing man lifts instead of scaffolds," stated Alejandro Vega, general manager of Ava Montajes, a local EPC and industrial assembly contractor working in on Codelco's Collahuasi.
The incorporation of technology is poised to have a transformative impact on Chile's competitive construction industry, especially when AI and data analytics are used which present a compelling economic logic for clients. As a result, partnerships and acquisitions are emerging between construction and tech companies to maintain competitiveness. Investment in the development of construction technology more than doubled over the past decade, McKinsey reports.
"The mine of the future would rely on sophisticated technology using artificial intelligence, robotics and automation in mining processes to facilitate a fully automated plant and operation," said Dave Lawson, president of the mining and minerals division in Wood, the British multinational engineering and consulting, currently working on the detail underground design for Codelco's Chuquicamata. "Covid-19 has pushed the industry further towards the digitalization of processes overall. Mines are now looking to operate from control rooms in remote locations." ■



Mario Theurl & Dirk Pförtner

MT: Technical Manager
STRABAG ZÜBLIN
DP: Commercial Manager
STRABAG ZÜBLIN CHILE

MT

DP

Can you introduce Züblin and its role in the mining industry?
Züblin is under the Austrian-based STRABAG Group, one of the largest European contractors. STRABAG fully acquired Züblin in 2016. We have been established in Chile for over 30 years and have vast experience in the Chilean mining industry, where mining represents approximately 50% of our business.
We are a major player in the development and preparation of underground mines, providing services from construction to mining. Our experience covers civil works and mining infrastructure, as well as the integral exploitation of mines.
Over the course of our time in Chile, we have built a collaborative relationship with our clients and successfully established long term relationships. We have partnered with renowned clients such as Lundin Mining for more than 15 years, and for the last 20 years we have worked on sizeable mining projects at El Teniente, Chuquicamata and Andina.

What is Züblin's offering to the underground mining industry in Chile?
Züblin actively participates in all significant underground mines across Chile. We offer the best technical and economically viable solutions to large-scaled mining ventures for clients such as Codelco. Our main attributes focus on the quality of our operations as well as the high safety standards that are an integral part of our working culture. For example, we have collaborated with Codelco on Chuquicamata since 2015, boring tunnels at an estimated rate of 1,800 meters per month during our peak performance, recording a staggering 5 million hours of work without lost time accident.
In March of 2019, we acquired a contract for El Teniente to construct tunnels averaging a length of 32.5 km. Given the challenging seismic conditions near El Teniente, we apply and rely on some of the latest tele-commanded technology on the market to execute the project. The equipment required to build the tunnel is operated remotely to comply with strict safety measures on site and ensure our staff's safety.

Can you elaborate on some of the most exciting innovations happening in underground mining today?
Technology development in underground mining today is focused on enhancing safety in combination with increased productivity. As mining worldwide dives deeper and becomes increasingly more challenging, the industry is in need of faster and safer ways of operating. We see this in the case of Codelco, for example, where the company is choosing to adopt more remote equipment and trucks in their operations. Züblin was part of a pilot program where operators drive the scaler and an excavator from a cabin stationed away from the working front. Another example is our use of Photo ADAM technology for cutting-edge photo mapping. The software allows for images to be overlapped with one another to create 3-D models for geological and geotechnical analysis. The use of equipment such as Boltec, for pre-drilling and mechanized fortification, is another noteworthy example of technological developments in this field.

How do you use your BIM.5D technology, and what are its applications in your mining projects?
BIM.5D (Building Information Modelling) is an important pillar in the execution of our corporate strategy and improves our project delivery from design to take over by our clients. It can be used in the design, realization, and operation phases of a project. It is a model-based planning method that provides a visual representation of a project as it progresses. It highlights the materials and quantities required for the project and provides a timeline that demonstrates how changes in the design would impact the project. This level of digital planning technology is revolutionary in the construction industry, as it enhances cost efficiency design and scheduling. It also helps identify missing information and conflicts detected in the design, which helps avoid errors overall.

How is Züblin perceived by its clients?
Züblin is perceived as a reliable partner with a proven ability to execute projects in an efficient manner. Our ambition is to be the leading technology partner in construction of the future. Our value as a partner is our commitment to quality, reliability and innovative spirit. ■

> **Given the challenging seismic conditions near El Teniente, we apply and rely on some of the latest tele-commanded technology on the market to execute the project.**

Rodrigo Prado

General Manager
TECNO FAST

What is the history of Tecno Fast in Chile?
Tecno Fast was established in 1995 when Chile's mining industry was experiencing a critical boom. The company's evolution has strong links with the country's development in infrastructure and mining. In line with this growth, today, our focus is on infrastructure services for mining operations, such as the rental of infrastructure. In 2013, we launched a line of privately-owned hotels where we offer a complete housing solution to service providers and operators on-site. We have always had a unique link with mining, but the company's strategy has grown beyond it. In this evolution, Tecno Fast has also expanded internationally with a presence in other countries such as Peru and Colombia.
Mining represents 50% of our business. The rest is diversified in various industries such as construction, infrastructure and services. Diversifying our scope of action is a company priority.

Can you elaborate on some of the current projects you are working on?
Right now, we are working on Teck Resources' QB2 and Salares Norte by Gold Fields. We have also worked in Minera Sierra Gorda and Los Pelambres, where we helped expand their campsites. Energy projects and solar panel farms have also presented good business opportunities, as we worked on ENEL's Sol de Lila project.

How did you sustain growth despite the challenges posed by the pandemic?
Tecno Fast did not halt operations during the pandemic. We focused on training and set up protocols and systems to improve bio-security. Among the techniques we have used were dividing teams into smaller groups, expanding remote work where possible and controlling outbreaks with weekly testing. Fortunately, we have been able to limit exposure and prevent risks. The pandemic has been a period of high business activity because operators were expanding eateries, housing capacity and office spaces.

What are the logistics of the installation process, and how do you ensure robustness in Chile's challenging weather conditions?
We have 25 years of experience in the market, and we are aware of the importance of using quality and durable materials. Preventing high maintenance costs is a priority. Our department of procurement focuses on sourcing materials that meet strict standards. Sustainability is also an aspect that we incorporate in our business. We are conscious of the environmental impact of processes and products. Our plan is to be a carbon-neutral company; the entirety of our production process is carbon neutral, and all the energy we use for production is generated through solar-powered means.

Can you elaborate on the innovations in modular homes and systems that are energy efficient?
In 2018, we initiated an ambitious project of installation to improve our productive system using automation and by robotizing the plant's entire process using cutting-edge global technology. We incorporated solar energy in order to be carbon neutral. Overall, 80% of Tecno Fast's energy consumption during production processes is self-generated. We include sustainability initiatives in all the projects we are involved in, for example, by utilizing LED lighting and water-saving artefacts.

Should we expect Tecno Fast's initial public offering, and if so, how are you preparing for it?
The IPO was delayed due to the social unrest we experienced in 2019 and the uncertainty surrounding the pandemic. However, despite postponing it, we did release bonds which allowed us to capture new resources and stick to growth plans. The IPO will resume when external variables are favourable and attractive. We are monitoring the possibility constantly and waiting for the appropriate moment. Emitting bonds makes us a public company and means we must adhere to standards of transparency, risk and reporting in the same way as a publicly listed company. ■

> **Our plan is to be a carbon-neutral company; the entirety of our production process is carbon neutral, and all the energy we use for production is generated through solar-powered means.**

Francisco Casas

General Manager
NEXXO

What is the role and history of Nexxo in the Chilean mining industry?
Nexxo's history is more associated with the petrochemicals industry since 1980, and entered the mining and paper and pulp industries later in the early 2000s. Today, mining represents 45% of our sales, compared to just 15% a few years ago. We have a broad spectrum of services, including mechanical and industrial maintenance through long-term contracts and plant shutdowns, as well as specialities related to maintenance. Among other specialities, we are recognized as leaders in the maintenance of reactors and catalyzers in melting plants, as well as chemical and high-pressure water cleaning. We also provide a long list of other industrial services, including dredging and pre and operational tests. In mining we see an immense growth potential for our mechanical maintenance capabilities.
In Chile we work with all the major mining companies such as Codelco, AMSA, Lundin, Lumina, Glencore and BHP, and we currently have 10 long-term mechanical and industrial maintenance contracts in mining. Nexxo focuses immensely on safety and maintains high standards.
Since 2013, Nexxo operates as a subsidiary of the Echeverría Izquierdo Montajes Industriales group. The acquisition by the group provided us with additional technical support and financial backing.

Can you elaborate on your safety and quality assurance mechanisms?
Nexxo has the ISO-45001 certification, and our relationship with Echeverría Izquierdo Montajes Industriales guides and supports our safety policies. We operate in an industry that has high safety standards, and we abide by them strictly. We are proud to have been awarded in 2018 and 2019 four stars in the Honor´s Roll by the Chilean Chamber of Construction. In 2020, we improved our safety results further.
In maintenance, Nexxo works through constant evaluation of the site and the conditions, which are different when compared to construction companies. We use tools and procedures to conclude and quantify risk and act upon it accordingly. We have identified our critical risks and their precursors and are working every day to minimize them. Our safety approach is preventative.

Even if it did not save costs, we would still prefer the use of robots and specialized equipment for safety considerations.

What trends have you witnessed for your services recently?
Clients in the mining industry tend to prefer managing their assets and to prepare their own plans. The role of Nexxo fits in by providing support in carrying out the maintenance guidelines defined by the clients through long-term contracts, plant shutdowns or spot services. This process differs from elsewhere since in other countries and industries, the whole process is outsourced. Another trend we witnessed is that in the last years, mining companies prioritized cost reduction in contracted activities. Therefore, we focused our work on improving productivity, reducing the number of staff in long-term contracts and implemented more cost-saving mechanisms and equipment. Innovation is also something that Nexxo has always had as a priority to remain competitive.

