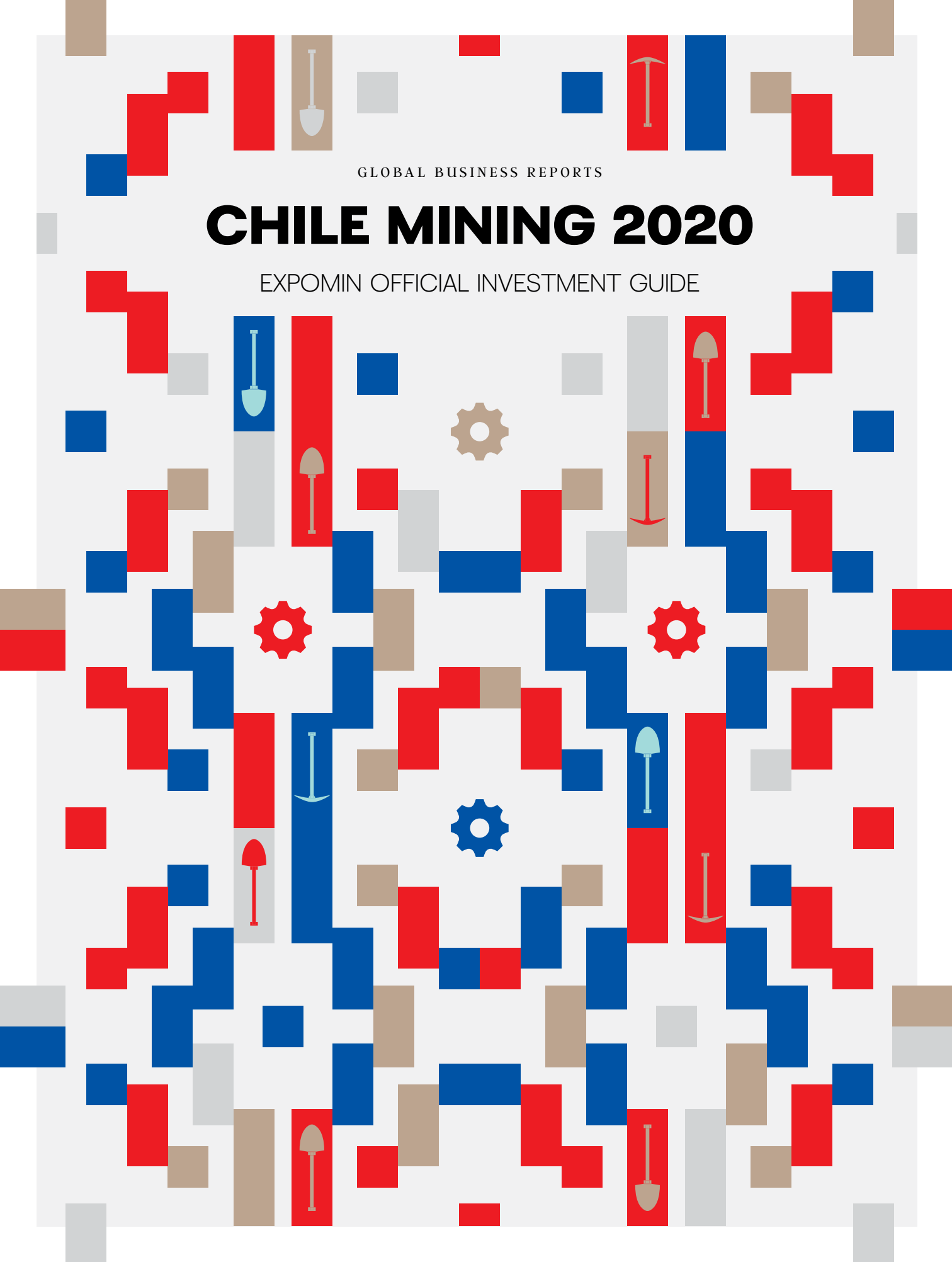
GLOBAL BUSINESS REPORTS

# CHILE MINING 2020

EXPOMIN OFFICIAL INVESTMENT GUIDE



## Dear Reader,

Chile, long considered a stalwart of stability in the Latin American region, experienced an unusually tumultuous 2019. An eruption of civil unrest and mass protests over the country's high rate of inequality and the rising cost of living raised questions regarding the stability of the country and its most important industry.

Despite the headlines, Chile's miners continued to invest in large brownfield expansions and, to a lesser extent, greenfield projects, in hopes of tapping the country's vast geological potential for decades to come. According to Consejo Minero, the country anticipates investments amounting to approximately US$72 billion, coming from projects to be developed in the 2019-2029 time period.

At the beginning of 2020, things looked promising, as the copper price had began its recovery on the back of improved trade relations between the US and China. The general sentiment was that the global economy was on the mend. These dynamics have since shifted drastically as coronavirus spread around the world. Few, if any, countries have been untouched and as a result of government enforced lockdowns, movement and commerce have come to an abrupt stop. Consequently, demand for most metals has fallen substantially.

This is a profoundly complicated problem for Chile at a time when the country is depending on its trusted mining industry to bolster its economy and lead it out of social crisis. Across the value chain both local and global companies are eager to deploy the latest technology and cutting edge engineering approaches to capitalize on the wealth of opportunities in everything from lithium, copper and gold. However, it is unclear how the pandemic will affect the overall health of the Chilean mining industry going forward.

Certainly, conferences have been temporarily put on hold, which is why Global Business Reports is releasing its digital format Chile Mining 2020: Official Investment Guide to EXPOMIN, produced in partnership with FISA, the organizers of EXPOMIN. As we navigate these uncertain times, it is crucial for both national and international investors, mining executives, and technical experts involved in Chile's mining industry to support each other and remain well informed.

This publication offers widespread coverage of the current state of Chile's mining industry, including its leading producers and operating mines, exploration companies and their projects, as well as examining the different providers across the value chain, from engineering to mining equipment and services. We sincerely hope that you have a great conference, full of business and networking opportunities. Thank you for your participation in EXPOMIN, and we hope you enjoy reading Chile Mining 2020.

**Alice Pascoletti**
Managing Director
Global Business Reports

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## Chile



**CHILE MINING 2020**
*EXPOMIN Official Investment Guide*
Global Business Reports and EXPOMIN

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# INTRODUCTION TO CHILEAN MINING

**» Chile has been a mining country since before the arrival of the Conquistadors and will be a mining country for much longer. We want to maintain Chile's status as the largest producer of copper in the world. «**

**- Baldo Prokuriça,**
**Minister of Mining,**
**Government of Chile**

Image courtesy of Vinícius Henrique on Unsplash

# Chilean Miners Display Resilience Despite Socio-Political Uncertainty

## SOCIAL TURMOIL FORCES RECONSIDERATION OF PINOCHET ERA DEVELOPMENT MODEL

Prior to October 2019, the pervasive view held amongst Chileans and outside analysts was that Chile was immune to political destabilization and social unrest. Although populism was spreading across Latin America and several other parts of the world, Chile was viewed as a consistently strong economic performer with relatively moderate politics. At the sustainable mining conference in Santiago in September 2019, the most profound challenges facing the Chilean mining industry were outlined: weakness in the price of copper and lithium, water scarcity, declining ore grades, social license, high energy and labor costs to name a few. One concern absent from that list was internal stability.

For the past three decades, Chile has been viewed by investors as a bastion of calm in an otherwise politically precarious region. Chile achieved its status as a leading mining jurisdiction not only because of its high quality and easy to exploit resource base, but also because its policies toward mining were regarded as best in class from an ease of doing business perspective.

In light of the October 2019 protests that shocked the country, questions have been raised regarding Chile's ability to maintain its status as Latin America's most stable and successful country. The civil unrest was seemingly triggered by increased metro ticket prices, but at its core the disorder is fuelled by a gathering sense of economic inequality. Since 1990, the country's restored democracy has maintained the broad outline of free-market policies installed by Pinochet's dictatorship, which have enabled consistent, long-term economic success. Famed economist Milton Friedman referred to this growth from deregulation and open markets as "The miracle of Chile."

The poverty rate has fallen from over 40% in 1990 to under 9% today, according to World Bank figures. The middle classes now form a majority, income inequality is below the Latin American average and Chile received the region's highest score on the United Nations Human Development Index, which is predicated on a blend of life expectancy, education and national income per capita.

In the context of the region, this performance is strong. However, compared to its rich country peers in the OECD, Chile ranks highest in economic inequality. UN reporting found that the richest 1% of the population earns 33% of the nation's wealth. This fact is one of the principal reasons why there is such widespread anger. Poor and middle class people, who rely on public transport, feel that the burden of state funding is being unfairly placed on them at a time when middle class wages are stagnating and low skilled jobs are being replaced with technology. Rising expectations that have gone unfulfilled are surely a part of this story.

Much of Chile's economic success has come on the back of a robust mining sector that has been, and will continue to be, the lifeblood of the economy. Chile is the world's top producer of copper and exports of the metal account for approximately 10% of the nation's GDP. It also possesses the world's largest lithium reserves, according a U.S. Geologic Study (USGS) report.

It is unclear what, if any, backlash there will be on heavy industries such as mining in the long-term. The protests caused disruption to the typically efficient operational environment throughout the country, but strikes within the mines were limited to a few union groups and interruptions were overall minimal.

According to Joaquín Villarino, president of Consejo Minero: "October and November 2019 very hard months for Chile. We believe that the social unrest is transitory. However, it will mean profound changes in certain public policies in the country in order to improve the quality of life of those Chileans who are suffering. We are optimistic that regulation of the mining industry will not change dramatically."

In Chile, mining is taxed at a rate of 40%, one of the highest percentages globally. Villarino continued: "There is not much room to raise taxes, but it is something we are anticipating."

Mining Minister Baldo Prokuriça is similarly optimistic that the mining industry will continue functioning as normal: "Chile has a long history with a stable mining investment climate and the current situation will not erase that. There are doubts regarding the referendum and the new constitution, but it must be remembered that Chile has very clear laws protecting investors and respecting private property, freedom of expression and human rights."

It is not just those who took to the streets armed with clanking pots and pans who were disappointed in the pace of economic growth in 2019; mining companies also had high expectations going into the year. However, predictions of demand outpacing supply for copper and lithium never materialized. The demand shortfall for these commodities can be blamed on a variety of global economic factors, but the most salient are the China-U.S. trade war and economic stagnation in Europe. These have taken a toll on global manufacturing activity and, given copper's critical end usage in everything from carmaking and earth-moving to advanced electronic components, a slowdown in manufacturing was bound to put downward pressure on the commodity price. Adding to the pain was the fact that Chilean copper production fell 2.5% in the first half of 2019 on the back of declining copper grades according to a study by the International Copper Study Group (ICSG). 2020 has seen a precipitous drop in the copper price, due to coronavirus and will undoubtedly put producers and service providers under extreme pressure until the disease is subdued and global economic activity begins to recover.

Given these dynamics in the market and protests that crippled the nations retail economy in October and November 2019, it is a testament to the dynamism of the Chilean economy and sound management practices in its mining industry that the economy still managed meagre growth. Although growth was well below expectations, it is still far better than that of its regional peers; Argentina, which is in recession, and Brazil, whose economy has stagnated.

**GDP (PPP)**
Source: World Bank 2018
**US$474 billion**

**POPULATION**
Source: Censo 2017 Instituto Nacional de Estadísticas (INE)
**18.4 million**

**GDP PER CAPITA (PPP)**
Source: World Bank
1970
**US$2,300**
2018
**US$25,222**

**POVERTY RATE**
Source: Ministerio de Desarrollo Social
1989
**47.0%**
2017
**8.6%**

**MINING**
Source: Banco Central de Chile
**10% of GDP**

**PRINCIPAL MARKETS**
Source: Dirección General de Relaciones Económicas Internacionales Chile
**China 30%**
**USA 17%**
**EU 14%**

**TRADE**
Source: Dirección General de Relaciones Económicas Internacionales Chile
**26 FTAs**
(64 markets)

**INFLATION (CPI)**
Source: IPC June 2019 Instituto Nacional de Estadísticas (INE)
**2.3%**

# Baldo Prokuriça

Minister of Mining
**GOVERNMENT OF CHILE**

**Chile can maintain and increase copper production despite ore grade decline, and the aim of our government is to help facilitate an environment that encourages further investment in the mining industry.**

**What are the most important initiatives and policies the Mining Ministry has promoted during your term?**
The most important initiative was to help reactivate mining investments in the country and reshape the industry to become more environmentally friendly and productive. In addition, we have focused on providing strong support for small and medium-sized mining companies. During our term, the State-backed mining companies began working in lithium and we are working to improve the situation of the national mining company. We want to generate a new national mining policy that will help Chile sustain its competitiveness through 2050 and I believe that we have achieved progress in this area.

**What progress is being made in Chile to reduce carbon emissions and make the country a leader in sustainable mining?**
Chile has made it a priority to focus on electro mobility. The country has invested US$2,2 billion in Codelco and US$80 million in ENAMI to reduce emissions from smelters. US$200 million have also been invested in private smelters. We invested US$3 billion in December 2018 in order to significantly reduce the emissions of Chilean smelters. There are a lot of mining companies that are using renewable energy. In 2021, ENAMI will operate on 100% renewable energy. BHP has just made a public tender of 6 gigawatts to use 100% renewable energy in 2022. Codelco uses renewable energy and electric vehicles in their mines and the trucks in which they transport their workers. Chile is a leading jurisdiction in terms of renewable energy adoption.

**What production level do you expect Chile to reach for copper? Do you expect the country to be able to maintain and grow copper production in the future?**
We currently extract 5.5 million mt/y of copper and hope that by 2020 we can reach 6 million mt/y. We believe we can achieve this with the upcoming projects that are currently in development and with Codelco´s pipeline of investments. Chile can maintain and increase copper production despite ore grade decline, and the aim of our government is to help facilitate an environment that encourages further investment in the mining industry.

**How is the government incentivizing efficient use of water and technologies such as desalination?**
Chile is experiencing its worst water crisis and its worst drought in the last 60 years. From that point of view, there has been a lot of effort on the part of the mining industry to reduce continental water usage. Today, 8% of Chile's copper mining projects use desalinated water and we expect that number to grow substantially in the future. There is a great effort to recycle water. That is why there are projects from companies like Anglo American, that recycle up to 80% of water and forecast to have 100% recycled water in the future.