To what extent does Nexxo incorporate the use of technology to enhance operational efficiency?
We rely on the use of robotics to reduce the number of staff on-site and minimize risks. For example, robots are used to clean near or under conveyors. The use of robotics reduces costs considerably, which allows Nexxo to be more competitive. However, even if it did not save costs, we would still prefer the use of robots and specialized equipment for safety considerations.

How is Nexxo consolidating its market share in Chile?
Even though we have a more substantial presence in the petrochemicals sector, we have grown our presence in mining in recent years, which Nexxo is well-suited for. Working in the petrochemicals industry is more complex than working in mining due to the higher operational risk and quality requirements. Therefore, Nexxo's strength in mining is a result of the experience gained in petrochemicals. Our goal is to stand out from the competition by providing value to our clients through our service offering to complement the long-term contracts, which includes alliances with maintenance engineering companies such as Monitoring (local company) and companies specialized in the maintenance of crushers and mills. ■

Darrell White

Executive General Manager Americas
THIESS

Can you explain the company's history in Chile, its service portfolio for the mining industry and how it fits into the Thiess's global strategy?
Thiess commenced operations in Chile in 2015 with a contract awarded to undertake pre-strip operations for a client in the Antofagasta region. That established our base, and we've used that initial entry as the foundation for future growth in Chile. As the largest mining services provider in the world, Thiess brings deep experience, capabilities and strength to optimise mining operations in Chile. A key service offering and differentiator for us is strategic mine planning, both short and medium term, designed to meet specific client needs. Drill and blast design and execution are also considered part of our core business with scope to modify this for client needs. Traditional load and haul of waste material and ore, as well as maintenance of all core assets and auxiliary equipment on site are included in our offering.

What are some of the current and upcoming projects you are working on, and how you were able to cushion the impact of Covid-19 on your operations?
In addition to delivering load and haul services and pit operations for clients in the region, we are exploring other opportunities, including at existing gold and copper operations as well as green field opportunities. The impact of Covid-19 has come in waves for Thiess and has certainly been an ongoing challenge to manage and reduce its impacts. Our priority has always been focused on the health and safety of our people. We have learned the value of being proactive and quickly taking decisions and implementing processes to protect our people and operations. Importantly, we have been able to limit Covid-19 transmission on site by following government protocols and directives, and enacting workforce and recovery plans quickly.

How does Thiess differentiate itself in the competitive sphere?
Thiess leads with its technical capabilities, bringing value through mine optimisation and extraction techniques that add commercial value to the operation, which in turn enables Thiess to move material more efficiently. We create lasting value for our customers, people and community by focusing on smart solutions when we go about our business and not just on moving the material volumes. Additionally, Thiess' strong focus on safety across its global operations is very well aligned with the requirements of the local industry.

In what way is Thiess introducing innovation in sustainable mining solutions?
We now have full autonomous drilling rigs in Australia and are looking for the right opportunity to bring that technology to Chile. We are also going trialling a fully autonomous haul fleet project in Australia and look forward to bringing that to market in the future. Certainly, digitisation is our future. Through the convergence of operations and technology, we can create smarter ways of working that drive efficiency through the mining value chain enabling quality client outcomes.

How is Thiess responding to the trend in underground mining in Chile's mining industry?
While Thiess successfully operates underground projects in other parts of the world, our current focus in Chile is delivering our core services in an open cut environment.

Can you elaborate on the importance of having a social license to operate in the industry?
At Thiess, we believe strong social performance starts with proactive, genuine and positive community engagement. This approach supports successful project outcomes by building understanding of culturally acceptable customs, managing community and stakeholder expectations, creating opportunities with local and regional business, promoting diversity and inclusion and, most importantly, paving the way for meaningful, two-way communication between Thiess and project-affected communities.
Areas that we are particularly proud of in Chile is the establishment of our Allies program, which supports LGBTIQA+ communities, increasing the diversity of our teams with our first female truck operator and 40% female representation on our leadership team, and building the capacity of our people and industry through scholarships and pathway programs.

What are the company's plans and strategy for growth in Chile for 2021 – 2022?
In 2021 and 2022, our team is focused on fulfilling current contracts, adding contracts that fit our portfolio, and continuing to bolster the business for growth. We see tremendous opportunities in the region for the services Thiess brings and see us having a key role in providing sustainable solutions to customers. ■

EQUIPMENT AND TECHNOLOGY

"One barrier to innovation in Chile is that mining companies refuse to incorporate unproven products and services into their operations as it risks their volume or continued operation. There are not many places to pilot technology on an industrial scale. Approximately one-third of Chilean mining suppliers do not allocate resources to innovation."

- Philippe Hemmerdinger,
President,
Aprimin

Image courtesy of DSI Underground

Equipment and Technology

THE JOURNEY TO SMART MINING

Driverless machinery and mining expeditions using robots were once only a product of imagination. Today, they are a reality as we embark on the fourth industrial revolution, especially after the Covid-19 outbreak. "There is no doubt that the pandemic accelerated the move towards automation and autonomous mining techniques in Chile," elaborated Patricio Apablaza, sales vice president of Andean & South Cone for Sandvik Mining and Rock Solutions. "The Covid-19 pandemic means fewer people on-site, working to achieve the same result (ktpd); this means that digitization has become a vital efficiency mechanism for the survival of mining operations."

Innovation is the new language of mining, as it helps minimize costs, enhance safety, optimize mineral processing and improve the economics of resources in the face of structural challenges such as remote locations and declining ore grades. In Chile, the use of technology is also essential in managing water and energy sources, considering the ongoing drought and the industry's high energy costs. A report by consultancy firm BDO highlights that automation of mines will cut costs by more than 30%, while accidents in mining will be reduced by 75% as workers are trained to manage the robots.

In the equipment space, the highest level of investment in mining technology is in autonomous vehicles, robotic process automation and analytics tools, according to a KPMG survey. Over the course of 2020, the mining industry was able to adapt and continue operations during the pandemic as a result of the rapid adoption of technology that allowed smooth remote operations, to the extent that Komatsu Cummins' 2020 sales outperformed those of 2019, according to Darko Louit, CEO of the company in Chile. "A strong interest in autonomy has been a significant factor impacting demand over the past 18 to 24 months, leading to a very busy schedule of implementation of autonomous operations in the country for the next 2-3 years," he added. ■

Hugo Salamanca

President
HIGHSERVICE CORP

> In 2020, we introduced robotics in the change of mill lining, which is critical both from the point of view of production and the risk it entails for people.

How did you overcome the challenges posed by the pandemic?

2020 was a year of extraordinary efforts to sustain operations, with a solid focus on controlling and managing the pandemic. Despite these challenges, we are very satisfied with the results as we maintained our growth amid the outbreak. Our construction company witnessed increased sales, despite being one that faced the most challenges as there was an operation with more than 1,000 people, but thanks to the safety protocols and the workers' commitment, the result was excellent.

The technology company also experienced significant advancement. In 2020, we introduced robotics in the change of mill lining, which is critical both from the point of view of production and the risk it entails for people. We advanced technology in Minera Los Pelambres with AMSA. It is a pioneering application worldwide, and we are pleased because we were able to demonstrate robotic arms' performance. This technology will come into operation this year with AMSA, which will be a global milestone. We are also working on the same technology with Minera Escondida.

What advances have you made with robotics?

In Peru, we have a very solid position, for example, in Antapaccay, as well as in the ports of Matarani and Callao. We have an exciting application of casting in Magotteaux in the US, which reduces the need for individuals in the assembly of moulds in foundries.

On the other hand, last year, we contacted potential clients in European, particularly foundries in Finland and Sweden, for applications in melting furnaces. We are in the implementation phase at BHP's Olympic Dam in Australia and see applications for foundries in France. We have also presented our developments to Anglo American foundry specialists globally.

How are the company and the industry changing to incorporate more technology in mining?

In other industries, such as automotive, robotics is highly developed, but in mining, it had a very low level of penetration until last year, when the Covid-19 crisis promoted a new approach focused on increasing productivity and reducing risks. The applications are multiple; for example, we are currently developing a robotic washing process for large mining trucks.

Internally, we are making relevant changes in the company to respond to new business opportunities. We signed an agreement with the University of Concepción to incorporate artificial intelligence in the application of robotic technology to the change of mill lining. With this, we are going to structure an entire artificial intelligence program for the company. We are also developing a global monitoring centre for all the robotic operations that we are implementing. It is a process in which we already have relevant experience. Years ago, when we developed the plant maintenance services company, we set up a monitoring centre for the mills and their motors in different operations in Chile, Argentina, Peru and Brazil.

Do you think Chile is going to become a significant mining technology exporter?

Chile, due to its strong, established mining industry, is becoming a pole of technological development. We are a company with an innovative outlook, and innovation has been a strategic pillar from the beginning. Robotic applications have been operating for several years in the US and Peru, and we see applications in Australia and Europe. In the group, we already have a unique global scale robotics development centre for mills.

Where do you see the highest growth potential for the company in the coming years?

The copper industry is to witness bullish projections due to electro-mobility and technological developments that rely on copper, which will continue to increase demand. Our vision is to become a leading robotics company worldwide in the mining and heavy industry sectors. To achieve this, we have transformed into two entities: on the one hand, we are launching a company specialized in the application of robotics in mills. On the other hand, the robotics base company, MIRS, has been reinforced with new executives for the international development of the business, as we recently opened the MIRS office in Australia. ■

Pedro Damjanic

Senior VP of Mining
FINNING

> As part of our training for autonomous operators, we invested in a Simulation School located in our facilities in Antofagasta, and being replicated in Santiago to prepare for upcoming projects.

How has Finning maintained supply chain continuity amid the pandemic?
We were able to take all possible measures to ensure the safety of our employees: over a thousand started working from home. We also applied special Covid-19 protocols to every job, adapted the workspaces, and created multiple campaigns to help with the mental health of our personnel and their families.
Additionally, we created the Operational Continuity Committee to manage and secure all the required equipment and spare parts in our inventory and in our customers' inventory to continue supplying them.

How does Finning's distribution agreement with Resemin better position the company in the Chilean underground market?
We offer a comprehensive portfolio in the open-pit space, but there was a shortage of product line in relation to underground. Our representation of Resemin gives us a substantial position with the jumbo and other relevant lines. We also have to consider that Finning has the representation of Elphinstone for Special Underground Auxiliary Equipment. Today, Finning has, under the umbrella of one company, the largest portfolio and the most comprehensive lines of equipment for underground mines. We are receiving positive feedback from our customers, showing that Resemin is a great addition to what we offer.

Can you give an overview of the technology the company offers in autonomous mining?
We developed a robust strategy that starts with a new specialized organization that includes qualified managers, engineers and a complete organization platform in autonomous projects to support the customers from the conceptual idea up to the implementation, all in close connection with CAT and with our organization in Finning Canada. As part of our training for autonomous operators, we invested in a Simulation School located in our facilities in Antofagasta, and being replicated in Santiago to prepare for upcoming projects.
By mid 2021 we will work with Teck Resources' Quebrada Blanca Phase 2 (QB2) project on the Autonomous Mode. This is our first open pit project of this kind. It will operate with the Diesel Electric Truck CAT 794 AC. In underground, we are working with Codelco's El Teniente in the second phase of the semi-autonomous project with great success, and we see interest in extending this plan for the mine.
We are witnessing strong commitment and demand from customers to move to autonomy. Caterpillars' autonomous system is the best option for customers, as it allows for a 30% increase in productivity and has many advantages compared to other brands in the market, as it can run both on the CAT fleets but also on different equipment from other brands, as well as in a mixed mode.

What products and services does Finning offer that emphasize sustainability?
By 2040, the mining industry is aiming for the elimination of gas emissions. Many mining companies are already switching to renewable energies to reach this goal. In collaboration with Caterpillar, Finning is also heading in a more sustainable direction.
We also believe in building capacity for the future. That's why we partner with communities to empower learning and training the future generation in science, technology, engineering, and math. We are also committed to decrease the gender gap in the mining industry by providing free training and scholarships to women.

What are the barriers to mining innovation in Chile?
There are no significant barriers to innovation, and the mining industry has made tremendous innovations over the last years. Approximately 95% of the demand for renewable energy in Chile came from the mining industry. The desalinations plants are supporting the increasing investment in technology development within the industry. The mining industry is also the first to initiate operation management centers from one location, which increases operational efficiency and labour flexibility.
The Covid-19 pandemic encouraged digitization in the mining industry regarding supervision and maintenance. Maintenance on sites is now conducted through drone surveying which improves productivity, reduces risks, and is less expensive. ■

Patricio Apablaza

Sales Vice President of Andean & South Cone
SANDVIK MINING AND ROCK TECHNOLOGY

What are your main business lines in the Chilean market?
Sandvik is divided into three main groups: Sandvik Material Technology, Sandvik Rock Processing (included as of this year), and Sandvik Mining. We, under the Sandvik Mining division, are currently working in underground mining with Codelco at Chuquicamata and El Teniente. In November of last year, we were assigned an important project in El Teniente, leading automisation for the underground loaders and underground trucks. Cemin is another mine we work closely with, and is one where operations rely on automisation to a large extent. Our strength in Chile lies in our atomised offering, as our products can be used across various mining sites regardless of the mine size.

Has the pandemic accelerated the move towards mine automation in Chile?
There is no doubt that the pandemic accelerated the move towards automation and autonomous mining techniques in Chile. As Covid-19 impacts linger, miners are headed faster towards digitalization. Our customers today are able to work and operate their sites from miles away. Across South America, the target is to reduce the number of people on site, which is being done through machinery replacing multiple human tasks on the mine, especially underground due to safety concerns.
The challenge we face with automation is not developing the technology, but it is its implementation, which was amplified under the health crisis as travel restrictions were enforced. We are overcoming this challenge through the establishment of our Sandvik Digital Training Centre, allowing us to train our employees as well as our customers' technicians.

Which market segment have you identified as key for Sandvik's future growth?
In addition to automation, a key market segment for us is surface operations' equipment. Chile and Peru produce between them approximately 40% of the global copper production, so Sandvik will continue to consolidate its presence in these markets and respond to their trends. ■

Charlie Ekberg & Rodrigo Izzo

CE: Managing Director
RI: Business Line Manager
EPIROC CHILE

CE

RI

What changes has the company undergone since we last spoke in 2019?
CE: We have incorporated further technological advancements into our offering, to include more automation and digitalization and, over last 2 years, we saw demand for our services increase as a result. Epiroc will be the first company in Chile to offer fully electric loaders, under our offering of the zero-emissions fleet, which will be at Codelco's El Teniente. We also have several projects for underground production equipment (Simba), which will be operated via tele-remote. Overall, our technology is facilitating the growth and consolidation of our market share in Chile.
We are also working on our certification NCH3262 ref to gender diversity. Like many companies, we believe it's very important to ensure an equal, diverse working environment. The certification and implementation process will take place during first semester 2021.
RI: Recently, we successfully tested operating rigs from control centres in Santiago for Los Bronces and Los Pelambres. Los Bronces is looking to start remote operations of their autonomous machinery from Santiago in March of 2021.
Throughout 2020, we took on new challenges as we are now supplying Minera Los Pelambres with two autonomous rigs, operated from an office at the mine site, in addition to BHP's Minera Escondida, where we are supplying six fully autonomous rigs. Anglo American partnered with Epiroc to develop and implement the new tele-remote drilling project at Los Bronces to allow more accurate and safer drilling. We are also supplying two fully autonomous rigs in mid-2021 to Candelaria's open-pit extension, Esperanza Sur. Later in 2021, Epiroc will introduce autonomous management of the electric rigs.

Where does Epiroc see the highest growth potential in the next two years?
CE: Automation and digitalization will continue to drive our growth.
RI: Our surface mining offering will increase growth through continuous optimization of our customers' value chain by offering interoperability solutions. We aim to develop an agnostic platform that allows control of drilling, loading, hauling and auxiliary equipment on-site. ■

Continuous investment in autonomous technology by OEMs

Unmanned drilling rigs and trucks are no longer an uncommon sight in Chile's mining industry. Original Equipment Manufacturers (OEMs) such as Epiroc, Sandvik, Caterpillar, Komatsu, Volvo and Liebherr are revolutionizing the industry and introducing disruptive technologies. "We are witnessing an increasing demand for automated products in Chile, especially for autonomous trucks and smart equipment," confirmed Dale Clayton, managing director of Liebherr in Chile.

To give the mines more flexibility, Liebherr introduced truck autonomy packages that allow customers to use the truck with any management system available on the market. The German-Swiss manufacturer also allows data to be processed and downloaded from the equipment to be analyzed remotely to predict maintenance times.

Meanwhile, Epiroc is also investing in facilitating remote operations as it successfully piloted the autonomous operation of the two Pit Viper 351 diesel drills at Los Pelambres, allowing the operators to work from an office environment in Santiago. The results show that operational drilling speed and well depth accuracy increased by 10% and 96%, respectively.

"We successfully tested operating rigs from control centres in Santiago for Los Bronces and Los Pelambres. Los Bronces is looking to start remote operations of their autonomous machinery from Santiago in March of 2021," commented Rodrigo Izzo, surface mining business line manager at Epiroc in Chile.

Due to the pandemic and the resulting measures, automation solutions have gained traction and popularity. "The pandemic has changed circumstances radically and has given our clients an inevitable push towards the adoption of new solutions to counter challenges such as social distancing," stated Marcelo Schumacker, country division manager of ABB in Chile, pioneering technology solutions provider.

The Covid-19 outbreak also pushed companies to be creative to ensure the same quality of after-sales service to reduce unplanned downtime. "Equipment diagnosis, for example, is a task that is done increasingly through remote means," highlighted Francisco Errázuriz, CEO of Sigdo Koppers' subsidiary SKC Maquinarias (SKCM), distributor of world-renowned brands' machinery in Chile. "Brands are developing products with a focus on track-and-trace and telemetry in order to monitor equipment better and conduct maintenance proactively."

Another approach to maintenance is being developed by geospatial solutions equipment provider Geocom by relying on augmented reality (AR). "This technology can be a game-changer in the industry. It will enable remote distance support and provide management with a real-time visual guide to operations. The use of AR in mining will disrupt and revolutionize the industry and is set to change the future of mine safety," stated the company's general manager, Carlos Escudero. ■

Darko Louit

CEO
KOMATSU CUMMINS CHILE

How has demand changed for Komatsu amid the pandemic?
In mining, we did not witness significant fluctuations in demand in Chile. There were several brownfield projects and fleet renovations that we took part in. Actually, our mining equipment sales for 2020 outperformed those of last year. In this sense, Komatsu was chosen as the most preferred supplier by its customers. During 2020, the implementation of Covid-19 related protocols posed several challenges as we managed to ensure operational continuity while protecting our workforce's safety. In addition, a strong interest in autonomy has been a significant factor impacting demand over the past 18 to 24 months, leading to a very busy schedule of implementation of autonomous operations in the country for the next 2-3 years.

Can you elaborate on Komatsu's latest technology in its autonomous fleets? Has the pandemic impacted autonomous equipment demand?
The Komatsu Autonomous Haulage System (AHS) was first introduced in Chile, at Codelco's Radomiro Tomic and then Gabriela Mistral mines, and since then it has accumulated over 3 billion tons of material moved in operations around the world. We have witnessed strong interest from the market for additional autonomous fleets in Chile and Peru. Therefore, we set up an AHS base in Santiago consisting of specialists and engineers to support the fleet deployment and operations. Although in our opinion the pandemic has not been a significant factor in influencing demand trends for AHS, since drivers for the decision to adopt this technology respond to longer term safety and productivity gains, we believe the Covid crisis has put in evidence the need and viability for remote solutions, for example, monitoring and diagnostics used to support optimization decisions.