**In the wake of social unrest, how can the government reassure investors that Chile will remain a leading mining jurisdiction in the future?**
Chile has a long history with a stable mining investment climate and the current situation will not erase that. The record of stability in Chile supports the idea that we will be able to resolve our differences and that the social turmoil will be solved. I think there are doubts regarding the referendum and the new Constitution, but it must be remembered that Chile has very clear laws protecting investors and respecting private property, freedom of expression and human rights.

**What potential does Chile have to grow its presence in other minerals such as cobalt and to remain competitive as a lithium producer?**
We are promoting investments from companies in cobalt mines so that this element, which is key to lithium-ion batteries can be marketed and included in foreign investments in our country. The ultimate goal is for Chile to become a supplier of lithium ion batteries to the global auto sector. We want to jump into the value-added chain. We are the world's second-largest lithium producer; we have salt flats, and we would like to get as close as we can to the manufacturing of batteries and the manufacturing of elements to store energy, which we believe could create more revenue, more jobs and more opportunities for Chilean families.
Codelco and ENAMI have both signed agreements to develop projects and Codelco has committed to invest US$10 million for exploration in the Salar de Maricunga. ■





# Joaquín Villarino

Executive President
**CONSEJO MINERO**

**Mining production in Chile grew considerably until ten years ago and then stabilized at around 6 million mt/y of copper, which is 27% of the world's copper, making it the largest producer in the world. This year we will probably see a small decrease, but production will be around 5.9 million mt/y. The industry has the capacity to produce that amount of copper for at least 30 more years.**

**Could you provide us with some context about Consejo Minero?**
Consejo Minero is an organization that is 22 years old and brings together the major mining companies in the country, which combined produce 97% of copper, 71% silver; 55% gold and 97% molybdenum in Chile.
We have four fundamental targets. The first is to communicate what the mining industry does in terms of investment, profitability and taxes. Second, we try to foster a competitive and sustainable industry. Thirdly, we have the mission to participate in the discussion of public policies that affect the mining industry. Finally, we are focused on promoting the improvement of the skills of workers in the country. We are in contact with educational organizations to ensure that the training and education of workers is keeping pace with technological changes in the industry.

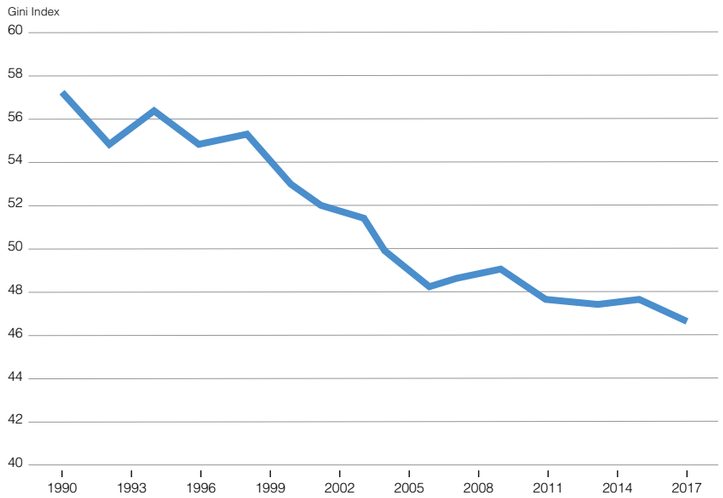
**What are the medium and long term prospects for the mining industry in Chile?**
Mining production in Chile grew considerably until ten years ago and then stabilized at around 6 million mt/y of copper, which is 27% of the world's copper, making it the largest producer in the world. This year we will probably see a small decrease, but production will be around 5.9 million mt/y. The industry has the capacity to produce that amount of copper for at least 30 more years.
From the perspective of investment, we have a pipeline of approximately US$72 billion in new projects to be developed over the next 10 years. 58% of that portfolio is highly likely to happen; the rest will depend on factors, such as the copper price, which has been kept low by the trade war between China and USA. We will have a sustained increase in demand for copper in the world that, with the market projections, it will be hard to satisfy, so there should be an upward pressure on the copper price, which would make it possible to execute all the projects.
October and November have been very hard months for Chile. We believe that the social unrest is transitory, but it will mean profound changes to certain public policies. This will help improve the quality of life for many Chileans who are suffering from not having access to basic services. We expect that violence is going to be controlled and we are optimistic in our belief that regulation of the mining industry will not change dramatically. In Chile, mining pays around 40-43% of taxes; it is second only to Australia in taxes paid.

**There is a trend in Chile where open pit mines are transitioning to underground operations. What are the implications of this transition?**
It is a paradigm change for Chile, which has been characterized by having large open pits, with the exception of El Teniente. Chuquicamata, after being the largest copper pit in the world for many years, is going underground. The expansion of Los Bronces is also planned to go underground. This generates challenges and opportunities. The underground deposits imply stopping the exploitation of many mining resources buried, but they have less impact on the surface, so places where there are glaciers or vegetation remain intact and, in addition, it generates less dust. On the other hand, it is a great opportunity to introduce technological changes in the field and have more machinery that is remotely operated, which improves safety and efficiency.

**What are the reasons why Chile has a high cost of production?**
We have a higher energy cost because we had stress in our energy grid for many years, which led companies to sign long-term contracts at prices of more than US$100 per MWh. That is more expensive than in Canada, Australia, US or Peru. This problem is being solved because tenders have changed, and renewable energy is now being introduced, which is causing prices to decrease. Another reason for the high cost of production in Chile is that our workforce is expensive. Salaries for Chilean miners are similar to the US, Canada and Australia. However, productivity is lower. Lastly, Consejo Minero is working to promote a more reasonable legal framework in which the approval of projects does not take so long. ■

## INCOME INEQUALITY IN CHILE

Source: World Bank




## YEARLY PER CAPITA INCOME IN LATIN AMERICAN COUNTRIES (2018)

Source: World Bank


Chile's history of churning out successfully run local businesses devoted to the mining industry is undoubtedly a positive driver of wealth creation. In describing the advantage Chilean companies have over large global enterprises, Ivan Rayo, general manager of Chilean engineering consulting firm JRI, said: "Being a Chilean company means that our clients benefit from increased flexibility. For example, many operations are struggling to stay profitable with a depreciated copper price. Local businesses excel in responding quickly to adjust costs and implement solutions."

Another locally run business, PerfoChile, has 35 years experience as a drilling services provider. General manager Osvaldo Carmona outlined his approach to weathering turbulent times: "We have focused on building our cash reserves over time in order to invest through good and bad economic and political climates."

Although mining is not experiencing its best year, companies continue to invest. Almost US$66 billion has been earmarked for Chilean mining projects for the period of 2018 to 2027, and 43 mining projects will be built or will begin production by the end of 2023, according to the Ministry of the Economy. The biggest project is Teck Resources' Quebrada Blanca phase II, which involves US$4.2 billion in investment over the next five years to extend the life of the copper mine in the Tarapacá region. Antofagasta Minerals, meanwhile, will invest US$3.7 billion to expand its Centinela copper mine, with construction starting in 2021. The third biggest project is Nueva Unión, a joint venture between Teck and U.S.-based Newmont GoldCorp, that needs US$3 billion over five years for construction of a copper-gold mine.

These new investments are needed to offset a potential decline in production from some of Chile's largest and most reliable sources of copper. After 104 years of production, Codelco's Chuquicamata, the largest open pit mine in the world, closed its surface operation and commenced its underground phase, and there is uncertainty surrounding the mine's ability to maintain current production levels, particularly in the near-term. Codelco is expected to invest US$5.58 billion according to Consejo Minero in order to achieve a production level of 140,000 mt/d of ore, with an approximate mine life of 45 years.

At the end of the day, it is important to keep in context the sheer size of opportunity the Chilean market represents. Chile holds 22% of the world's copper reserves, 11% of molybdenum reserves, 5% of silver reserves, 7% of gold and 48% of the world's lithium reserves, according to Invest Chile. Furthermore, the quality of these reserves is often described as best in class. In light of the civil unrest, political sensitivities have become a more important part of the discussion regarding mining in Chile, but given the role that the mining industry can play in delivering a better future for Chileans, it is important that it prevails in the face of any populist backlash. Jorge Maldonado, general manager of Superex, a leading company in sonic and diamond drilling, summed this sentiment up: "Sometimes Chile forgets how vitally important a strong mining sector is to the health of its broader economy. We must not miss our opportunity to lead in mining." ■





# Jorge Cantallopts

Vice President
**COCHILCO**

**What is the mandate and mission of Cochilco?**
Cochilco is a government institution that was established in 1976. Our main focus is advising the Chilean government on the implementation and evaluation of public policies, strategies and actions that contribute to the sustainable development of the national mining sector. Cochilco also aims to safeguard the interests of the state and its mining company Codelco, supervising and evaluating their management and investments.

**What areas of mining today are most in need of policy reform?**
Improving the level of engagement between the mining industry and the community is critical. We believe that previous relationships between mining companies and communities have been more transactional rather than developmental. The mining industry should be more involved in the development of local communities, so we are studying how to improve these relations.

Mining is perceived as a dirty industry, but we need to educate communities that mining can be sustainable, environmentally friendly and contributes significantly to the economic development of Chile. Good public policies are necessary to build a new system that encourages companies to build relationships with local communities. We also believe that the government should have a more active role in early stages of mining projects to promote and incentivize sustainability and efficiency through the implementation of technologies.

**What is Cochilco's view on automation and digitization?**
One of the issues with automation is that you are taking the worker out of the mine, which can be a great thing in terms of safety and cost efficiency. The problem is that automation is often viewed as a threat to today's workforce. It is the responsibility of the industry to educate people that automation is not replacing human capital, but rather creating different and safer jobs.

**Can you highlight some of the policy proposals Cochilco has made over the last three years?**
We are working on developing our long-term vision, which involves improved engagement between mining companies and the communities. We are also proposing a new mining code which will incentivise new exploration in Chile. Another topic of discussion is the use of public infrastructure for desalination. We have been working on proposals to create incentives for the use of public infrastructure for water projects.

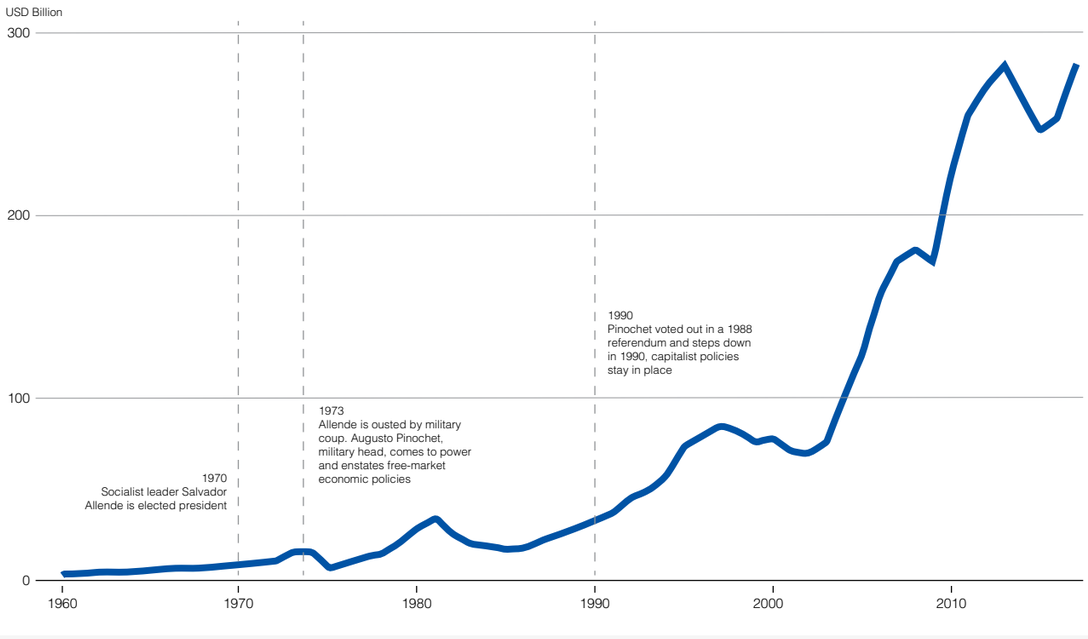
**Is there anything that is being done to try and streamline the permitting process in Chile?**
Cochilco investigated how long it takes a company to obtain approval and licences. We proposed solutions to the Minister of Mining to speed up the process. Some of the proposed solutions have been implemented, but the permitting process is still a challenge. Currently, it can take up to two to three years to obtain permits for exploration. In addition, environmental and social permits are also required. The entire process can take up to a decade, which is way too long and also gets quite expensive. This scares investors and thus it is necessary for Chile to streamline the permitting process to attract more investment. Because the permitting process is timely and expensive, the Chilean mining market is dominated by major mining companies and there are too few junior companies operating in Chile.

**How does Cochilco see the ability of Chile to offset some of the more mature ore bodies?**
The best way to fight the decreasing grade of ore bodies is by increasing exploration. This is one of the reasons why we want to create incentives for exploration in Chile. Another way for mining companies to offset declining ore bodies is to improve their processes and to become more efficient in implementing technology. Declining ore grades are a huge challenge, because it leads to greater demand for water and power. It is a great advantage that electricity prices in Chile are decreasing and this is impacting the decisions of mining companies operating in the country.

**Do you foresee that the civil unrest in Chile will have any backlash on the mining industry and business climate in general?**
I believe that we are going to see some big changes in the near future. How politicians develop and implement new policies will be one of the major changes. We have to be careful as we do not want to deter investment, but at the same time we want the money to be spent in the right places. Now is the right time to implement policies, which will empower and uplift communities. ■

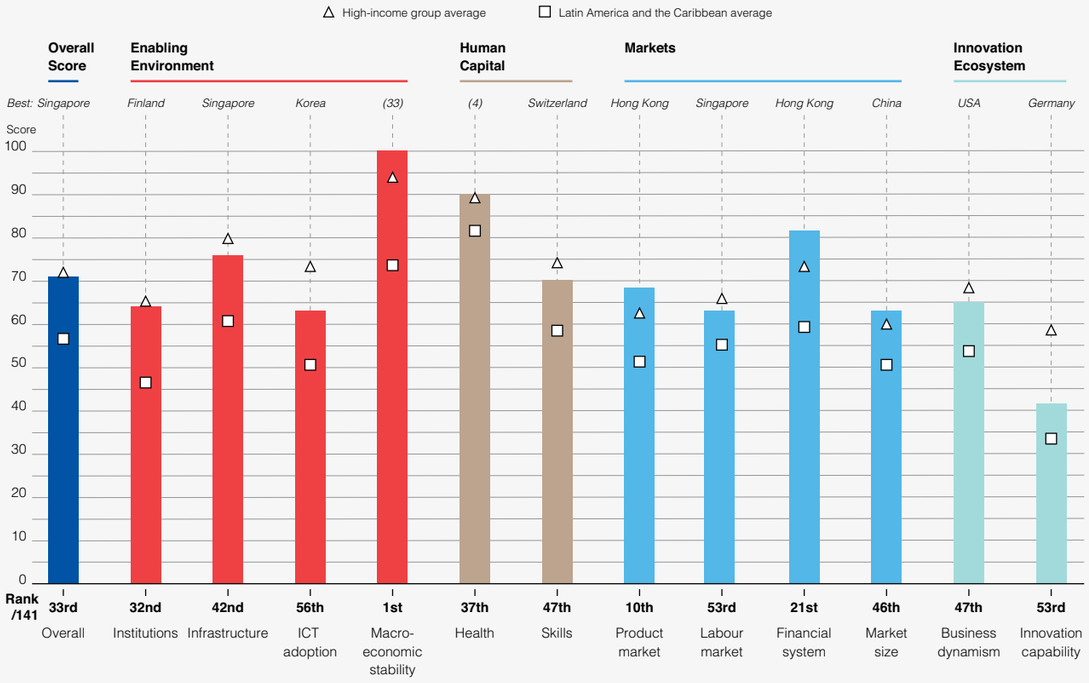
## CHILE WEALTH GROWS WITH MARKET-FRIENDLY POLICIES (GDP)

Source: The World Bank




## CHILE PERFORMANCE OVERVIEW 2019

Source: Global Competitiveness Index 4.0








# Eduardo Valente

Chile Advisory Managing Partner
**EY**

**Chile is a good place to invest, but if you change the fundamentals of doing business in the country with the Constitution, tax structures, royalties, and property rights, investments will slow. Investors are not yet pulling out of their commitments in Chile, but they are certainly acting with extreme caution at the moment.**

**Can you provide a brief overview of the services EY provides to the mining sector in Chile?**

EY has four major lines of service. We provide consulting, audit, transaction and tax advisory services. Consulting or advisory services focuses on strategy and innovation for the mining sector and how to apply it. We help organizations with operational projects to reduce costs and become more effective and efficient. Also, we assist in supporting businesses by implementing new technologies such as robotic processes automation and data analytics. We recently bought a Chilean company called Metric Arts, that was built to work with client data to improve their business using artificial intelligence and mathematical models. The last area of our business provides management services. For some clients we run their supply, financial and accounting and HR processes. Additionally, we provide IT, supply chain management, and customer relationship consulting.

**How has social unrest impacted the investment climate for investors?**

Before October 18th, miners were staying on track with their plans to invest. In fact, we saw an acceleration of investment in the mining sector and we were having a good year in terms of new investments and projects. We had a lot of companies investing in digital transformation programs, automation and robotics technology. At the same time, we saw a lot of interest from companies to keep investing in brownfield operations. We didn't see a lot of greenfield projects but a lot of projects were focused on improving existing operations. After October 18th, everything changed. Although the mining sector has not been affected to the same extent the retail or banking sector has, mining is affected by the social environment.

Right now, if you have a change in the way that the mining properties are regulated in Chile, it will have a big impact on investment and the way we calculate projects. Investors are waiting to see what will happen with the Constitution. We are seeing a two year timeline where we expect to see the market slow down quite a bit. Chile is a good place to invest, but if you change the fundamentals of doing business in the country with the Constitution, tax structures, royalties, and property rights, investments will slow. Investors are not yet pulling out of their commitments in Chile, but they are certainly acting with extreme caution at the moment.

**When you look at Chile as a jurisdiction from a tax and regulatory perspective in mining, what are the advantages?**

Chile is a great place to do business. We have trade agreements with 150+ countries and we are very global in our thinking. We see big potential for more renewable energy investment, desalination, water, and infrastructure investments. China is looking to invest a lot in Chile. In the past three years Chile has seen a huge increase in Chinese businesses purchasing Chilean infrastructure companies.

**EY listed license to operate as the biggest risk facing the global mining industry. If you could tailor this list specifically for Chile, what would be the biggest risks?**

Every year it is becoming harder to communicate to the world the importance of mining to our economy, society, the way that we consume things, and its importance in creating jobs. We still have a lot of room to improve how we connect with society, the environment and how we transform mining into a greener and more sustainable process by reducing water consumption, carbon footprint, and waste. At the same time, the license to operate means companies need to consider how to best connect with the government and the broader ecosystem of suppliers, and universities. This broad concept is a big risk, because we are seeing a big shift in how people view the mining industry. The same goes for Chile.

The second biggest risk is about attracting the right people and how the companies can transform themselves to make workers jobs more attractive. Mine sites are not attractive places to live because they are far from big cities and good infrastructure. The ability to bring in and retain talent in the world of digital transformation is one of the most important risks companies face. ■

# Francisco Sotomayor

Managing Director
**GL EVENTS CHILE**

**What is GL Events experience in the organization of trade and industry events such as EXPOMIN?**
GL events is a French business group founded in 1978, that is currently present in 26 countries and had revenues of US$ 1.2 billion in 2018. We have 40 years of experience in the events industry, and we employ 10,000 staff. Some of the events produced by the group include the Rio Olympics in 2016, the Pan American Games in Toronto in 2015, the 2014 World Cup in Brazil, G8 and G20 summits, and COP summits.
GL Manages more than 300 own fairs and sets up over 4,000 events per year in industries such as the food, mining, culture, fashion, gastronomy, environment, and more. In Chile, we have operated since 2014 through the FISA and Tarpulin subsidiaries. FISA is the main organizer of fairs in this country, with events such as Expomin, Expo Vivienda, Expo Hospital, Expo Naval, Edifica, Seguridad Expo, Expo Andes, and others. Meanwhile, Tarpulin is the leading player in temporary infrastructure solutions and also industrial solutions.

**What are your expectations for EXPOMIN 2020?**
The goal for 2020 is to host more than 1,300 exhibiting companies and more than 70,000 professional visitors from Chile and overseas. We expect the participation of over 5,000 foreign visitors, from over 35 countries, with more than 20 international pavilions. Our estimation is that there will be 2,500 business meetings during the framework of the fair, resulting in approximately US$ 1.7 billion in business deals.

**What are the main challenges for the Chilean mining industry, and how do you plan to address these within EXPOMIN?**
Within the framework of EXPOMIN, we have the XVI International Congress, under the slogan "Mining facilitating the future." 13 seminars will be held with 120 speakers who will make presentations on issues such as projects, regional mining, innovation and productivity, digital transformation, logistics, markets, inclusion and diversity, and environment.

**Has the recent social unrest affected the country's attractiveness for foreign investment in mining?**
According to a COCHILCO report on the 2019-2028 period, the expected investment in mining for the next 10 years amounts to US$ 72.5 billion. This includes 23 private, large and medium-sized copper mining projects, for US$ 28.3 billion, and eight Codelco projects, amounting to US$ 23.1 billion. Other minerals such as gold, silver, iron, lithium and industrial minerals account for another 13 projects worth US$ 6.9 billion of investment. Therefore, mining is a very relevant sector and can be a driver for economic recovery, as highlighted in the latest executive committee of EXPOMIN that was headed by minister of mining, Baldo Prokuriça, and which included high industry representatives. It was reiterated that EXPOMIN is a key event in this context, because it showcases the strength of this industry and the interest it generates at a global level.

**How is Chile positioned as an R&D hub for the mining industry?**
EXPOMIN is the largest mining fair in Latin America, and that gives us the opportunity to present to the community the technological advances that are setting industry trends. These are the ones that generate changes and transformations that increase the mining potential of the different countries, improving efficiency and productivity.
At the XVI International Congress, we will promote important areas of discussion and analysis on the key trends in our industry. The seminars will be focused on how mining has developed in the region, so we will examine issues, such as innovation and productivity, the development of mining activities, and the promotion of women in mining. In addition, we will have technological events, where companies will present their experiences in areas such as water management, hydrometallurgy, solutions and innovations in electromobility and energy, environment, lithium and cobalt processing in Chile and elsewhere, and the potential development of these industries.

**Would you like to add a final message for the readers?**
EXPOMIN 2020 is a great opportunity to showcase new technologies and exchange ideas and experiences on relevant topics such as the environment, innovation, productivity, digitalization and automation. This exhibition allows us to project what is coming in the future in order to innovate and thus move towards the mining industry that the world needs. ■





# Pascual Veiga

Chairman
**APRIMIN**

**There is no solution to climate change mitigation without the mining industry. Challenges such as the lack of water, the cost of energy and the cost of labor in Chile will continue to be increasingly high and less competitive compared to other mining countries, so improving productivity will be a must. The lack of support and positive perception of citizens is an obstacle that must be solved.**

**What kind of activities does APRIMIN carry out to promote the development of the mining industry in Chile?**
APRIMIN's mission is to be a strategic partner within the mining sector in order to make Chile an attractive country for sustainable mining investments. Our goal is to help Chile become a developed country through the mining sector and its suppliers.
Most of the suppliers in Chile are very involved in mining operations and seek to have permanent support that ensures the continuity and sustainability of the business in the long term. APRIMIN provides support in this regard.

**Has Sebastián Piñera's government carried out actions to create a more favorable environment for the Chilean mining industry?**
Yes. There has been a very special emphasis on trying to facilitate the approval of projects through the Oficina de Gestión de Proyectos Sustentables (Sustainable Project Management Office) and attempts have been made to facilitate permit approval processes through government policies. The main mission of this is to reduce permitting time without leaving the quality standards and environmental regulations behind. Some attempts have been made to avoid repetitive processes.

**What is the biggest challenge that service providers currently face in the mining industry?**
The relationship between mining actors and communities has greatly improved, but there are still situations where people view mining as a problem because of a failure of contextual understanding. Sometimes people do not see the benefit that the projects bring to the community. Regarding the water shortage issue, the Antofagasta region has the largest desalination plant in Chile for the benefit of the population and mining companies. Now, desalinated water has been used for most projects due to the country's water limitations.

**How has the mining industry's attitude towards innovation evolved in Chile over the last two years?**
There has been a positive change. The mining community has been criticized in recent years for resisting innovation, but the reality is that there has been a lot of innovation and the attitude of mining companies has evolved. This positive change has resulted in more interest and willingness to create the necessary agencies to be able to do pilot testing. There is an ongoing initiative to achieve more innovation in the mining industry in Northern Chile. Companies such as CODELCO, BHP, Anglo American and Collahuasi are working with the *Fundacion Chile* (Chile Foundation) and the *Expande* organization.
There are startups dedicated to the creation of innovation for the mining industry in Chile. There are large companies that are doing many innovation improvement initiatives that use Chile as a laboratory due to the many different types of operations, variation in the mine locations and diversity of rock type. Experiments and differentiated products have been made in Chile. Medium-sized suppliers are promoting and making significant innovation and improvement in the process, transportation and information systems sectors. These local companies use technology from other parts of the world but apply it in Chile and create their own system and methodology.

**What is your vision for the Chilean mining industry in the next three years?**
The mining industry will continue to be Chile's main source of income and export due to its size, geological potential and experienced work force. There is no solution to climate change mitigation without the mining industry. Challenges such as the lack of water, the cost of energy and the cost of labor in Chile will continue to be increasingly high and less competitive compared to other mining countries, so improving productivity will be a must. The lack of support and positive perception of citizens is an obstacle that must be solved. It is true that there have been environmental problems caused by the mining industry, but this has changed over the last decades and more environmental awareness is being developed. Chile has the capacity to continue operating for many decades. ■

# PRODUCTION AND DEVELOPMENT

**» The last couple of years have been slow globally, but we are starting to see an increase in mining investment. Compa- nies that had put projects on hold have decided to move ahead with the invest- ments. The current project pipeline for mining projects in Chile for the period 2018 to 2027 is close to US$66 billion, which is encouraging. Considering the current social and political juncture that Chile is facing, we are confident that the country is and will continue to be a good destination for foreign investment, especially in the mining sector. «**

**- Christoff Janse,**
**Investment Promotion Officer,**
**Invest Chile**

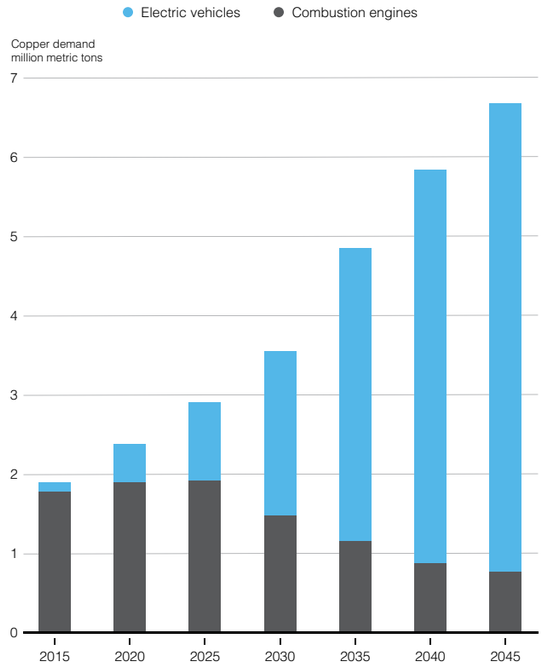
Image courtesy of Black & Veatch

# Copper

## INCREASING NECESSITY FOR NEW PROJECTS TODAY TO MEET TOMORROW'S DEMAND

### ELECTRIC VEHICLES WILL CAUSE HIGHER DEMAND FOR COPPER

Source: Anglo American




Take a flight to the north of Chile and, as the plane descends, you may notice one of the many deep holes that dot the landscape. Of the top 20 highest producing copper mines globally, seven are located in Chile: Escondida, Collahuasi, El Teniente, Los Bronces, Los Pelambres, Chuquicamata, Radomiro Tomic are all stars in the global mining constellation. Maintaining high production from these large mines, along with additional new production, is essential as the world transitions to a new energy economy. Simply put, the green economy is far more metal intensive than the fossil fuel economy. So long as demand continues to rise for electric vehicles and solar and wind energy, demand for copper will rise synchronously.