Given the company's recent milestone at Sierra Gorda, what can you tell us about how Komatsu's equipment enhances productivity?
Our aim has always been the provision of reliable and dependable equipment. In addition to our reliability, we place a huge emphasis on increasing efficiency using data analytics. We collect and analyse data from the equipment and the surrounding environment to help our customers optimize their operations. We are proud to say that our customer Sierra Gorda managed to break a world record as they loaded 230,400 tons in just 24 hours, with one P&H4100XPC AC Komatsu shovel.

What measures is the company taking to reduce its carbon footprint?
Komatsu is dedicating its efforts and resources to the reduction of greenhouse gases and the carbon footprint of its manufacturing operations, and also of our equipment fleets. Our goal is to reduce our emissions by 50% in all of our production bases globally by 2030, relative to 2010. Another target is to source 50% of all the electric power usage from renewable sources by 2030. Finally, by 2030 we also expect to reduce our emissions from our equipment by 50% compared to 2010. The haulage fleets are the biggest consumer of diesel and a significant source of emissions in the mining sector. Therefore, we are working on developing power agnostic vehicles for mining that can operate with a variety of power sources – such as hybrid engines, batteries, trolley systems and hydrogen fuel cells. The application will determine the best solution based on the environment the customer is operating in.

As commodity prices recover strongly, how does this resonate to your operations?
The expectations for the future increase in demand for green technologies is driving the long-term bullish sentiment for copper prices. This has positive consequences on the Chilean mining industry and its suppliers, such as ourselves. Therefore, we are optimistic about the future and expect to see solid demand and customers' interest in the implementation of the new technology we offer.

Where does Komatsu see the highest growth potential for 2021 – 2022?
We are expecting an increase in our mining sales in 2021 relative to 2020. As the construction industry recovers, it will also contribute to our sales forecasts. Commodity prices recovery will benefit aftermarket sales volume as customers increase their operational capacity and usage of equipment. In 2022, we foresee further slight recovery in demand compared to 2021, mainly driven by brownfield expansions and fleet renewals. ■

Dale Clayton

Managing Director
LIEBHERR CHILE

The Chilean mining industry was already leading the way to develop more autonomous mining before the pandemic, however, as social distancing measures were enforced, there has been a stronger emphasis on autonomous mining equipment as the mines wanted to minimise the exposure of their workforce.

What has been Liebherr's biggest milestone since its establishment in Chile in 2001?
A turning point for us was our second contract with Codelco at the Radomiro Tomic mine, which led to our third at Collahuasi. In October last year, we started the ESTRS trial in Escondida for BHP to determine their future truck requirements, another great milestone. We also developed our ultra-class excavator fleets, firstly with Thiess entering in the market in 2017. Last year we were very pleased to deliver the first R9800 800 tonne excavator for Liebherr in North and South America to BHP at the Spence mine.

How was Liebherr able to maintain supply chain continuity in the face of the pandemic?
The management team's focus was first to ensure the safety of our people. For spare parts supply, we have a very advanced planning department and, with this, we project our parts usage 18 months in advance. There were some delays in deliveries of spare parts, however we managed to use our existing stock in Chile to compensate. We also adjusted our orders in 2020 to account for increased lead times from our suppliers because of Covid. In 2021, we continue to use these adjustments to our processes to maintain parts supply.

Automation is playing a greater role in the Chilean mining industry. How does the technology Liebherr provide allow it to differentiate itself in the market?
We are witnessing an increasing demand for automated products in Chile, especially for autonomous trucks and smart equipment. Liebherr made the decision early to offer our truck autonomy packages via an open protocol philosophy, allowing our customers to use our truck with any management system available on the market. This gives the mines more flexibility as they are not bound to one OEM supplier.
We also offer our LMD system (Liebherr Mining Data) allowing data from the equipment to be analysed remotely, as opposed to physically downloading the data from the truck. This allows us to send data on a truck's status so we can study the truck's parameters to plan maintenance accordingly. We are constantly developing this system to improve.

Did the pandemic accelerate the move towards autonomous mining in Chile?
The Chilean mining industry was already leading the way to develop more autonomous type mining before the pandemic. However, as social distancing measures were enforced, there has been a stronger emphasis on autonomous mining equipment as the mines wanted to minimise the exposure of their workforce. For Liebherr, it is also important to consider that the autonomous technology and new developments need to demonstrate benefit to the operations and not solely a reduction in personnel.
We also believe that in the upcoming years, the mining industry will struggle to find people that want to work on mine sites and will prefer to be in major cities. This will only push the industry towards processes that rely less on a physical presence in the mine. Even though the skill dynamic and distribution will change in the upcoming years, the mining industry will remain a very large employer. At Liebherr, we have continued with our apprentice and training programs so we have the necessary skills for this future workforce.

Where does Liebherr see the highest growth potential in Chile?
We will continue to consolidate our truck fleet. In terms of volume, we expect our trucks to remain the major part of our business. However, we forecast demand for growth in our excavators and dozers as well and we are very keen to expand this area of our business. Liebherr's electric engine options for our excavators allow for a unique position in the market as it offers a more sustainable solution than diesel-powered engines. We intend to follow the same pattern with our trucks and are working hard on alternate propulsion options. We already have trolley assist systems operating in other parts of the world, which significantly reduces the fuel needed to operate a fleet of trucks. Our industry continues towards a sustainable future that will thrive on various technological advancements and Liebherr will be at the forefront of this development. ■

Francisco Errázuriz & Jorge Ríos

FE: CEO
JR: Commercial Manager
SKC MAQUINARIAS CHILE

FE

JR

Could you provide us with the company's most recent developments?
FE: Distribution and rental are our main businesses. When we last spoke, we were experiencing a boom in mining. All the markets related to mining have fallen since. We continue to focus on making the company sturdier and more efficient. The company's cash flow processes have been developed through digital transformation and LEAN Technique. The pandemic accelerated industry trends such as remote operations and electric mobility. Augmented reality is a process we are using to provide assistance and technical support to our clients. Fortunately for Chile, the country is geologically endowed and conditions are favourable for mining. For this reason, the country is projected to benefit from technological advancements. We must set the stage by promoting the cultural habits that will ensure a swift transition.
JR: We are undergoing an important process of transformation, and our focus is to work closely with partners and manufacturers to align our objectives.

What does SKC offer in the autonomous machinery space?
FE: Remote-controlled machinery is crucial in today's mining environment. Equipment diagnosis, for example, is a task that is done increasingly through remote means. Brands are developing products with a focus on track-and-trace and telemetry in order to monitor equipment better and conduct maintenance proactively. Our office handles remote maintenance for the machinery we commercialize that incorporate these technologies.

To what extent has the industry recovered from the pandemic?
FE: Mine production in Chile was less affected than mining elsewhere in the world. However, mine construction activities in the country were severely impacted and even halted. In general, however, recovery has been rapid - thanks to the strong rebound of copper prices that reached an all-time high. Regardless of whether or not we are in a super-cycle, we must make the most of these prices. Fortunately, the market recovered quickly, and the forecasts going forward are also encouraging. We expect strong demand for copper and lithium to satisfy the world's electric mobility needs.

What can you tell us about your after-sales services and their significance to your Chilean operations?
FE: Our supply network is composed of 11 nationwide branches offering product and after-sales support. We also have on-the-ground mechanics who work for SKC to provide preventive maintenance to machinery and advise clients accordingly. TPS and other LEAN processes are very important in allowing us to provide better support to our clients.
JR: We are focused on improving the uptime of our products by focusing on strengthening the company's client-attention capabilities and prioritizing the incorporation of technology. It is very important for the company to help operators improve their productivity. SKC helps companies become more cost-efficient and improve safety. We use a set of key indicators to monitor progress in matters of safety and the environment.

Where do you see the highest growth potential, and what is your strategy to facilitate this growth?
FE: Chile's investment plan for the next five years accounts for US$70 billion, of which 36% is dedicated to mining, 29% to public works and 14% to energy. The project pipeline is strong. Although we have exposure to mine construction, our business focus is projects already in production that require maintenance. We believe that SKC must generate new business, primarily by making using of digital capabilities. Despite the challenges that are in store for Chile and the world, we are optimistic because there are interesting opportunities. We must move aggressively to become a service-provider involved in helping clients navigate operations and taking care of their needs holistically.

Do you have a final message to our international readership?
FE: Adaptability is the most important company trait in today's business environment. We must focus on listening to clients in order to discover opportunities for collaboration and improve our capacity to be adaptable. We want to incorporate technology and tools that can make SKC stronger. One major focus for SKC is to place the employee experience at the top of its priorities. Teamwork has become a central part of our work preparing staffs towards innovations and new technologies enabling our company to seize greater business opportunities. ■

Underground Equipment

Image courtesy of DSI Underground

Autonomous solutions in drills, trucks and scanning technology for underground mines in Chile are of increasing relevance to the mine's demands. For example, Sandvik is providing automated underground loaders and trucks to Codelco's El Teniente and Chuquicamata. Epiroc is offering battery-powered underground loaders, drills and trucks in Chile. DSI Underground, which was recently acquired by Sandvik, recently introduced to the undergoing mining equipment market an alternative to steel vents known as the Flexline and semi-rigid Hardline flexible vents, under its JV with ABC Canada. "Our vane axial fans are very aerodynamic and use less energy than models of older technology," explained Carlos Leigh, the regional CEO of DSI Underground in LATAM. "The flexible ducts are made exclusively for mining with resistance to mining conditions, reducing energy consumption, and maintaining good ventilation for the miners, thus increasing work safety."