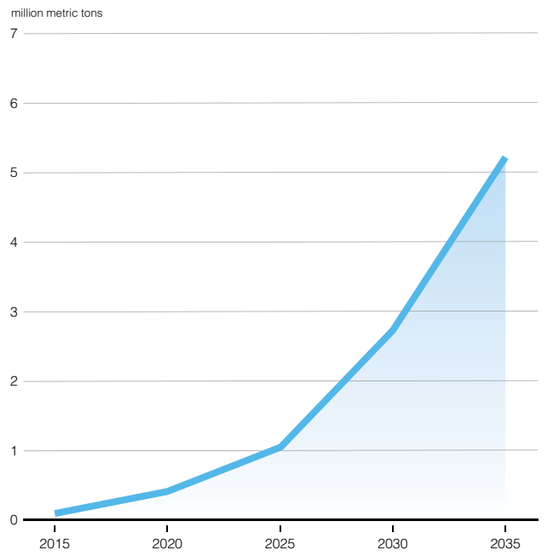
Wind and solar energy requires three to 15 times as much copper per unit of output as fossil fuel generation, according to the Financial Times. A report from Deutsche Bank expects the global electric vehicle market to grow 22% annually to 2030, led by China's 25% market growth. Estimates are that copper demand for electric vehicles, which was 0.9% of the global total in 2017, will rise to 8.2% of total copper demand in 2030. Given these dynamics, it is increasingly important that Chile continues to invest and innovate in order to offset production declines.

Although Chile is considered a mature mining jurisdiction, Timothy Beale, CEO of Revelo Resources, a prospect generator with a portfolio of copper and gold-silver projects focused in Chile, described the quality of the country's mining assets:

22>>

### ...AND DEMAND WILL KEEP STRONG DUE TO THE DECARBONIZATION COMMITMENDS AND NEW TRENDS

Source: CRU



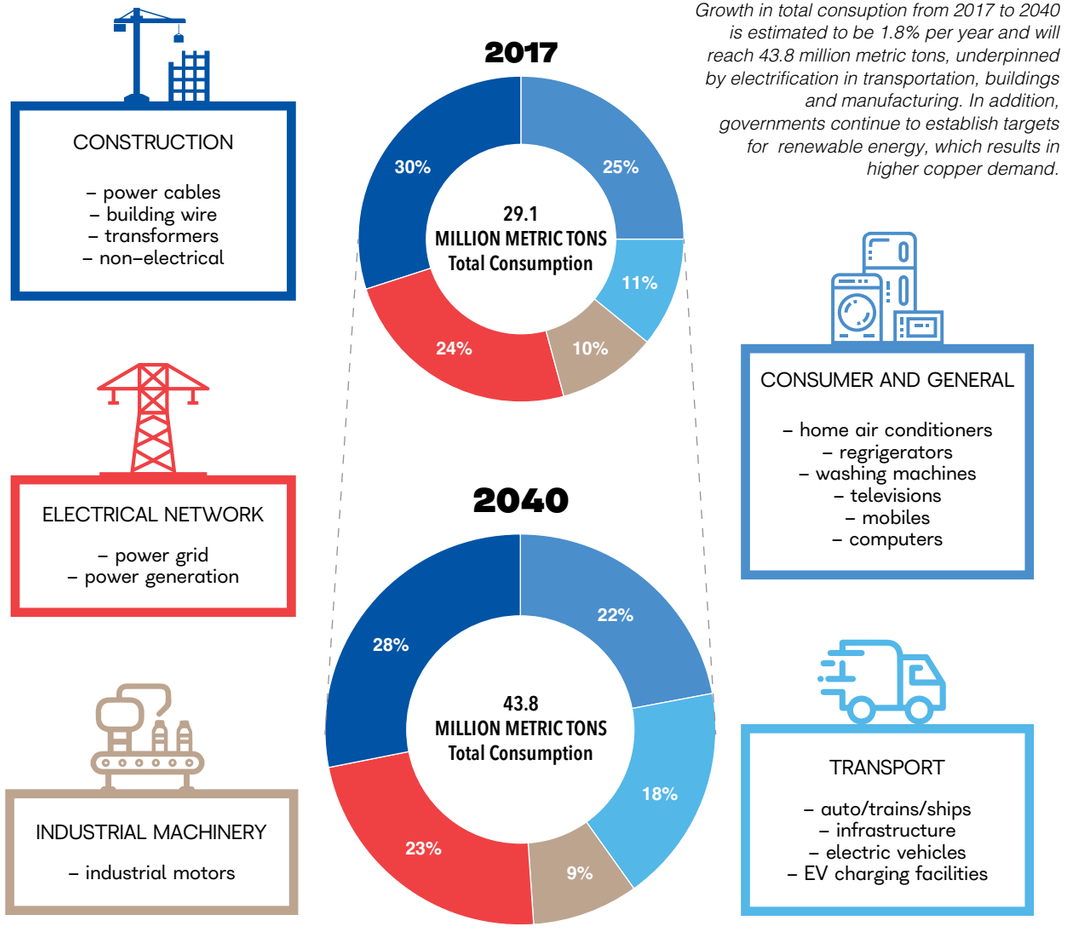





### GLOBAL COPPER CONSUMPTION BY MARKET SECTOR

Source: Wood Mackenzie, Copper Outlook December 2018

*Growth in total consuption from 2017 to 2040 is estimated to be 1.8% per year and will reach 43.8 million metric tons, underpinned by electrification in transportation, buildings and manufacturing. In addition, governments continue to establish targets for renewable energy, which results in higher copper demand.*




### COPPER PRODUCTION IN CHILE

Source: Consejo Minero

**31.5%**
state owned

**68.5%**
private companies

### CHILE'S GLOBAL PRODUCTION RANKING

Source: Consejo Minero

| | | | | | |
|---|---|---|---|---|---|
| Cu | 1ST | global rank | Ag | 6TH | global rank |
| | 27% | share of global production | | 5% | share of global production |
| Mo | 2ND | global rank | Au | 14TH | global rank |
| | 20% | share of global production | | 1% | share of global production |

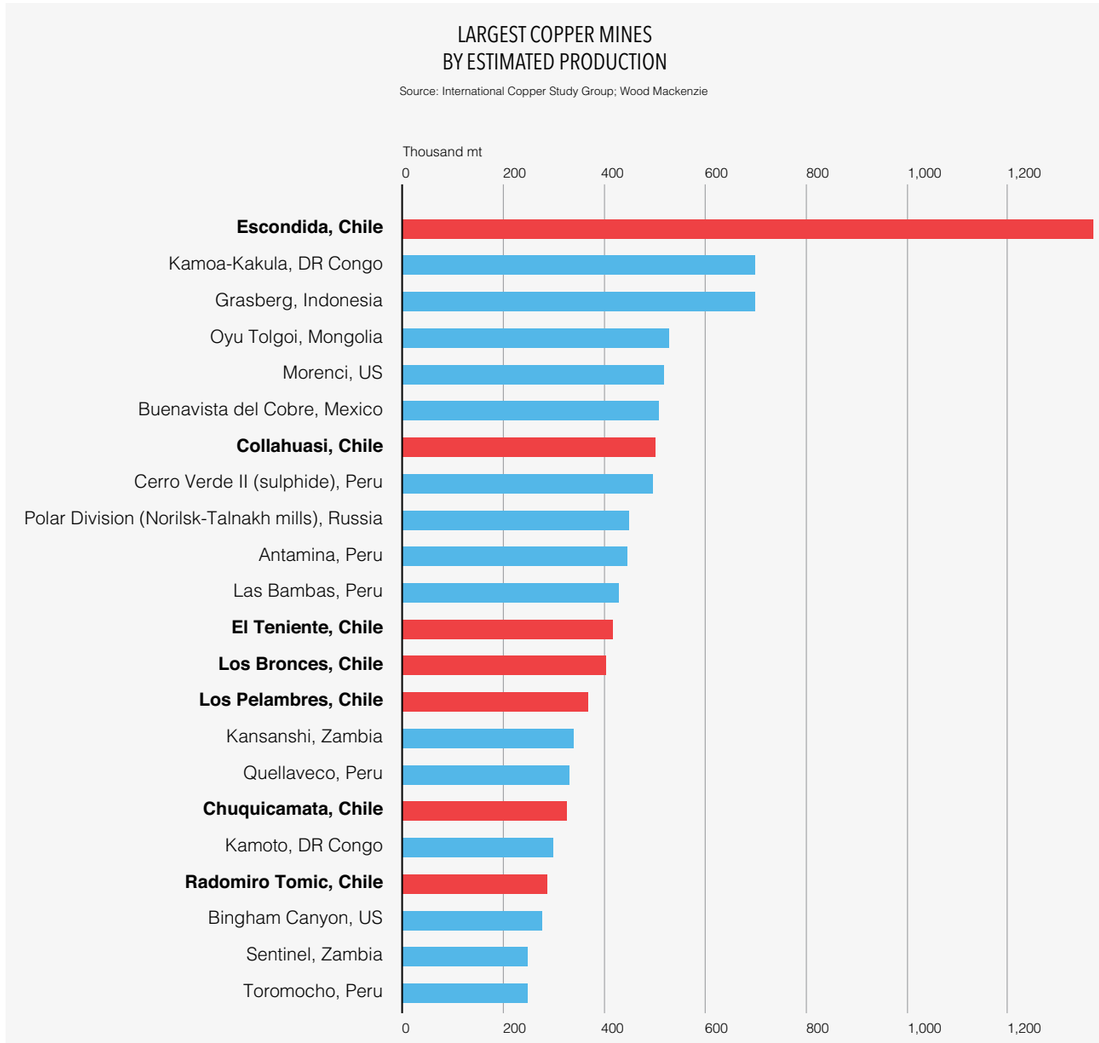
"World class means long life of mine and scalability of production, and Chile has several truly world class mines. These huge mining districts in Chile will all be mining for decades into the future."

A prolonged period of high production is imperative, because copper mining plays an instrumental role in the development of the country. Consejo Minero data shows copper accounts for more than 90% of the country's mining exports, has been the economic sector with the highest contribution to fiscal revenue and has contributed 12.1% of GDP over the last decade. There are efforts to diversify the Chilean economy and grow exports in other areas, but it is clear that copper will continue to play an outsized role in its contribution to Chile's overall progress. It will also be a critical part of funding a new wave of social spending into the future.

**Codelco**

*Same mission, New urgency*

Before the protests and riots began in October 2019, Codelco was already facing the difficult task of having to invest billions just to maintain production levels and keep costs from rising. Now, as the government faces a long list of spending demands to appease protesters, the challenge is more formidable. Piñera's administration announced US$5.5 billion of additional government spending in December 2019 and the state owned miner will be expected to help fund a larger welfare system in the country. The company can also anticipate a much more tightfisted response from the state in its allocation of funds to meet Codelco's financing needs.




On the spending side, Codelco is now looking to shrink its project budget through 2028 by US$8 billion or 20%. According to the companies Q3 2019 reporting, there are no plans to suspend any planned projects. At the same time, the company is looking to generate an additional US$1 billion in gross earnings from 2021 onward. According to CEO Octavio Araneda, Codelco is making a "great effort" to help generate the cash Chile needs to address social demands. To achieve the capex savings Codelco will simplify project design and reinforce operations maintenance and supply. "Codelco's future depends on finishing structural projects on time and at lower costs. Without them, our production will fall significantly," Araneda said.

Fortunately for Codelco, the company owns a portfolio of some of the most prodigious copper producing assets in the world.

Chuquicamata has been in operation for over 100 years and is now entering into a new phase underground. Codelco reported that, although the ramp up period of the underground mine is projected to take seven years to reach 140,000 mt/d, work to maximize process efficiency aims to shorten this period to five years (2024).

El Teniente produced 465,000 mt of copper in 2018 and has now completed 54% of development on its New Mine Level work. The plan is to boost production at the mine to more than 500,000 mt/y by 2025. This ramp up in output would place the mine as a top five producer globally and the company intends to invest US$3.4 billion to carry out the expansion.

At Radomiro Tomic, a mine producing 310,000 mt/y of copper, Codelco filed an updated environmental impact assessment (EIA) for an US$882mn, mine life extension plan in Antofagasta region.

Overall, 2019 was a difficult transitional year for the company as it struggled to boost production and earnings. The world's largest copper producer had 1.12 million mt of copper output from January to September 2019, which represented a fall of 6.7% in relation to the same period of the previous year. Company reports also showed a drop of 57% in pre-tax earnings year on year. Driving these results were February rains, a 14-day strike at Chuquicamata, lower head grades and lower levels of treatment.

Although this past years' performance was below company expectations, there is no denying the historical impact Codelco has had on the pace of development in Chile. For almost half a century, it has provided a reliable stream of revenue to the country. Moving toward the future: "The hope is to transform ourselves in order to continue contributing to the progress of Chile for at least 50 years more," Araneda said.

**Majors**
*Jurisdictional preference remains strong*

In 2018 Chile reached record levels of copper production, with 5.831 million mt. The industry was able to achieve this because of consistent investments made in years prior. In order for the country to continue its status as a leading producer in the future, investments must resume. In 2018, US$4.5 billion of investment and 68.5% of production came from private mining companies, according to Cochilco.

Some of the biggest global players operating in Chile are Anglo American (Collahuasi 44% , Los Bronces 50.1%), BHP (Escondida 57.5%, Spence), Teck (Quebrada Blanca, Carmen de Andacollo) Antofagasta Minerals (Los Pelambres 60%, Centinela 70% ), Rio Tinto (Escondida 30%), Glencore (Collahuasi 44%), Lundin (Candelaria) and Freeport McMoRan (El Abra 51%).

According to Joaquín Villarino, president of Consejo Minero: "Mining production in Chile grew considerably until ten years ago and then stabilized at just below 6 million mt/y of copper, which equates to about 27% of the world's copper, making it the largest producer in the world. In 2019, we will probably see a small decrease, but industry has the capacity to produce that amount of copper for at least 30 more years."

The three largest mines owned by private companies in Chile are Escondida, Collahuasi and Los Bronces.

At Escondida, the highest producing copper mine in the world, 2019 results came up short of projections. Copper production at Escondida in FY 2019 decreased by 6% to 1.135 million mt, as a consequence of a 12% decline in copper grades. Revenue from Escondida also fell by US$1.5 billion to US$6.9 billion overall for the year. According to BHP's end of fiscal year 2019 (Australian) conference call on June 30th, it is believed that Escondida will continue to be a very good cash returner for the next decade despite the down year.

Collahuasi, majority owned by Anglo American and Glencore, is a copper mine located in northern Chile. The mine produced 560,000 mt of copper in 2018 and, for the first nine months of 2019, production was flat. Meanwhile, at Anglo American's Los Bronces production was down 3% over the same period, due to unprecedented drought conditions. 2019 was the driest year with the longest drought ever recorded in central Chile and water scarcity remains a risk for 2020 production.

Perhaps the most successful producer through the first three quarters of 2019 in Chile was Antofagasta Minerals. Copper production for the first nine months of the year was 584,200 mt, 15.6% higher than in the same period last year on continued higher throughput and grades. This higher production at all operations resulted in mid year EBITDA increasing by 44% to US$1.3 billion.

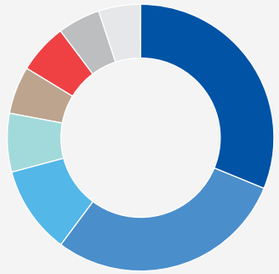
Building off the company's success, the board of directors approved a US$1.3 billion expansion of the Los Pelambres copper mine in November of 2018. With the expansion the company will be able to increase production from the mine by around 60,000 t/y of copper over the first 15 years of operation. The project will involve the construction of a desalination plant and water pipeline. Antofagasta was initially targeting startup in H2 2021, although in April 2020 the company announced a four-month suspension of the project due to the coronavirus.

The other big project in Chile's copper investment pipeline is Teck's QB2. The company is reliant on the project to transform its copper business and as a result, has committed US$4.7 billion toward its development. One of the strongest characteristics of the project is that it possesses a strip ratio of less than 1:1 and has significant expansion potential. In relation, Escondida and Collahuasi both have strip ratios of over 2.5:1. Therefore, QB2's cost of production will likely be lower.

Construction is expected to be completed in the fourth quarter of 2021, with ramp-up to full production during 2022. The project is estimated to produce 316,000 mt/y of copper during its first five years of operation, making it one of the world's largest undeveloped copper resources.

WORLD COPPER PRODUCTION

Source: Cochilco



| | |
|---|---|
| **Chile** | **28%** |
| Peru | 12% |
| China | 7% |
| USA | 6% |
| DR Congo | 6% |
| Zambia | 5% |
| Australia | 5% |
| Rest of the World | 31% |





# Octavio Araneda

CEO
**CODELCO**

**What is the current status of your different operations, and can you highlight your most important investments?**

Codelco is currently developing a strategic transformation plan that seeks to position it as a more sustainable, profitable and competitive company. This process involves achieving savings of US$ 8 billion in its investment portfolio between 2019 and 2028 through better designs, project prioritization and construction optimization, following efficiency goals and continuous improvement. This amounts to a 20% reduction in the investment budget, including structural projects, without diminishing the value contribution of the portfolio.

The first of these, Chuquicamata Underground, was inaugurated in August 2019. Tests have been carried out and we have already initiated the operation of the mineral transport system. It is a complex technology that includes a 14 km belt, which will allow the transport and feeding of ore to the concentrator plant up to 140,000 mt/d of material.

At Radomiro Tomic we are updating our Environmental Impact Assesment in order to extend the useful life of the oxide deposit for 10 years, until 2030. In parallel, we are continuing with the feasibility study of the RT Sulfuros Phase II project.

In Atacama, in our Salvador Division, the Rajo Inca project is being advanced through its early stage work, while its environmental permits are being approved. Expectations are that operations will begin in 2021.

In Andina Division, the Andean Transfer project reached 80% in the progress of its construction and will be inaugurated in 2020. Andean Future Development, meanwhile, continues with its feasibility study, which currently is 40% complete, while advancing the main engineering and mining contracts.

In El Teniente, the New Mine Level is now 54% complete. In the North Andes, the excavation of the main maintenance cavern began. At the Diamante and Andesita projects, the early works progress is going according to schedule.

It is important to highlight that the Codelco transformation process seeks to position it in 2021 in the second cost quartile, ensure the financing and development of structural projects, and maintain the company's contribution to the country for at least 50 more years.

**How has 2019 been from a production perspective?**

Between January and September 2019, we reached 1.120 million mt of production, that is, 80,000 less than in the third quarter of 2018. There are several explanations for this issue, but the most relevant are the February rains, the 14-day strike in June, the lower head grades and lower levels of treatment. Next year our projections are to reach better production levels.

**How are the mines bringing economic and social value to local communities and the country?**

Our historical contribution to the development of Chile is unquestionable. For almost half a century (1971-2018), we have been one of the main engines of development in the country. Our exports of US$ 303 billion represent 20% of all sales abroad during the period. In surpluses for the State, we have generated more than US$ 116 billion, equivalent to 9% of fiscal revenues. In addition, our capital investments of US$ 65 billion represent 8% of the total investment made in Chile in the same period, and more than all the foreign investment materialized in mining in our country. We also contribute at the local level, with the generation of economic activity in the areas where our operations are located. This is highly valued by the communities, because it brings employment and improvements in infrastructure.

**What goals does Codelco wish to achieve over the next 2-3 years in Chile?**

Today we are focused on achieving challenging objectives, which are part of a strategic business plan and cultural transformation. To be more productive, profitable and sustainable we have three main goals. We must look for the best projects and execute them on time and with simpler designs, pursue excellence in all our operations and focus on further development of our mineral resources

This strategic plan aims to expand revenues by US$1 billion per year, starting in 2021. This will be in addition to to our projected savings of 20% in the total investment portfolio we have planned for the coming years. Our intention is to maintain the same projects, but to execute them with maximum efficiency. These resources will help us finance our projects and fulfill our promise to extend Codelco's life. ■

# CODELCO

**1ST**
worlwide
copper producer

**1.8**
million metric tons
copper production
*includes El Abra and Anglo American Sur attributable production to Codelco's share*

**2ND**
worlwide
molybdenum producer

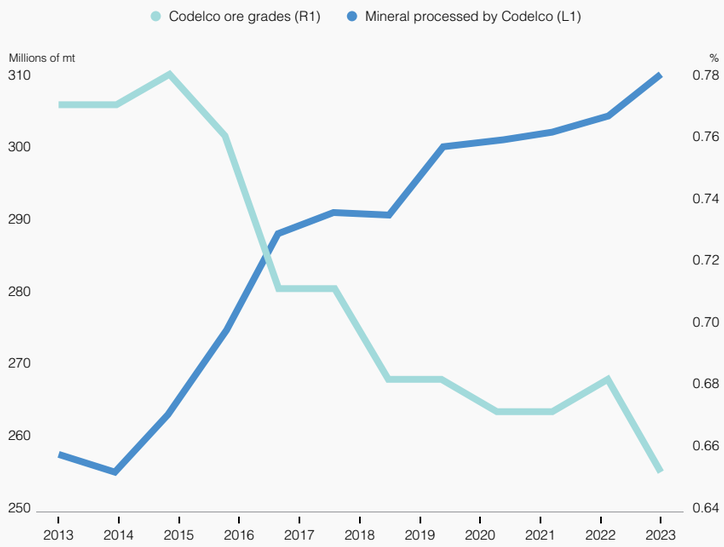
**139**
US$ cents per pound
C1 cash cost

**100%**
owned by the
Replubic of Chile
(A+/A1/A)

**1ST**
contributor to the
Chilean treasury

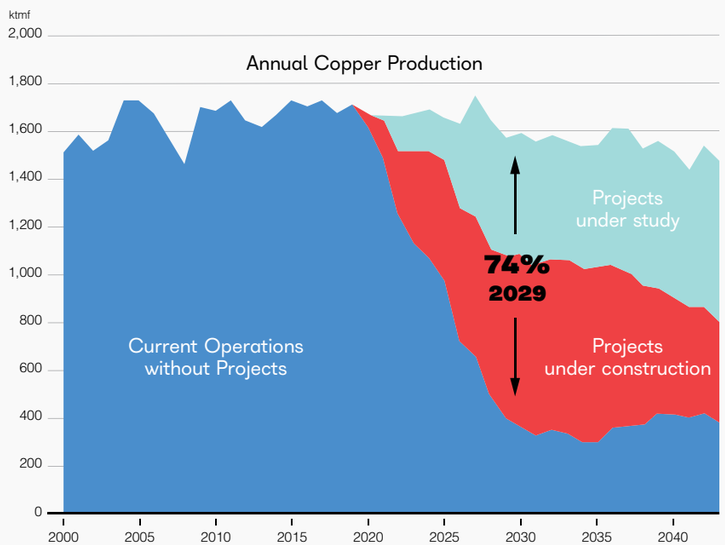
## FALLING GRADE
*CODELCO NEEDS TO PROCESS MORE MINERAL TO MAINTAIN OUTPUT LEVELS*

Source: Codelco




## CODELCO'S INVESTMENT PROGRAM IS KEY TO THE COMPANY'S FUTURE

Source: Codelco




## El Teniente

production
(December 2019)
**459,744**
**METRIC TONS OF FINE COPPER**

internal staff
(December 2019)
**4,058**
**PEOPLE**

extraction method
**OPEN PIT AND UNDERGROUND MINING**

in operation
**SINCE 1904**

location
**MACHALÍ, REGIÓN LIBERTADOR GENERAL BERNARDO O'HIGGINS**

products
**COPPER ANODES AND CONCENTRATES**

## Chuquicamata

production
(December 2019)
**385,309**
**METRIC TONS OF FINE COPPER**

internal staff
(December 2019)
**4,899**
**PEOPLE**

extraction method
**OPEN PIT AND UNDERGROUND MINING**

in operation
**SINCE 1915**

location
**CALAMA, REGIÓN DE ANTOFAGASTA**

products
**ELECTRO-REFINED AND ELECTRO-WON CATHODES AND COPPER CONCENTRATE**

## BHP

Source: Cochilco, USGS

In 2019, BHP in Chile produced

**1,452,900**
**METRIC TONS of fine copper**
from its Chilean operations*
*(948,100 mt Cu attributable)

**1,187,800**
**METRIC TONS at Escondida** (57.5% owned)
(683,000 mt Cu attributable)

**265,100**
**METRIC TONS Pampa Norte** (100% owned)
(683,000 mt Cu attributable)

of which

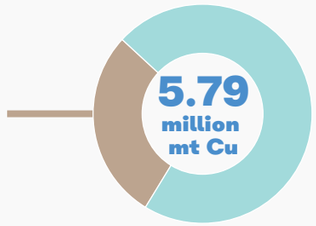
**193,400** MT at Spence

**71,700** MT at Cerro Colorado

Equivalent to

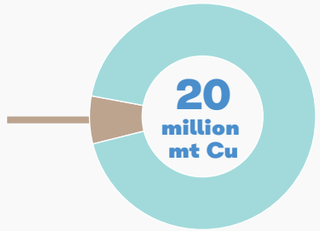
**20.5%**
**of Chile's copper production**

Total production in chile




**5.9%**
**of world copper production**

Total production worldwide




### ECONOMIC CONTRIBUITION IN CHILE

Source: BHP Economic Contribution Report 2019
Period: 1 July 2018 to 30 June 2019

**US$3.71 BILLION**
**Suppliers**
Payments to suppliers in Chile for goods and services

**US$928 MILLION**
**Taxes**
Taxes and other payments to the government
Taxes: Refers to expenditures for tax provisions.

**US$573 MILLION**
**Employees**
Payments to employees, wages, incentives and others

**US$928 MILLION**
**Social investment**
Direct investment and administrative expenses

**US$5.23 BILLION**
**Total economic contribution**
Excludes payment to shareholders.





# Aaron Puna

CEO
**ANGLO AMERICAN CHILE**

**Our copper assets in Chile are of exceptionally high quality and there is potential for growth at both sites. Los Bronces has been mined for more than 150 years, and potential exists to extend the current life of the mine beyond 2040.**

**How is Anglo American positioning itself as the mining industry transforms itself?**
In the decades ahead, mining must transform more significantly than it has in the last century. This involves addressing the industry's critical challenges, including safety, productivity and the use of energy water and land. In addition, society expects that the mining industry should contribute more effectively to socio-economic development, while reducing its environmental footprint.
In this context, we define as our purpose to re-imagine mining to improve people's lives. We do this through FutureSmart Mining™, our innovation-led approach to sustainable mining. It is our blueprint for the future of our business. A future in which broad innovative thinking, enabling technologies, and collaborative partnerships will shape an industry that is safer, more sustainable and efficient, and better harmonised with the needs of our host communities and society as a whole.

**What is the overall importance of Chile in the context of Anglo Americans broader project portfolio?**
Anglo American has had a presence in Chile since 1980; it has interests in two of the world's largest copper mines, Los Bronces and Collahuasi, and employs more than 10,700 people. In addition, we operate El Soldado mine and Chagres smelter.
Our copper assets in Chile are of exceptionally high quality and there is potential for growth at both sites. Los Bronces has been mined for more than 150 years, and potential exists to extend the current life of the mine beyond 2040.