Another promising innovation in underground mining is that being offered by Züblin is the Photo ADAM technology for photo mapping. Mario Theurl, technical manager at STRABAG Züblin, explained: "The software allows for images to be overlapped with one another to create 3-D models for geological and geotechnical analysis."

Overall, the trend we are witnessing in underground equipment technology is the increasing reliance on unmanned machinery in addition to the use of AI and IoT. Driving innovation is the need for safe underground mining with minimal waste production. The global underground mining equipment market in Chile is to witness considerable growth between 2021 and 2022. ■

We see the market recovering at its own pace for 2021 as mines across LATAM reactivate their operations, slowly in some cases. In some tunnelling projects we expect some delays as a result of environmental approval processes.

- Carlos Leigh,
Regional Chief Executive Officer LATAM,
DSI Underground

Comminution and Material Handling

TECHNOLOGICAL ADVANCEMENTS TO LOWER CARBON FOOTPRINTS AND INCREASE EFFICIENCY

Concentration begins with comminution, involving crushing and wet grinding, which consumes around 50% of mine site energy and is the process representing the largest or second-largest capital and operating expenses. Considering the energy-intensive nature of comminution, the circuit design of the process can make or break an operation's profit margins, which is decided upon primarily based on the ore's characteristics, plant capacity and product size. A traditional option for circuit design is SAG milling, however, there are more than 20 variations or alternatives to it.

The SAG circuit is considered due to its capacity to process high tonnages. However, it is one of the most inefficient circuits of comminution. If the ore characteristic allows for it, then the use of high pressure grinding rolls is more energy-efficient. Hofmann Engineering is investing in innovations in HPGRs. "We are always looking at opportunities to carry out product improvement on the components we manufacture through redesigning, using better materials, heat treatment and machining processes to aim for longer lifetime and therefore lower operational costs," commented Simão Antunes, general manager of Hofmann in South America.

On the other hand, Weir Minerals supplies Enduron HPGRs, which maximize crushing pressure using large lateral walls to ensure the materials do not exit the high-pressure area without undergoing crushing first. As a result, it decreases energy consumption by up to 40% compared to traditional grinding circuits.

Meanwhile, Metso Outotec is minimizing energy consumption and downtime in crushing processes by relying on performance centres to remotely monitor the crushers. "The size of the particles entering and leaving the crushers and mills can be controlled online," elaborated Eduardo Nilo, general manager of Metso Outotec in Chile. "We developed sensors for analyzing particle size on trucks (VisioTruck) and on conveyor belts (VisioRock and Rock Sense), which are based on image analysis using camera or laser technologies."

As for innovation in mills, ME Elecmetal is using sensors to reduce downtime by ensuring the right amount of tension on the bolts. The company launched several initiatives to introduce smart mill liners. "ME PolyFIT products are part of a new generation of mill liners that combine different materials including rubber, castings, steel plates and ceramics among others, that fit each operation depending on the type of ore and operational conditions," elaborated José Pablo Domínguez, general manager of ME Elecmetal in South America. ■

Ricardo Garib

President
WEIR MINERALS

What is the role of Weir Minerals in the Chilean mining industry?
Weir Minerals is the leading provider of equipment for any wet substances such as slurry or water. We supply equipment to transport these substances, as well as pumps, valves, compressors and turbines. The company consists of three divisions: the minerals division, oil and gas, and the ESCO division. A decision has been made to divest our oil and gas division, so we will focus solely on mining. We can supply the mines from the pit to the comminution and processing of the plant, providing our customers with a solution.
In 2014 we acquired Trio, a Chinese-American manufacturer of crushing and separation equipment for the mining and aggregates markets. More recently, in 2017, we acquired Esco, a leading US-based manufacturer of Ground Engaging Tools (GET) for the mining and construction markets, which operates as a separate division under Weir.

How did the pandemic impact your operations and the Chilean mining industry from your perspective?
We are fascinated by the resilience the Chilean mining industry has shown amid the pandemic, considering its impact on mines around the world. The industry globally adapted to the circumstances and recovered, especially as commodity prices rebounded.
From Weir Minerals' perspective, the pandemic confirmed the importance of our workforce's wellbeing to our organization. Secondly, amid the delays and closures, we persevered and continued supplying our customers around the world. Finally, we were able to leverage our Synertrex Digital platform to monitor and support equipment remotely.

Can you elaborate on some of the technology you use to increase operational efficiency in your processes and equipment?
Our Synertrex platform relies on advanced IIoT (Industrial Internet of Things) technology, using a cloud and smart sensors placed on the Weir product. It collects vital operational data that is transformed more visually to the customer through a digital interface. The service provided by the platform allows problems to be identified before they occur, reducing downtime and optimizing equipment performance throughout a circuit. Equipment wear and tear can be easily controlled, and trouble spots can be detected before they become major problems. As the mines are maximizing operational efficiency and profits, we support them as our service team is on call to ensure no time is lost. However, even though the industry is accepting digitalization today, it is lagging in the implementation of technology relative to other industries, as it preferred to rely on more traditional operations.

How does your recent partnership with Andritz better position you in the market?
Mining companies face immense challenges with regards to the social license to operate. Therefore, they must implement sustainable water management solutions, especially in Chile, where water is scarce. Our partnership with Andritz allows us to offer complete tailings solutions to the mining industry, as they supply dewatering technologies. Under the brand name IsoDry we offer customers a range of mechanical separation technologies, such as thickeners, filter presses, centrifuges and vacuum belt filters, reducing the size of the tailings dam to a tenth of what it used to be.

What are the main challenges facing the mining industry in Chile today?
The mines are located in remote areas, where talent acquisition is difficult, especially since today's workforce, due to Covid, is unwilling to relocate to the site for long periods. Therefore, regarding labour, the industry is finding it challenging to retain talent. We are witnessing changes to the mining working culture with increasing digitalization as many mines are operating their mines from control rooms in Santiago, such as Codelco's Hales. Secondly, energy consumption is another challenge that is being overcome by the shift towards renewable energy sources. Finally, the social license to operate and incorporating communities into the operations continues to challenge the industry.

What goals would you like to achieve as Weir Minerals over the next three years?
Weir Minerals wants to increase its presence as a reliable partner in mining operations. As the mines focus on producing the minerals, we want to continue providing support and the solutions across the operation. ■

Eduardo Nilo

General Manager
METSO CHILE

> **The size of the particles entering and leaving the crushers and mills can be controlled online. We developed sensors for analyzing particle size on trucks (VisioTruck) and on conveyor belts (VisioRock and Rock Sense), which are based on image analysis using camera or laser technologies.**

To what extent did the Covid-19 outbreak impact Metso's operations?
One of the main challenges was to maintain the operational continuity of our clients' tasks without the physical presence of our experts. Due to movement restrictions, it was necessary to apply innovative measures to continue providing know-how through remote assistance methods. Therefore, our remote-control solutions offered us an excellent opportunity to fulfil our objectives more flexibly than in the past.

What are the latest technological developments in crushing and grinding processes using automation?
To minimize downtime, Metso Outotec is using performance centres to remotely monitor customers' crushers. The machines are equipped with sensors and critical maintenance-related data, such as bearing temperatures or vibrations, is collected remotely. Our team of experts provides analytical dashboards that detect anomalies in trends and alarms to take timely preventive actions and avoid costly downtime.
The size of the particles entering and leaving the crushers and mills can be controlled online. We developed sensors for analyzing particle size on trucks (VisioTruck) and on conveyor belts (VisioRock and Rock Sense), which are based on image analysis using camera or laser technologies. Metso Outotec's PSI technology enables the particle size of grout in grinding circuits to be measured online.
The MillSense sensor provides information on the mill's ball load, allowing the mill to always run at the optimum ball load. A SmartEar acoustic sensor detects whether the mill is under or overloaded. Both conditions reduce grinding efficiency, and the lightly loaded mill can lead to premature wear and, in extreme cases, shell cracks, which can be avoided by monitoring the sound.
The operating conditions in the hydro cyclone process directly impact the availability of the plant and the efficiency of the grinding and flotation circuit. Our new CycloneSense metering system will help ensure continuous optimal hydro cyclone operation by providing direct, steady and reliable online monitoring of the hydro cyclone air core. Our unique technology will allow you to see inside the hydro cyclone and visualize its performance. It enables continuous online measurement of cyclone air-core shape, size and location based on process tomography, helping find and maintain the optimal operating point for the hydro cyclone. Additionally, the measurement system helps detect potential issues, such as wiring, and prevents them from occurring.
In advanced process control, Metso Outotec offers OCS-4D & ACT as an applicable optimisation system for all mineral processing operating units. Ensuring stable conditions in mineral processing circuits, optimal particle size for downstream processes, higher throughput, and the recovery of metals and water with minimal energy use are critical factors for our customers. Regarding milling, our APC system uses data optimization particle size feed RockSense, load analysis MillSense and particle size measurements sludge PSI, and other metrics available online.
During crushing, VisioRock and RockSense help adjust the crusher to compensate for wear and control product size. Level sensors monitor tank and crusher fill levels. When the shredder is equipped with a variable frequency drive (VFD), speed can be used as a shredder control variable based on feed and product size sensor readings. For primary gyratory crushers, the SmartStation concept has been introduced, which allows the control system to dynamically adjust operating parameters to improve efficiency and promote longer product life and overall equipment protection.

Where does Metso see the highest growth for 2021 - 2022?
At Metso Outotec, the focus of our work is to provide our clients with tailored solutions according to their needs. Today we have more than 15,000 professionals in more than 50 countries. From the first day of the recent merger, we have used and combined our strengths to form an outstanding team of professionals with knowledge and experience and an offer of high-end equipment and technology to support clients.
I believe that the tremendous technological capacity and the development of new tools that Metso Outotec offers will make the mining industry more sustainable. We will be a company that will contribute to the development of professional technicians with a thorough knowledge of the latest technological developments. ■

Fernando de la Lastra & Joerg von Loebenstein

FL: General Manager and Co-Founder
JL: Engineering Manager and Co-Founder
TECNIPAK


FL


JL

What is the role of Tecnipak in Chile's mining industry?
JL: Tecnipak serves the agricultural and mining industry, specifically mineral processing plants in mining. Mining represents approximately 50% of our sales.
We identified a niche in the transfer chutes of conveyor systems in mineral transport. Initially, we started supplying parts, however, we are now leaders in the design, engineering and manufacture of complete equipment for transfer points and chutes. We also provide several components to better streamline and increase the efficiency of mineral transport, including a full line of belt cleaners and speciality wear plates. Tecnipak currently works with all major mining companies in Chile.

Why did you incorporate the use of black ceramic and stainless steel into the belt scrapers?
JL: We use different grades of stainless steel because the environment is corrosive due to the chemicals of the mining process that wear the coatings rapidly. High-grade stainless steel guarantees a long lifespan of our components - over at least five years. Black ceramic is used for the cleaning edge due to its wear resistance and strength against heat and chemicals. Our products are typically more expensive than those of our competitors, who target more generic processes, while Tecnipak tailors to the needs of the Chilean mining industry's huge processing volumes. Along with black ceramics, we have borrowed many materials from the aerospace and defence industries to combine them with smart assembly techniques to provide superior products. We also incorporate sensors and automation to monitor and adjust the belt cleaners remotely, giving the operator enhanced safety and control.

How does Tecnipak position and differentiate itself in the market?
FL: We managed to differentiate ourselves by finding new and innovative solutions to global problems. Tecnipak is always at the site with our clients, understanding their needs to combine their field experience with our technical expertise and implement advanced solutions.
JL: Tecnipak targets a niche market as opposed to competitors. It is hard to compare us to other providers because their products are more generic, for less demanding bulk handling environments in a much broader array of markets.

Can you elaborate on Tecnipak's curved wear plates efficiency and capabilities?
JL: The conveyed material is directed from one belt conveyor to another or to a crusher, mill or stockpile, and this requires transfer chutes. These chutes have curved surfaces called "deflectors" inside, which are lined with wear plates. Deflectors have a curved shape because the transfer of the material does not go in a straight line, but the wear plates used to protect the surface of the deflector are usually flat due to convenience in manufacturing. Tecnipak has been a pioneer by succeeding in making curved wear plates that gradually redirect the ore so that it flows towards the next equipment in a convenient manner. With this shape, we have made the transition more fluid, which allows the transport of a larger amount of ore in less time, increasing productivity, reducing wear and generating less dust.

How is Tecnipak looking to grow in the upcoming years?
JL: Our strength is in catering to the large hard rock mining operations, where we have a domestic market share of 45-55%. We see room for growth in foreign markets with similar large-scale operations, such as Australia, Peru, Brazil and Canada.
FL: Despite seeing the potential for growth in other markets, we consider Chile a world leader in technology for copper production, and therefore, when our technology is successful in our country, this serves as a good reference when entering overseas markets.

Do you have a final message to our readership?
JL: Mining is a risky activity that can be negatively perceived due to its environmental impact. Tecnipak's mission is to provide mining companies with reliable equipment that can help them reduce pollution and increase productivity and safety. We have a lot to offer in this sense, especially in large scale mineral processing operations, where 30% to 50% of unplanned downtime can be traced to malfunctioning transfer chutes.
FL: Tecnipak also aims to incorporate technology to minimize direct human intervention in transfer chutes and their supporting equipment. Through our technology, we hope to provide the ability to manage conveyor transfer chutes, regardless of their location, remotely. ■

Simão Antunes

General Manager South America
HOFMANN ENGINEERING

What facilitated the company's growth beyond Australia?
The Hofmann family wanted to grow the business, so we targeted markets with a high potential for growth worldwide and expanded to other strong mining markets such as Asia, Africa and particularly South America, where we have been operating for over 30 years.
Nowadays we are well established and with modern workshops and skilled teams in Chile and Peru assisting both mobile mining and fixed plant equipment.

What differentiates Hofmann Engineering in the competitive sphere?
Our products are known for their quality because we constantly invest in product improvement and use the best manufacturing processes in house. However, another way we differentiate ourselves is via our unique customer service experience and we leverage our network of sales and technical engineers who are as close to the customers as possible. Hofmann is also investing in keeping stock in South America – in Chile and Peru, to have components available and reduce lead times.

Where do you see a high growth potential for the company in South America?
The South American market holds significant potential for our expansion. We are established in the markets with the biggest potential: Chile and Peru. In Peru, we foresee rapid growth in the near future. We are also attentive to the Brazilian, Colombian, Mexican and Ecuadorian markets, where we operate on a smaller scale through agents or directly.

Do you have a final message to our international readership?
We now have seven factories around the world (currently building the 8th) and South America is a significant market for Hofmann Engineering, already representing 25% of the company's turnover. We are witnessing our South American operations' fast growth annually, which speaks of our products' quality, price and service level in such a competitive market.
Competition in the market is healthy, drives innovation and efficiency to finally benefit customers. ■

Marcelo Celis

General Manager
BOSCH REXROTH

What are Bosch Rexroth's most recent developments since 2019?
This year we celebrate our sixth anniversary in Chile. We developed our engineering capability in mining and pulp and paper with Hägglunds to rely on technology using IoT for predictive analysis (Condition Monitoring premium). We also developed our independent aftermarket service, including pumps, motors, gearboxes, mobile controls for shovels, drill rigs, loaders and trucks equipment. Lastly, we strengthened our service workshop in Antofagasta to include centralized support and provide the-best-in-class repaired components, all of which will be reinforced soon with an specialized field service team that will support our Hägglunds installed bases in Iquique, Calama and Antofagasta.

What are some of the demand trends you are witnessing this year for your services?
The mining industry in Chile and globally is headed towards machine modernization. Our Rexroth connected hydraulics leverage smart electronic sensors, supported by our IoT-ready Online Diagnostics Network (ODiN) for hydraulic power units and Condition Monitoring premium (CMp) for Hägglunds drives, enabling instant analysis and predictive maintenance. The second trend we witness is an emphasis on specialized field service contracts, demanding an increase of product knowledge and on-site technical support that secures process reliability. Finally, certified service repair is another trend we are seeing, which is crucial for the product lifecycle, especially to reduce costs and the environmental footprint.

Can you elaborate on the digitalization of connected hydraulics offered by Rexroth?
Bosch Rexroth is leading industry 4.0 with connected hydraulics, with CytroBox and CytroPack, under the CytroConnect concept that uses state-of-the-art IoT-ready technology providing functionality and health data that can predict unplanned system downtimes. ■

The use of data analytics

Data has been granted the title of 'the new gold' in recent years, as its processing and analysis can lead to considerable improvements in operations and efficiency as well as reducing costs. Data is relevant to every stage of mining, from exploration to production and mine closure. It is also pivotal in enhancing operational safety during blasting in underground and open-pit operations. "The mining industry today leverages vanguard technologies in its processes, such as automated or remote-controlled machinery and smart sensors for the collection and analysis of large amounts of data," stated Roberto Saragoni, operations manager of Sistemas de Transporte de Materiales (STM), a bulk material handling equipment provider. "Real-time data from these sensors attached to material handling equipment helps to optimize performance by reducing maintenance stops."

According to Eduardo Gorchs, CEO of Siemens in South America (without Brazil), Chile is leading the digitization efforts of data acquisition and analysis in material handling. "Peru is seen as a world leader in digital mining, but many digitalization technologies for mining are developed in Chile as a hub," he confirmed. "One of these digitization initiatives is conveyer belt monitoring, where data is sent to a cloud system which allows for building a digital twin of the conveyer itself."

The amount of data collected every day at mine sites is immense, and it is difficult to identify which could be of use to enhance operational efficiency, especially since data and analytics tools are still at the beginner stage in the industry. Many companies are still working on the advancement and development of data analytics tools across machinery and equipment components, such as Fast Pack, Bosch Rexroth, Outotec Metso and Weir Minerals.

The prevalent use of real-time data analytics in the mining industry is to predict when a piece of equipment or machinery could fail. For example, Bosch Rexroth uses Internet-of-Things (IoT) in its connected hydraulics solutions to predict unplanned system downtimes. Weir Minerals also leverages IoT with smart sensors on its products. "It collects vital operational data that is transformed more visually to the customer through a digital interface," elaborated Ricardo Garib, president of Weir Minerals. "The service provided by the platform allows problems to be identified before they occur, reducing downtime and optimizing equipment performance throughout a circuit. Equipment wear and tear can be easily controlled and trouble spots can be detected before they become major problems."

Even though the use of data will revolutionize mines' efficiency, it is challenging to source data from multiple platforms and equipment onto one system to make informed decisions. The industry has only scratched the surface of data analytics and there remains significant room for development. For example, an area of potential growth using data analytics is the logistics aspect of the industry, which tends to be the most inefficient process. ■

Chile is becoming a technological hub as one of the few Latin American countries with fast advancement towards 5G. As a reflection of this, five submarine cables are currently being built in Chile. Digitalization and data management are growing exponentially, together with remote work due to the pandemic.

- Dante Arrigoni, Director, Grupo Arrigoni

Miguel Ángel Peña

VP of Innovation and Start Ups
ENAEX

What have been Enaex's most recent developments?
Enaex has been working very hard on flight tests with our robotics. 2020 was a challenging year due to the pandemic, and mines were operating cautiously, so we could not undertake any testing in clients' mines and some of our plans were deferred to 2021. However, in the case of Enaex Bright®, we managed to complete some testing in some mines to achieve the completion of some of its libraries/modules.

This year, we will be testing our robotics developments in various underground and open pit mines. We are also pushing hard to research new blasting agents for the mining market. Enaex also expanded its presence to Australia and South Africa. We will continue with R&D activities in Chile and will then export these technologies.