**What are Anglo's future plans for the continued development of Los Bronces?**
We have recently submitted for environmental evaluation Los Bronces Integrated (LBI) project, which was designed to prevent significant environmental impacts. The project is the result of six years of scientific territorial studies, analysis of international experience and three years of active dialogue with local communities and various stakeholders. These activities identified the conditions to be met by the project's design allowing a harmonious coexistence with its surroundings.
As a result, the LBI project was designed under the following sustainability criteria: No impact on glaciers; no impact on the biodiversity of protected areas; no additional fresh water use in processes; using already authorised capacity of tailings and waste rock deposits; using existing processing plants and no additional traffic on the access road.

**What initiatives does Anglo American have in place to enhance the sustainability of its operations and to contribute to the well being of communities in Chile?**
Globally, we have acquired several commitments to accomplish our purpose: 30% reduction in energy use, 50% reduction in water abstraction and 30% reduction in GHG emissions by 2030. In Chile, Anglo American has applied its FutureSmart Mining™ approach boosting actions to have more sustainable operations.
We are implementing a new Strategy of Water Management, which seeks to be able to face the challenge posed by climate change and drought through an action plan that considers: Water use optimization by the use of new technologies in the mining process; collaborative work in the areas of influence to support water availability for communities; access alternative sources of industrial water, not good for human consumption nor agriculture; and develop scientific studies to have up to date data which will help us make a better use of the resource. Related to this strategy, we can mention that Los Bronces recirculate between 70% and 80% of the water the operation uses in the mining process.
In the same way, we continue implementing and developing new technologies to reduce our emissions such as the introduction of electric buses to transport our workers, TIER 4 engines and the Start Stop system for the trucks we have at Los Bronces.
In addition, we recently signed a contract to have 100% of supply from renewable energy sources that will reduce our CO2 emissions 70% from 2021; a similar agreement was reached by Collahuasi which will take effect in April this year.
Furthermore, the company has installed the first photovoltaic plant built on a tailing's facility in the world at Las Tórtolas. These floating solar panels will help to reduce evaporation from the tailings facility, therefore making more water available for the water recirculation system. At the same time, it will generate clean energy for the operation. ■

## COPPER PRODUCTION PER OPERATION

| Mining Unit | Main Controller | 2019 production (Thousand mt) |
|---|---|---|
| Escondida | BHP Billiton | 1187.8 |
| Collahuasi | Anglo American / Glencore | 565.4 |
| El Teniente | Codelco | 459.7 |
| Los Bronces | Anglo American | 389.2 |
| Chuquicamata | Codelco | 385.3 |
| Los Pelambres | Antofagasta Minerals | 375.9 |
| Radomiro Tomic | Codelco | 266.4 |
| Centinela (Sulfides) | Antofagasta Minerals | 195.5 |
| Spence | BHP Billiton | 193.4 |
| Andina | Codelco | 170.3 |
| Ministro Hales | Codelco | 151.8 |
| Caserones | Lumina Copper Chile | 145.5 |
| Zaldívar | Antofagasta Minerals / Barrick | 116.1 |
| Sierra Gorda | KGHM | 114 |
| Candelaria | Lundin Mining | 111.4 |
| Gaby | Codelco | 104.1 |
| Mantos Copper | Audley Capital Advisors | 86.3 |
| El Abra | Freeport McMoRan | 81.9 |
| Centinela (Oxides) | Antofagasta Minerals | 81.1 |
| Lomas Bayas | Glencore | 78.9 |
| Antucoya | Antofagasta Minerals | 71.9 |
| Cerro Colorado | BHP Billiton | 71.7 |
| Andacollo | Teck | 54 |
| Salvador | Codelco | 50.6 |
| Quebrada Blanca | Teck | 21.1 |
| Michilla | Haldeman Mining | 12.5 |
| Other | | 245.6 |
| **TOTAL** | | **5787.4** |

**Mid Tier Mining**

Although over 90% of Chile's output comes from large mines, the country has several promising mid size mines in development. Mantos Copper has its MantoVerde and Mantos Blancos projects, Pucobre is developing El Espino and Capstone Mining is looking to begin construction on its Santo Domingo project.

According to Tomás Buttazzoni general manager of Technosteel: "There are two trends driving the mining market in Chile today. One is big mining sites that are expanding and the other is new mid size projects. Mid-size companies have been much more efficient in the use of funds because they have exponentially less cash available for investment."

Capstone mining's Santo Domingo is now shovel-ready with all building permits having been obtained and construction is ready to begin in early 2020. The project has a mine life of 17.9 years and a projected IRR of 21.8% after tax. The projected cost of development is US$1.7 billion.

In 2019, Mantos Copper secured US$250 million to fund the expansion of the sulphides concentrator at its Mantos Blancos operation, which will extend the life of the open-pit mine until 2035 and reduce costs.

For Pucobre, its El Espino mine has an estimated investment of US $ 624 million and its annual production is projected to be 42,000 mt of fine copper and 20,000 oz of gold. Pucobre plans to enter into operation at El Espino in 2022 and it will double the company's production capacity.

**Investment Climate Summary**

Heading into 2020, the investment climate remained positive and resilient throughout the country. In 2019, mining companies weathered a commercial war between the US and China and one of the biggest political crises in modern Chilean history. Nevertheless, projects are moving forward and progressing, for the most part, on time. Substantial geopolitical and domestic political risks remain a cloud on what could become a vibrant investment landscape, but so long as there are no major unforeseen developments, progress will continue to be made.

According to Mark Venning, South America's regional mining leader at Stantec: "The trade war has created nervousness in the mining sector, because investments are big. A large copper mine costs US$5-10 billion, and if you don't understand the direction the world is going, copper price uncertainty can stifle investment decisions. The copper price fell to levels where most Chilean mines are still profitable, but not generating considerable cash flow, as had been anticipated. Towards the middle of the year (2019), a lot of projects started drying up." He continued saying that if prices were to recover to levels above US$3 per pound: "projects will be reactivated and fast-tracked in a second, especially in Chile."

On a probability of materialization basis, Cochilco sees upwards of 55% of planned investment from 2018-2027 as highly likely to occur. Development of the remaining 45% of the portfolio in the country is dependent on factors such as copper price and other dynamics affecting the potential return on investment.

For example, companies are fearful that the new constitution could bring about a more burdensome environment for mining operations. Eduardo Valente, managing partner of EY's Chile advisory posits that although Chile's mining sector has not been affected to the same extent the retail or banking sector have, mining is still affected by the second order effects, resulting from changes in the social environment. "If you have a change in the way that the mining properties are regulated in Chile, it will have a big impact on investment and the way we value projects. Investors are waiting to see what will happen with the constitution. We are seeing a two year timeline where we expect to see the market slow down quite a bit. Chile is a good place to invest, but if you change the fundamentals of doing business in the country and tax structures, royalties, and property rights change, investments will slow."

When discussing the investment climate, perspectives vary greatly. There are many who view the impact of the social crisis as an opportunity for Chile to move into a new era of greater clarity for investment. According to Carlos Leigh, CEO of Latin America at DSI Underground: "It is important to remember that mining investments are very long term, so companies will continue moving forward with the development of their assets. Social demands are being made and it is giving Chile the opportunity to solve its problems. Chile was never considered, in its recent history, a populist country and I still believe it will not become one. The silver lining of the crisis is that social issues will now be incorporated into the law and we can move forward as a country."

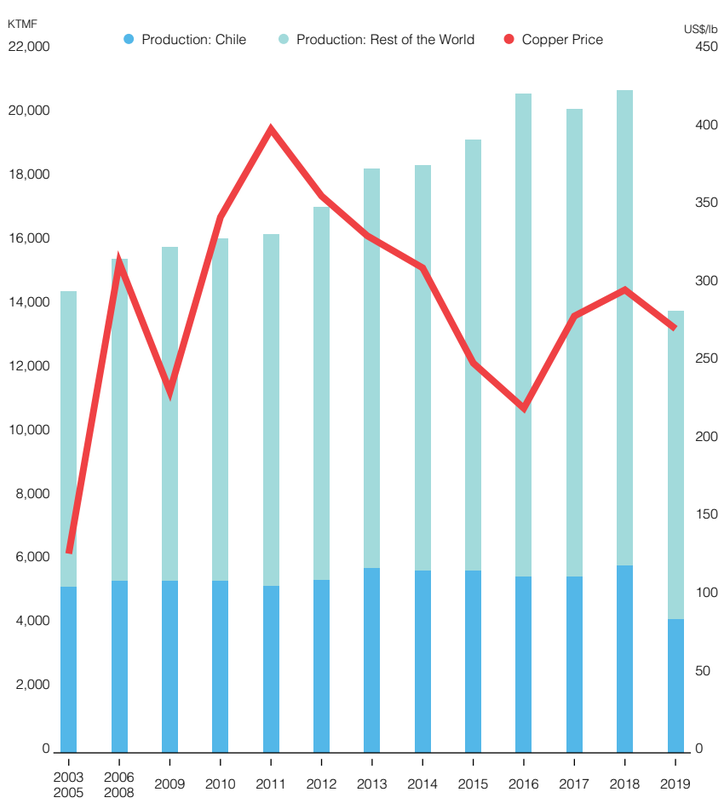
For the foreseeable future, investment decisions will have to be made more cautiously than they may have been in the past. However, companies should not be dissuaded by headline risks, as the operational environment shares more in common with Canada than it does Congo. Mining is an irreplaceable part of Chile's economy and geologically speaking there is still a lot of copper to be exploited at a competitive cost. Given the potential for copper to be a high yielding asset in the coming years, it is clear that Chile remains a favorable destination for miners.





## COPPER PRODUCTION AND PRICE EVOLUTION

Source: Consejo Minero




**If you have a change in the way that the mining properties are regulated in Chile, it will have a big impact on investment and the way we value projects. Investors are waiting to see what will happen with the constitution. We are seeing a two year timeline where we expect to see the market slow down quite a bit. Chile is a good place to invest, but if you change the fundamentals of doing business in the country and tax structures, royalties, and property rights change, investments will slow.**

**- Eduardo Valente, managing partner, EY Chile**

# Gold

While Chile is less famous as a gold producer than Peru and Mexico, the country was discovered in the quest for gold, its exploration was financed by the precious metal, and in 1810, on the eve of its independence, it was producing as much gold as Peru and Mexico combined. In 2019, gold production and investment are a fraction of that devoted to copper. However, it still plays an important role in bringing jobs, technology and economic development to the country.

Chile produces 1% of the worlds gold and had the 14th highest production globally in 2017. In 2018, the country fell out of the top 20 as production has declined from its peak of 49 mt in 2012 to 36 mt in 2018. As of September 2019, gold production in the country had reached 29 mt for the first nine months of the year. Investment in projects totaled US$139 million for 2018.

Despite declining production, Chile still has an important lineup of gold projects set to come online by 2023. They are Gold Fields' Salares Norte, Kinross Gold's La Coipa Restart, Yamana Gold's El Peñón expansion, Rio2's Fenix and Kingsgate Consolidated's Nueva Esperanza.

The reason these projects are being advanced is largely due to a bullish outlook on long term gold prices, thus making funding more readily available for project development. In contrast to copper and lithium, precious metals focused companies have not experienced the same level of difficulty in financing their operations. With gold prices reaching a five year high above US$1,500 per oz and prices hovering around that mark for the majority of the year, projects are achieving good margins. Given gold's status as a reliable store of value and the trend amongst global central banks to devalue their currencies, gold is an in-demand investment class and projections are that it will remain that way. According to Enrique Garay, senior vice president of Rio2 Limited: "As long as there is international political and economic uncertainty, the price of precious metals will remain strong. We are confident that the prices for precious metals will continue to be elevated in 2020 and beyond."

One of the reasons for bullishness is gold-backed ETFs have seen positive flows in 15 of 16 months from July 2018 - November 2019 and they saw a 51% jump in their holdings in 2019 based off World Gold Council statistics. This is all welcome news for those seeking to reinvigorate the Chilean gold industry.

**Production and Investment Pipeline**

In analyzing gold mining in Chile, it should be recognized that a sizeable amount of the production comes from hybrid copper/gold operations and as a result of operational byproducts. KGHM's Sierra Gorda, Lundin's Candelaria, Antofagasta Minerals Centinela are all primarily copper mines that also produce gold.

Currently, Yamana Gold is one of the biggest producers in Chile as it has two producing mines in El Peñón and Minera Florida. The company's focus at El Peñón is on continuing to replace annual mineral depletion while exploring for significant new veins. It completed more than 100,000 meters of exploration drilling in 2019 and the results yielded high-grade intervals of mineralization, indicating "excellent potential for mineral reserve and mineral resource growth with potential to further extend mine life."

At Minera Florida the company is focused on replacing depletion in the core mine and investing in surface exploration and data modeling to generate new targets. Minera Florida will require more years of exploration successes and considerable efforts at development of newly discovered and prospective areas in order to deliver positive free cash flow and returns.







For Gold Fields, 2019 was an important year of progress as the environmental impact study for its Salares Norte project in the northern region was approved in December. Chile's environmental regulator has now given the green light to the country's second biggest planned gold project. Salares Norte, was discovered in 2011 and is expected to begin operations in 2022. The project has completed its feasibility study and hosts a gold mineral resource of 3.9 million oz of gold and 44 million oz of silver, while the reserves are 3.5 million oz of gold and 39 million oz of silver. Approximately 90% of the value and volume is in gold and 10% of the value and volume in silver. The initial life of mine is expected to be 11.5 years and the payback period is 2.5 years, given a US$ 1,200 gold price. According to Max Combes, Gold Fields Chile country manager: "At today's gold price, the mine would be very profitable."

Located at an altitude of 4,500 meters, the estimated investment in Salares Norte is around US$850 million in capital investment and a further US$450 million in sustaining capital over the life of mine. "We will create a peak of 2,700 jobs during construction of the mine and an average of 900 workers during the operational phase," mentioned Combes.

Another company making progress on its gold projects is Kinross. The La Coipa Restart project feasibility study is now scheduled to be completed in early 2020, with study results expected to be released in February. The timing of the completion of the feasibility study is not expected to have an impact on the overall project timeline.