Can you elaborate on the company's strategic partnerships regarding robotics?
As a subsidiary of the Sigdo Koppers Group, Enaex has a mixture of partnerships. Through acquisitions and joint ventures, our strategy is to continue strengthening our international presence in the most important mining regions of the world. Our partners include SRI International, ASI Robots, Corfo, AMTC (Advance Mining Technology Center), GHH, Thecne and SK Godelius. We are continuing to partner with start-ups (Dronia, etc.), academic institutions (Pontificia Universidad Católica de Chile, Santa María Technical University, etc.), and large companies to explore new areas which will complement our core business capabilities. With regards to start-ups, we are looking at companies that can assist us in the development of IoT, AI and augmented reality. From a research perspective, partnerships with academic intuitions have been extremely helpful.

What are Enaex's innovations to enhance safety and productivity?
Safety and an exponential increase in productivity are vital for Enaex, and we have an ongoing development process focused on the delivery of new products and services that address specific problems and innovatively contribute to production process efficiency. We have developed the Safelock system, which locks the detonator in the booster, thus avoiding decoupling and making the priming operation more secure. We have also demonstrated the increased safety and productivity aspects of electronic detonation. Our electronic wireless system communicates with a digital blasting system located a few kilometres from the blasting zone and is controlled by a wireless communication protocol specifically developed and optimized to ensure safe, reliable, and synchronized operation of hundreds of detonating elements in open pit mines. In partnership with SRI, we have also launched Robominer®, which has technology designed to improve safety for miners while also expanding access to minerals in complex and harsh environments. Robominer® in open pit mines and our UG-itruck® for underground mines will both remove people from risky zones. Robominer® works with our Mine-iTruck®, a mobile explosive manufacturing truck in field operations but without people on site. Regarding underground applications, I have to mention our new initiation system solution for tunneling development which will generate an increase in productivity.

How important is cybersecurity when moving towards more autonomous and digitized operations?
Cybersecurity is paramount. Enaex is in conversation with one of the leading communication network providers in the world to understand how we can assist mining companies. We are implementing a very robust plug and play system in mines that offers operational efficiencies but is also high security.

Where does Enaex see the highest potential for growth?
Our robotics solutions can significantly increase productivity, and we want to continue with R&D to keep innovating and provide better solutions to the market. There is also tremendous growth opportunity with regards to sustainability as we want to become a leader in offering sustainable products to the industry. We are focused on energy savings and the reduction of emissions, and we constantly work to improve all activities related to sustainability. The electromobility for our equipment is also an area of growth that currently has our attention. ■

Image courtesy of Enaex

Barriers and challenges to mining technology

There is no doubt that the industry is keen to promote and incorporate technologically advanced equipment and machinery into its open-pit and underground operations, however, it remains risk-averse regarding introducing or allowing piloting of new technologies at mine sites, which is key to developing any new technology. Therefore, new technologies must be introduced through cooperation with piloting centres, such as Ciptemin. "Ciptemin is financed publicly and focuses on providing the means to trial mining technology," explained Cynthia Torres, executive director of the company. "We offer test spaces imitating real operational conditions at the industrial and semi-industrial level so that the supplier can validate their solutions. Once the technology is tested successfully, the supplier is granted a certificate, and proceeds with commercialization separately."

Following the successful trial of the new mining technology, the next step is more crucial: implementation. This stage could pose a challenge to the process if the workforce lacks the necessary skills to correctly execute it. The implementation process challenge was amplified under the health crisis' travel restrictions. Sandvik, for example, responded by establishing the Sandvik Digital Training Centre, allowing for remote training options for employees and customers' technicians.

Meanwhile, Epiroc has a new approach to ensuring a highly-skilled workforce "We are recruiting professionals from other industries such as communication who quickly adapt to the software, as well as expats from Venezuela in the case of El Escondida," commented Izzo.

Finally, another challenge and risk that tends to be overlooked as mining companies move to modernize their mines is cybersecurity. As the industry opens up to internet-connected technologies, it also opens itself up to cyberattack vectors that must be addressed through proper internal controls, or else it risks crippling operations by a single attack.

Ramon Opazo, CEO of Antirion, a leading software provider for mining companies in Chile, stated: "The Chilean mining market is aware of the importance of preventing cybersecurity breaches. There is an improvement in technological culture; however, we believe that progress can be made in some areas." ■

Andrés Costa

Managing Director
SGS CHILE

Can you introduce to us SGS in Chile and its role in the mining industry?
SGS is a world leader in the provision of TIC (Testing, Inspection, and Certification). Our services are primarily dedicated to the mining industry in Chile, representing 90% of our sales. We have a whole metallurgical department dedicated to assisting customers in improving their mineral processing. Meanwhile, our geological department provides certificates for exploration, and the engineering department supports brownfield projects. SGS covers the entire mining value chain from exploration until certification of final product in mining ports, passing through plant design, engineering, processes control and optimization, modelling for production plans, and closure. In Chile we are currently increasing our capabilities in other areas like Big Data and AI, leveraging the global SGS knowledge from areas different than mining because we see significant room for adding value to our mining customers with this expertise due the complexity in copper ore bodies today.

How did you maintain business continuity amid the pandemic?
Our priorities at the beginning were focused on maintaining our support service to our clients while keeping our staff safe, supporting a strategy of headcount reduction on mine sites as well. We implemented some radical changes and modifications to our day-to-day activities to continue operating since the mining industry and production were not halted. The market has undergone massive changes in the last two years regarding the manner of communication with clients, which Covid-19 accelerated even further. Some of the modifications we introduced include remote inspection and the elimination of closed space offices. We developed a single open space office called "Co-Work" where our employees can work as a flexible cell and connect physically when they need to.

To what extent are you integrating technological platforms into your service offering?
SGS communicates with clients using an online platform where they can easily access the testing process, results and timeline from any device. We also offer remote certification and assistance where the laboratory equipment can be connected from a distance to move data and analyse it. While all of these processes were available as part of our offering in the past, companies started paying more attention to these services in 2020. Mining companies were more cautious and conservative in the past regarding sharing data.
SGS is looking for partners in AI in Chile and elsewhere to advance and develop further its digital offering.

Can you elaborate on SGS's mobile laboratories solution?
Previously, we operated using a central laboratory where all the collected samples were analyzed. Today, we offer solutions such as a laboratory owned by the customer on-site, while we provide the expertise and analysis services. Another creative solution we implemented is SGS's mobile laboratory, which moves flexibly to different sites, taking advantage of our expertise and experience in real-time at the remotest locations. Both solutions allow for the rapid processing of samples and data, especially when taking into account the rapid communication technologies under development, such as 5G.

Which of SGS's services has been the most popular in the Chilean mining industry recently?
SGS Eng & Optimization area has been developing an Asset Integrity monitoring project in a remote manner, modelling the performance of critical assets supporting operational continuity and FTEs reduction. In addition, our metallurgical support has gained more traction recently, as we offer a comprehensive range of unit operations in support of flowsheet development and metallurgical process design such as flotation, comminution and beneficiation, gravity separation and others. We are also witnessing that the geological aspect of mining in Chile is becoming increasingly challenging for both open-pit and underground operations. Therefore, we see a growth potential for our services in this aspect.

Where does SGS see the highest growth potential in the upcoming years?
We want to utilize our capabilities to facilitate our growth by satisfying the needs of our customers to the highest degree possible. It is effortless for companies to declare their operations as sustainable, but actually to act upon it that is what differentiates corporate cultures. SGS is determined to innovate in a sustainable manner and live up to its sustainability promise to become the ideal partner in the mining industry. ■

Marcelo Schumacker

Country Division Manager
ABB CHILE

What are ABB's lines of business, and how do they relate to the mining sector?
ABB has four main lines of business, all of which add value to the mining sector. First, we are involved in process automation, offering systems formed mainly by automation and electrification including services. Second, we have a motion business through which we supply drives and motors. Our third line of business is related to electrification, through which we offer low and medium voltage products. In this area, we made a large acquisition of GE Industrial Solutions. Finally, we are active in the robotics sector.

What have been the company's main milestones in the last 12 months?
ABB has been involved in the automation and electrification process of Gold Fields' Salares Norte mine. We have also been engaged in Codelco Chuquicamata's project of ventilation on demand, where this solution could provide savings of 30-50% in energy consumption. I must mention that we are working hard to certify in Chilean Standard 3262 on Gender Equality and Conciliation (SIGIGC), working, family and personal life.
Finally, ABB has been involved in the most prominent mining construction project in Chile, in Quebrada Blanca Fase 2 (QB2) by Teck with most of the automation and electrification equipments portfolio, including GMDs, whole automation etc.

Which of ABB's technologies has gained traction during the pandemic?
Automation solutions have been becoming progressively more popular throughout the years, much before Covid-19. However, the pandemic has changed circumstances radically and has given our clients an inevitable push towards the adoption of new solutions to counter challenges such as social distancing.

What is the extent of digitalization in Chilean mines?
The level of digitalization in Chilean mines is remarkable and is reflected in projects by companies such as Gold Fields who are incorporating solutions of energy efficiency, asset management and digitalization. As a reflection of the willingness to innovate in the industry, Codelco has recently signed a Memorandum of Understanding with an innovation mining cluster from Sweden, supported by Business Sweden, including companies such as ABB and other strategic partners and providers, with the aim of advancing on topics such as sustainability, optimization of efficiency and productivity, and to exchange information and cooperation among Coldelco and some Swedish mining companies.

Can you elaborate on the contribution of ABB to Gold Fields' Salares Norte project?
Gold Fields' Salares Norte mine is a pioneer in the incorporation of new technologies and innovative solutions. ABB is currently working on the electrification and automation of this project. We will provide a digital solution based on Ability™ 800xA, including hardware and software, as well as six electric houses of approximately 700 square metres, with their electrical equipment, for the distribution of low voltage and medium voltage. In fact, we have worked with Claro and Nokia to carry out the first satellite test for this project, showing our client how Salares Norte, located in the isolated region of Atacama, can be managed from a control centre in Santiago thousands of kilometres away, but within reach of the satellite. Another test we carried out involved the use of 3D lenses to show how we can be constantly available for our clients, supporting them through new technologies from Santiago or from our ABB development units located abroad Chile. ■

Eduardo Gorchs

CEO South America (w/o Brasil)
SIEMENS

What are some of the current projects Siemens is working on in Chile?
We have been working with Antofagasta Plc at Los Pelambres for several years, and this was our first big maintenance project with a significant amount of technology involved. Approximately half of Siemens' gearless mill drives installed worldwide are in Chile. The latest implementations that we have done were for BHP's Spence mine and Codelco's Chuquicamata project. Every time we introduce new equipment into a project, we try to involve local know-how as much as possible, which also helps to build our team in Chile which nowadays is fully focused on introducing the concept of digital mines.

Can you elaborate on Siemens´ Mineral Digital Architecture approach and the use of AI and IoT in mining?
Siemens has an IoT offering, the SIDRIVE IQ, which records all relevant operating and condition data from drive components and transmits them to our cloud-based system, MindSphere. This system maximizes availability, serviceability, performance and efficiency. We already have over 20 digitization systems running in Chile, and the demand for these is also increasing in Peru. In terms of process, Siemens is using the concept of digital twins. A digital twin is a virtual representation of a physical product or process, used to understand and predict the physical counterpart's performance characteristics. They are used throughout the product lifecycle to simulate, predict and optimize the product and production system before investing in physical prototypes and assets.
In collaboration with Anglo, we are developing the first digital mine in Peru.

What is the extent of digitalization in Chilean mines?
Peru is seen as a world leader in digital mining, but many digitalization technologies for mining are developed in Chile. One of these digitization initiatives is conveyer belt monitoring, where data is sent to a cloud system which allows for building a digital twin of the conveyer itself. There are also significant digitalization efforts to increase safety with technological apps.

What demand is Siemens witnessing for its products and services, given the increasing shift towards sustainability and green copper production?
Sustainability is core to Siemens' business and can be simplified to digitalization, automation and electrification. The basis of digitalization and automation is electrification, and when you supply energy from renewable sources, you are enhancing operational sustainability. We invest in helping companies become more environmentally conscious. Water usage also goes hand in hand with sustainability, and there is currently a huge trend of desalination projects in Chile.
We are looking forward to becoming involved in these projects as we can provide solutions for pumping the water to the mines, which can become quite complex due to the high altitudes of Chilean mines.

What is Siemens' strategy for growth for 2021-2022?
From a safety perspective, we strive towards a zero-harm sustained goal. We also have a carbon reduction strategy, and we strive to be carbon neutral by 2030, not only internally but also with our customers and suppliers. Cybersecurity is becoming increasingly important as our digitalization efforts advance, and our goal is to have zero cyber incidents. ■

Carlos Escudero

General Manager
GEOCOM

What is the role of GEOCOM in the Chilean mining industry?
GEOCOM is the leading provider of geospatial equipment and software used in measurements in mining in Chile for the last 35 years, representing and distributing for world-class suppliers, such as Trimble from the USA, Riegl from Austria, Geoslam from the UK, senseFly from Switzerland, DJI from China and others. Our goal has been the provision of the best and latest technology available on the market. In 1990, we introduced GPS technology in mining and, in 2000, we installed GNSS reference stations on sites. A decade later, we started providing laser scanners, creating point clouds for precise measurements. We work with large-scale mining companies as well as juniors, as our drones offering is relevant across the industry.

How did the demand trends for geospatial equipment in the mining industry evolve?
Mining represents 50% of our sales, and as GEOCOM, we have a market share of approximately 43% in geospatial equipment in Chile. Today's industry is demanding remote control and automated equipment in all its processes to minimize the physical presence of workers on-site and optimize the operation.

Can you elaborate on the NASAP technology GEOCOM offers and how it enhances efficiency?
Several mines in Chile are located in the Andes Mountains at high altitudes, where snow in winter impact operations. This was our first comprehensive development for mining to navigate machines to help in removing the snow from the roads more safely. This is our HUSKY product. With this knowledge we developed new products such as NASAP, which uses HP-GNSS technology and other sensors and comms. This technology is used in drills to navigate and guide them precisely to each borehole and gather critical information for drilling and blasting operations.

Is there a market gap you identified that you are conducting R&D for at the moment?
GEOCOM has a department dedicated to R&D to develop equipment with the latest technology. We are focused on supplying technology that processes measurements in the shortest time frame, which is a market gap we saw in mining. Mining companies need a technology that saves time in processing and analyzing measurements, that usually take over one or two days, so we are looking at more products that allow real time processing.
Another area of research we are focusing on is augmented reality (AR) technology in mining. This technology can be a game changer in the industry, since it can be applied in different areas, such as drilling, critical inspection, site operator training, maintenance and repair as well as real-time operator assistance. It will enable remote distance support and provide management with a real-time visual guide to operations. The use of AR in mining will disrupt and revolutionize the industry and is set to change the future of mine safety.

Where do you wish to see GEOCOM in the market by its 40th anniversary?
Our teams travel the world to source the best technology for the market. We have witnessed rapid and sustained growth of our business over the last 35 years. Our strategy will continue to be one that thrives on technology and ensuring a high level of support to our clients by leveraging the unique skills of our workforce, who worked on mining sites and are familiar with their needs. ■

Carlos Ponce, Humberto Pasten & Jorge Marchant

JM: VP Mining Latin America
CP: General Manager
HP: Mining Division Manager
MATHIESEN


CP

HP

JM

Can you elaborate on the innovative and sustainable sourcing solutions you provide regarding tailings management?
HP: In Mathiesen our first objective has been to focus on optimizing the recovery of valuable elements (Cu, Mo, Ag, Au, etc.). We are promoting products that favor water recovery and improve the tailings management process, as these are essential topics, especially in Chile. We work with companies that are dedicated to tailings management for the extraction of copper, molybdenum, and water elements that have value through a sustainable exploitation reaction.
JM: Beyond being a supplier of chemical reagents, our company is constantly looking to introduce operational improvements in the recovery processes of different minerals and to provide support to mining companies by analyzing mineral samples for mineral recovery.

Are mining companies increasingly outsourcing their on-site laboratories?
JM: In mid-2020, our company invested in a laboratory in Peru, like the one we have in Chile, with highly qualified workers, which was constituted sharing practical and technological information. Mining companies can outsource certain activities to these laboratories to generate data and recommendations for decision-making.

What growth opportunities do you see in Chile in the next three years?
JM: Mathiesen plans to continue investing in strategic points such as Antofagasta, the center of our regional expansion in Chile. Recently, we have also invested in a new production plant in the northern part of the country. We also plan to continue investing in technology, innovation, human capital, and logistics.
HP: Given the unique chemical properties of mine tailings and the importance of its processing, the company also plans to boost investment in water treatment and to search for new chemical products that are more environmentally friendly and improve the recovery of copper and other secondary elements. The lithium industry is a potential new line of business. ■

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1. Concluding Thoughts

"The mining industry is one of the pillars of the Chilean economy, with its tentacles spread wide across the nation, supporting businesses in many regions. As a result of its significance, mining production was not halted amid lockdowns, curfews and the outbreak."

- José Castillo,
Managing Director,
Rema Tip Top Chile

"The industry in Chile is maturing to a large extent, which is pushing it to the realization that the cost advantages the industry benefited from in the past are no longer there. This is driving innovation to minimize costs and opening the industry for improvement."

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

"We will continue to invest internally in our production facilities and technology to enhance our production capacity. We are always on the hunt around the world for integrated solutions and technologies to implement."

- Tomás Cruz,
Piping Business Unit Manager,
Fast Pack

"Our greatest strength is that we take good care of our workers and the relationship with clients, and when this relationship is consolidated, it facilitates our business growth. Providing good service and having an excellent after-sales market is our key priority."

- Alejandro Miranda,
General Manager,
Doosan Bobcat

"Chile is undergoing dramatic changes politically and is in a peculiar position economically amid the pandemic. Therefore, considering the uncertainty in Chile's future, our primary goal is to maintain our current clients and consolidate our activities by providing excellent services to large-scale mining operator."

- Alejandro Vega,
General Manager,
Ava Montajes

Concluding Thoughts

"It is effortless for companies to declare their operations as sustainable but actually to act upon it that is what differentiates corporate cultures. SGS is determined to innovate in a sustainable manner and live up to its sustainability promise to become the ideal partner in the mining industry."

- Andrés Costa,
Managing Director,
SGS Chile

"One of our most significant milestones in 2020, is that we now supply all the major mining companies across the country. Under Polimet, we have increased our market share in the mid-tier mining sphere. Our competitive advantage is in the creation of robust engineering capacity, and our tech-focused manufacturing capacity."

- Tomás Buttazzoni,
General Manager,
Technosteel

"As the copper price robustly recovered, we are witnessing several clients in a hurry to move rapidly to develop their projects to take advantage of the current market dynamics. Therefore, our efforts are geared towards developing projects in the shorter schedules our clients are requesting."

- Roberto Saragoni,
Operations Manager,
Sistemas de Transporte de Materiales (STM)

"Sustainability is fundamental for Volvo Group. We are implementing a national strategy that brings together a series of initiatives that seek to positively impact the environment, society and the economy."

- Jorge Masias,
Managing Director,
Volvo Chile

"The destruction or loss of data is our main concern. In this sense, cybersecurity is essential and we allocate many resources to its prevention. We adhere to our cloud providers safety requirements and we have in-store procedures that go beyond that to ensure even better coverage."

- Ramón Opazo,
CEO,
Antirion

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