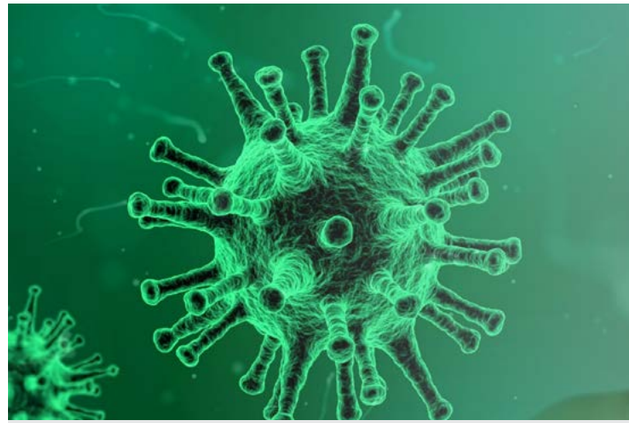
Meanwhile, the Lobo-Marte project pre-feasibility study is progressing and is on schedule to be completed in mid-2020. Both studies are evaluating the potential for a return to long-term production in Chile based on the concept of commencing Lobo-Marte production following the end of La Coipa's mine life.

**Pascua Lama's return?**

One of the high profile gold projects in Chile that never got the chance to go into production was Barrick's Pascua Lama. The project has been shuttered since 2013, when a Chilean court ordered the company to halt construction over environmental concerns. Barrick shelved the project, citing cost overruns and falling metal prices.

The original plan for the mine, which required a capital outlay of more than US$8 billion, contemplated an open-pit operation that would have had an effect on three small glaciers on the Chilean side of the Andes. It also involved major construction in the area and huge waste dumps.

As of end of year 2019, the company remains focused on resolving the legal and environmental issues around the project and, in addition to the ongoing remediation work, it had embarked on a technical review of the project parameters and potential. CEO Mark Bristow said: "We believe that despite the legacy challenges relating to the Pascua-Lama project there are exciting opportunities here, especially in the El Indio Belt, and we will be pursuing this in line with our strategy of creating value for all our stakeholders."



# Hedging the impact of COVID-19 with Gold

In times of deep uncertainty, it is increasingly logical to have insurance that limits downside risk. For centuries gold has proven to be a consistent store of value during turbulent periods and, in light of global economic activity screeching to a halt in the spring of 2020, it is currently amongst the most preferred asset classes. This is seemingly justified given the pervasive negative impact Coronavirus has had on economies around the world.

The response by most governments to mitigate the effect of the pandemic on citizens has been to dramatically increase government spending to historically unprecedented levels. As of April 2020, the US government committed upwards of US$2 trillion to soften the economic blow of the virus and it is believed that spending will increase substantially until the situation improves. Meanwhile, Chile has spent an amount equal to 4.7% of its gross domestic product for emergency measures aimed at saving jobs and protecting small businesses. These extraordinary actions taken by policymakers and central banks throughout the world to accommodate the systemic shock Coronavirus has brought will inevitably debase certain currencies that overreach. As a result, the price of gold has risen above US$1600/oz, with the potential to revisit all time highs reached in 2011.

With the copper price hovering just above 2016 lows, miners and service providers throughout the value chain in Chile are in for a painful period ahead. Of course, there is hope that economic activity and copper prices will bounce back quickly. However, it is inevitable that, given the rapid price increase in gold, its production will be prioritized and existing projects will be expedited. Thus far, the "currency of last resort" has proven to be a valuable hedge and will continue to be throughout this challenging time. ■

# Max Combes

Country Manager
**GOLD FIELDS**

**Salares Norte is a very low-cost operation and we still have potential to add additional resources in addition to our main project. We expect to start operations in 2022 and we are in the process of designing a mine of the future.**

**What have been the biggest advances on Gold Field's Salares Norte project over the past few years?**
Since 2017, Gold Fields has completed a pre-feasibility study (PFS) at our Salares Norte project. We had two phases of the study – an interim feasibility study and a definitive feasibility study (DFS). The DFS, approved by the board in February 2019, was based on developing Salares Norte as an open pit mine with combined counter-current decantation (CCD), Merrill-Crowe and CIP processing at an average 2 million mt/y plant throughput. We have commenced with a detailed engineering phase and are progressing well with 52% already completed. We are in a very unique position and, according to our plans, we will move into production with more than 80% of the engineering completed.
Gold Fields has also completed all the baseline studies for the environmental impact assessment (EIA), and we presented our EIA to the authorities in July 2018. We have been through the entire approval process and have made all relevant amendments to our EIA. We are now expecting the consolidated evaluation report to be completed and approved by mid December 2019. Our permitting timeline was very fast compared to industry norms in Chile as it only took us 18 months. This quick timeline was possible because of the strength of the project characteristics.
Gold Field's vision is to be the most sustainable gold producer in the world. This has been embedded in the design of our project. We have managed to build a very good relationship with all the stakeholders in the area, and we invested a lot of effort and money into creating a sustainable design that ensures water use is kept to a minimum. We have introduced filter tailings that allow us to recover most of the water and we will produce a dry tailing that will be moved with trucks to be compacted.

**What is the business case for the Salares Norte mine?**
Salares Norte is a very rich deposit with high grade gold and a lot of silver. Including silver as gold equivalents, the mineral resource is 4.5 million oz and the mineral reserve 4.1 million oz. Approximately 90% of the value and volume is in gold and 10%. Our strategy at this high-grade, open pit, gold-silver project is to stockpile the ore. We will then be able to select the right grade of gold and silver to process in the plant. We currently have an 11.5 year life of mine with a production average of 350,000 equivalent oz/y gold. We expect that for the first seven years of operation, we will be in the order of 400,000 to 450,000 equivalent oz/y gold. This makes the project very attractive and the investment recovery very low at approximately 2.5 years. In our financial model for the PFS we have used a price US$1,200 and with today's gold price, Salares Norte would be very profitable.

**Salares Norte is one asset in an entire land package that Gold Fields controls. What is Gold Field's vision for the overall project, beyond Salares Norte?**
We have different properties in the area of Salares Norte and we have concentrated our search efforts in this area. Gold Fields was able to consolidate some properties around our current project, and three years ago, we started with a systematic approach to do exploration on these properties. Our aim is to define targets, which we will then drill out. Because of our extensive work on Salares Norte, we have the ability to read the surface better and understand the potential of what we have.

**How do you plan to incorporate innovative technologies?**
Salares Norte is a very low-cost operation and we still have potential to add additional resources in addition to our main project. We expect to start operations in 2022 and we are in the process of designing a mine of the future. We are trying to implement advanced technologies into our design such as connectivity solutions. Salares Norte is very isolated and we are 150 km away from power infrastructure. We will power the mine through diesel, but we have also incorporated solar energy solutions in our strategy. ■





# Andrés Guzmán Bosque

VP-Country Administrator Chile
**YAMANA GOLD**

**What is the current status of Yamana's different operations in Chile?**
While we are monitoring developments closely in the country, the political protests have not impacted our operations.
Our focus at El Peñón is on continuing to replace annual mineral depletion while exploring for significant new veins. We completed more than 100,000 metres of exploration drilling in 2019 and these efforts, along with ongoing geophysical analysis of the property, generated encouraging results.
Drill results yielded high-grade intervals of mineralization, indicating excellent potential for mineral reserves and mineral resource growth with potential to further extend mine life. In addition, we discovered a second vein at the Laguna satellite deposit with high-grade intervals of mineralization, while ongoing exploration and infill drilling of secondary veins in the core mine area have produced strong results from several sectors, including Sorpresa, Dorada, and Aleste.
At Minera Florida, we are focused on replacing depletion in the core mine and we are investing in surface exploration and data modelling to generate new targets. The property consolidation completed in 2017 facilitated the development of targets that are producing good results at better than life-of-mine grade in the PV Sur-Fantasma corridor and the Patagua-Don Leopoldo corridor.

**What potential does Agua De La Falda bring to Yamana's portfolio?**
Yamana owns 57.74% of Agua de la Falda; CODELCO owns the remaining percentage. Agua de la Falda presents an excellent opportunity for value creation in the long term for the company. The property already has a significant inventory of precious metals with potential upside. It also has the geological potential for base metal deposits, which is being investigated. Yamana is currently assessing the best path forward for Agua de la Falda along with strategic options for development and financing.

**Chile and Canada are the largest sources of revenue for Yamana. How do the two jurisdictions compare?**
There are many similarities in the two jurisdictions. Both countries have distinguished mining pedigrees and a long history of support for the industry. Both have defined rules for developing mining projects as well as deep mining infrastructure, skilled workforces, and clear processes and expectations around permitting, health, safety, and the environment. There is also a degree of predictability and reliability with respect to the tax and royalty regimes in both countries.
In terms of challenges, the level of scrutiny from communities, governments, NGOs, and activists has increased in both countries in recent years, as have expectations around environmental stewardship. In Chile, expectations for benefits sharing as well as local hiring and procurement have increased and this sometimes manifests in protests that can delay production. Yamana has largely avoided these tensions by engaging respectfully, transparently and continuously with its community partners and by investing heavily in local development, quality of life, education, and culture. The company also maintains strict environmental policies and procedures that often go beyond local laws and regulations. One of the bottlenecks to obtaining permits and project approvals in Chile is that different governmental agencies often act together and have overlapping requirements. To help address this problem, the Chilean government created the Office of Sustainable Management to serve as a point of contact between companies and different government agencies.

**What initiatives does Yamana have in place to ensure efficient use of water and energy at its operation in Chile?**
Our focus is on increasing our reuse and recycle rates and minimizing overall raw water consumption. To that end, we use the dry-stack method of tailings storage at El Peñón, which allows 80% of the water contained in the tailings to be recovered. The El Peñón processing plant includes a secondary containment system with a capacity of 3,000 cubic metres that recycles 100% of the water to the plant. Water on the mine property is collected in surface pools and reused in processing, reducing consumption coming from local wells. El Peñón has four sewage treatment plants, including a treatment plant in the mine camp that treats 200 cubic meters of water per day, which is then used in the mine's tailings treatment process. In addition, per capita water consumption in the El Peñón mine camp is carefully controlled through the use of water metres. With respect to energy consumption, El Peñón implemented a new grinding system to improve energy control and optimization, reducing the energy consumption in the grinding process by 15% in 2018. The mine also generated a 14% reduction in energy usage related to ventilation last year after installing a ventilation-on-demand system. ■

# Marcelo Álvarez

Executive Director Chile and Argentina
**BARRICK**

**We own the largest package of highly prospective lands in the El Indio gold belt, creating opportunities for exploration and development in gold, silver and copper projects. As of today, we have created the most ambitious exploration plan in this region in the company's history, trusting more than ever in Chile as an excellent destination for mining investment.**

**Describe the importance of Chile for Barrick? What options is Barrick considering to expand elsewhere in the country?**

Over the past 10 years alone, Barrick has spent some US$8 billion in Chile on exploration, development, royalties and taxes, wages, and payments to local suppliers.

We own the largest package of highly prospective lands in the El Indio gold belt, creating opportunities for exploration and development in gold, silver and copper projects. As of today, we have created the most ambitious exploration plan in this region in the company's history, trusting more than ever in Chile as an excellent destination for mining investment.

In our track record we have operated El Indio gold mine since 1994 and were the first company to carry out a successful program to close a gold mine according to international standards that, to this day, remains a model for others to follow with thoughtful and responsible closure plans. Currently, over 80% of closure works are completed with US$80 million dollars invested in this process. Since then we've also partnered with local and international companies to explore, build and operate mines together. The best example is the Zaldivar copper mine (a joint venture with Antofagasta Minerals) which contributes significantly to Chile's economy and which, from June 2020, will become the first mine to operate on 100% renewable energy.

Our company also holds a successful exploration history in Chilean mining. Our latest discovery Alturas has a resource base that already puts it as one of Chile's largest pure gold deposits. It was the result from a systematic re-evaluation of Barrick´s landholding in the El Indio belt and a remarkable discovery, as it is extensively covered by barren unmineralized rock, but our exploration team understands these deposits better than anyone else, which represents a competitive advantage for Barrick. Pascua-Lama is also undoubtedly an exciting and virtuous project for Barrick and for Chile. With its complexities, under the guidance and values of the new Barrick, it can be transformed into a great opportunity for communities and the country's economy and is now the priority for the new team of geologists and experts who are reviving the value of this asset.

**What are Barrick's views on the potential of the El Indio belt?**

Barrick is a very different company today. Following the merger with Randgold and the arrival of Mark Bristow as president and CEO, it is a 'geocentric' organization; meaning our behaviors and actions are consistent with our values and we recognize the critical importance of understanding the characteristics of an ore body and its responsible development throughout its life cycle. In this strategy, Chile, where much of the El Indio belt sits, has abundant mineral wealth and remains a safe, reliable and transparent investment destination and therefore Barrick will continue to trust and invest.

Our understanding of gold deposits has evolved, as have the geological models and technologies used to explore them. Areas that were hidden by barren rocks or rocks that were deposited in the mineralization were rarely looked at. We are thus embarking on a 'third wave' or the next generation of modern exploration, and we are very excited and reinvigorated in our compelling belief that there are more discoveries to be made.

**Why is Barrick bullish on the fundamentals of copper? How do your views on copper compare with those of the gold market?**

If you are exploring along the Andean trend then more often gold deposits come with either copper and/or silver. Our view is the growth prospects and opportunities to discover Tier 1 gold deposits into the future are skewed to Central and South America and therefore looking ahead, it is possible, if not guaranteed, that the gold mining companies of the future will also be copper producers. That is the context of our view on copper. Regarding our view on its fundamentals, if you believe in EV and more ESG and a world that is more responsible towards the environment and pollution then copper can be considered one of the more strategic metals of the future. Just as gold looks to be the only remaining value/financial reference in a world that is obsessed with financial manipulation, quantitative easing and consequential value destruction. ■





# Lithium

In looking to diversify the mining economy and the products it exports, the Chilean government has made it known that lithium will play a key role in the future of the country. Since reassuming power in 2018, Chile's President Sebastian Piñera has vowed to ensure a combination of both state and private investment to double the country's output to 230,000 mt/y of lithium carbonate equivalent by 2023. This would represent a large increase in relation to the 96,083 mt mined in the country in 2018, as reported by Reuters.

The lithium industry, in general, is in a nascent stage in its development. However, Cochilco forecasts approximately US$1.8 billion of new investment in lithium projects by 2022 and the mining ministry is keen to increase that amount.

Lithium in Chile is mined by pumping water up through underground salt beds to create pools of minerals. Thanks to the dry air of the Atacama, these pools quickly evaporate to leave a yellowish, oily lithium liquid that then gets processed and put into lithium-ion batteries, which store energy that powers mobile phones, electric cars and electricity grids when attached to wind turbines and photovoltaic cells.

The reason Chile is such an attractive jurisdiction for lithium production is largely because of the Atacama Salar, which produces the most lithium of any salar in the world. Henk Van Alphen, CEO of Wealth Minerals, a company with a concession of 46,200 hectares in the Atacama salar, described why it is so compelling: "The Atacama Salar is the world's highest grade and largest producing lithium brine deposit and currently produces approximately one third of global lithium output from two production facilities operated by SQM and Albemarle. The Atacama possesses a very high grade of both lithium and potassium, and has a high rate of evaporation and extremely low annual rainfall. These characteristics make Atacama's finished lithium carbonate easier and cheaper to produce than its peer group globally. A key factor in lithium production costs is evaporation time and the Atacama Salar's evaporation rate is the highest in the lithium industry."

Despite prime production conditions and upward of 50% of the world´s reserves, according to United States Geological Survey data, Chile has not permitted a new lithium mine since the boom began in 2014 and only two private companies, SQM and Albemarle, are in production.

Chile´s policy toward lithium has been deeply criticized as unclear for newcomers because it requires private miners to partner with the State or obtain a special permit known as a CEOL to mine lithium on their own. The problem is that the government has yet to provide guidelines for obtaining a CEOL. Nor has it announced a uniform royalty or tax scheme that would help investors gauge the risks.

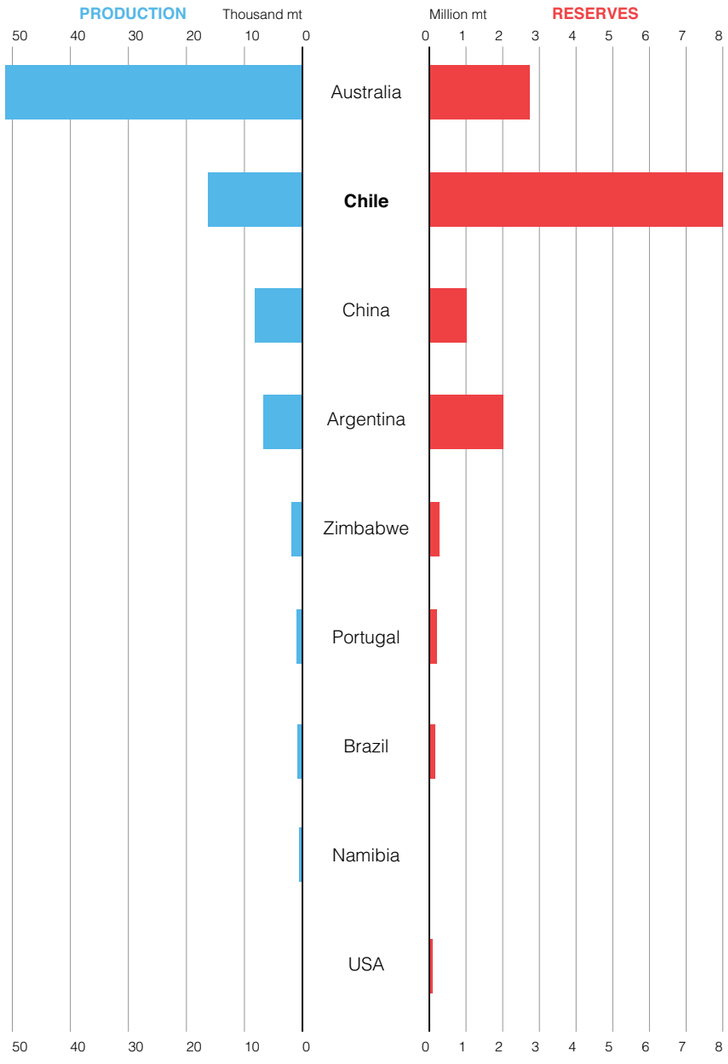
Regulations are another problem. Chile classifies lithium as "strategic" because it can be used in nuclear fusion. The nuclear energy commission limits the quantity of metal that can be mined. That is a worry for battery makers that might want to expand and depend on consistent supplies of lithium. In the past decade, Chile's share of global lithium production has dropped from 40% to 20%. According to Marcelo Awad, executive director at Wealth Minerals: "To make a change, the entire constitution will need to be brought back into congress for review and we have not seen a government willing to do this. The government is currently finding ways to comply with the constitution, but they are also trying to bring more production licenses to companies to develop lithium projects. I believe that we need more clarity from the government with regards to the current lithium laws."

**The New Great Game**

Despite, some of the regulatory complications, Chile is still a country lithium producers are hungry to access and deal flow is reflective of that. In December 2018, China based Tianqi bought a 23.8% share in SQM from Canadian fertilizer company Nutrien for US$4.1 billion, the largest deal in history for a lithium asset. In the wake of this deal, Uranium One, a subsidiary of Russian state run nuclear group Rosatom, signed a memorandum of understanding with Canada's Wealth Minerals that gives it the right to buy up to a 51% stake in the company's 46,200 hectare lithium project in the Atacama desert. The deal gives Rosatom access to major deposits of lithium that are dissolved in brine beneath the Atacama Desert.

COUNTRIES WITH MAJOR LITHIUM PRODUCTION AND RESERVES

Source: USGS 2019




**Moving up the value Chain**

Chilean producers currently export mostly unrefined lithium, not the higher-value battery parts the country hopes will someday generate added earnings for its export oriented economy.

According to Mining Minister Prokuriça: "With regard to lithium, we want to jump into the value added chain. We are the world's second largest lithium producer; we have salt flats and we would like to get as close as we can to the manufacturing of batteries and the manufacturing of elements to store energy, which we believe could create more revenue, more jobs and more opportunities for Chilean families."

An auction slated for 2020 offers a guaranteed supply of discounted Chilean lithium in exchange for a commitment to build battery parts plants in Chile. Oversupply and plummeting lithium prices, however, have made the deal a tough sell. In a previous tender in 2018, all three winners, including electronics giant Samsung SDI and South Korean steel mill Posco, subsequently dropped out.

**Falling prices spark investment delays**

A more than 50% drop in lithium prices from US$18,000 per mt in May 2018 to US$7,250 per mt in December 2019 unnerved the industry, fueling cuts to capital spending and halting expansions. Additionally, shares in major lithium producers have dropped as a result, exacerbating investor anxiety.

Big producers like SQM and Albemarle are responding by cutting costs and delaying projects. Albemarle's corporate statement affirmed it had begun a cost control program targeting over US$100 million in savings over the next two years. The world's largest lithium producer also delayed plans to add about 125,000 mt/y of processing capacity. SQM, the world's second-largest lithium producer, has also done its part, pushing back a key expansion at its Atacama salt flat operations from the end of 2020 to late 2021. The company has projected sales of 45,000-50,000 mt this year, well below its anticipated production of 60,000 mt.

All in all, there are a host of reasons to remain bullish on the outlook for lithium-ion batteries. Despite the market facing a triple negative of oversupply, excess stock and underwhelming demand in 2019, there is a strong argument that further along, as momentum builds, demand could outweigh supply. By 2030, the supply of lithium-ion batteries will need to increase more than 10-fold, Bloomberg forecasts, with electric vehicles accounting for more than 70% of that demand. "We expect to see serious growth in the medium term. It is projected that demand will rise to approximately 1 million my by 2025. Given that demand, financing should begin to become available for the junior producers. In the medium term, supply and demand will be better balanced, which will likely result in prices trending upwards," said Ellen Lenny-Pessagno, country manager at Albemarle. ■





# Ellen Lenny–Pessagno

Country Manager
**ALBEMARLE**

**Chile was the leading producer of lithium and now is number two, behind Australia. In Australia you extract lithium from hard rock and then process it. It is a much simpler and faster process. In contrast, the salars are complex and each salar has different brines. The current administration has stated that they want to maintain Chile's market share.**

**What is the history of Albemarle's involvement in Chile's lithium industry?**

39 years ago, alongside Corfo, Albemarle became the first company to develop the lithium industry in Chile. Over the years, we have seen a lot of change in the industry. Previously, lithium had very finite usages. In the last 10 years, with the rise of electric vehicles, use has expanded greatly. In order for OEM's to commit serious capital for investments in electric cars, Albemarle needed to prove that there would be enough lithium supply. This meant we needed to obtain government approval in order to pump more brine. We took six years to study the impact of additional lithium extraction on the salar and Albemarle proved that the impact of increasing pumping was sustainable. As a result, the government allowed Albemarle to increase its pumping from 142 liters per second to 442 liters per second. That sent a strong signal to the market in 2016.

**In what ways is Albemarle contributing to the development of Chile?**

Chile has clear competitive advantages in lithium production. When we received approval to increase our pumping rates, the government successfully capitalized on these advantages and ensured that the country captures the majority of these benefits. As a result, in the addendum to our original agreement, Albemarle agreed to pay the highest royalties in the world to extract lithium. We now pay up to 40% of the final sales price to the Chilean government. From July 2018 to July 2019, Albemarle paid US$100 million in royalties, in addition to taxes. We also committed to provide the largest financing ever devoted to research and development from a single company in Chile. Albemarle pledged US$300 million between now and 2043, and we are proud to take part in the effort to help grow the knowledge economy in Chile.

**What are your thoughts on Chile's potential to expand production in the future?**

Chile was the leading producer of lithium and now is number two, behind Australia. In Australia you extract lithium from hard rock and then process it. It is a much simpler and faster process. In contrast, the salars are complex and each salar has different brines. The current administration has stated that they want to maintain Chile's market share. At the end of 2020, Albemarle will complete construction and begin commissioning of Plant 3, which has a nameplate capacity of 40,000 mt/y, allowing us to double production. The growth we project in lithium demand cannot be met without leveraging the largest proven resources in the world, and we have access to the top three.

**How do you see the medium term dynamics of the lithium market?**

We expect to see serious growth in the medium term. It is projected that demand will rise to approximately one million mt/y by 2025. Given that demand, financing should begin to become available for the junior producers. In the medium term, supply and demand will be better balanced, which will likely result in prices trending upwards.

**How does Albemarle's La Negra plant add value to its operation in Chile?**

La Negra is a critical component of what we do. In the salar, we concentrate the lithium using the sun. We then truck the brine to La Negra and there we pass it through a complex chemical process and produce a molecule that can be used in cell phones, glass or electric vehicle batteries. Each cathode has a different requirement so we take 6-9 months to qualify the product with the customer. Lithium is not a commodity.

**How does Albemarle prove the sustainability of its operations?**

We have implemented the highest standard in measuring the hydrogeological levels of the salar, constituting the most advanced tools that exist in the industry for this purpose.

On the occasion of our RCA (Environmental Qualification Resolution) approved in 2016, the company presented an advanced hydrogeological model of the Salar de Atacama, with which the company established a new standard for the sustainable exploitation of the salar. In March of this year, we updated the model with real operational and measurement data of the last few years, so it is the most updated tool that exists and serves as a basis for authorities, communities and other companies with operations in the area. ■

# EXPLORATION

**» Chile can be viewed as a good place for juniors to operate, because it has stable rule of law, a stable economy, centrist politics, good enough infrastructure, and community relations aren't as bad as in other countries. There are also many challenges for juniors, and this starts with the fact that in the mining rights system in Chile, it is very easy for majors to block juniors from acquiring title. Here there is no "use it or lose it" policy for mining rights, no "minimum exploration commitments", so majors can keep mining rights forever, as long as you pay a small tax to maintain the mining right. It is an important issue for juniors, because the majors acquire a lot of these rights and end up blocking juniors. «**

**- José Ignacio Silva,**
**Country Manager,**
**Hot Chili Exploration**

Image courtesy of Gold Fields

# Copper: Juniors Progress Through Down Market

## BROWNFIELD EXPANSIONS REMAIN IN FAVOR

Taking a walk around the core shack at the SEG conference in October of 2019, it was obvious that Chile will continue to possess some of the most compelling geological opportunities regardless of its status as a mature jurisdiction with declining ore grades. Representatives of some of the top junior mining companies operating in Chile presented on the economic and geological promise of their projects. However, there was one topic of discussion that was ubiquitous. Obtaining financing to advance projects was an existential challenge. This is not an unfamiliar discussion. There was a multi year contraction in exploration expenditure from 2012-2016, after hitting a record high of US$1.04 billion in 2012.

During that period, returns mining companies had promised failed to come to fruition, leaving project financiers out of pocket and unwilling to fund more developments. This sentiment is continuing to affect project investment today, and is why most of the capital currently invested is 'stay-in-business' expenditure, typically replacing reserves through brownfield expansions.

The positive trajectory established in 2017 gave juniors hope that the market had finally turned for the better. But in 2018, the exploration budget in Chile dropped to US$576.2 million, down by around US$27 million year-on-year from 2017, based off Chochilco reporting. This positioned Chile in sixth place internationally, accounting for 6% of the global exploration budget.

In analyzing the drop in the countries exploration budget, the number seems small. However, the lack of funding opportunities have been more acutely felt by juniors, who decreased their budget by 52% in 2018, with their share of the total budget dropping to 5% in Chile. Meanwhile, the contribution of majors held steady due to their brownfield projects.

Dave O'Connor, chief geologist at Aethon Minerals, commented: "There is a lack of investment in junior companies resulting in a lack of activities from them. It has become increasingly difficult for juniors to raise financing on the stock markets. There has also been a slowdown in exploration activity from the majors, making it hard to do joint ventures."

That said, there are still many companies willing to endure soft market conditions in the short term in order to reap the benefits of remaining in Chile when the market turns up again. 110 companies are conducting exploration in the country and 46% remain active. Some 54% of these exploration projects are focused on copper, 25% on gold, 4% on lithium and 3% each on silver, cobalt and iron, a Cochilco study disclosed.

According to José Ignacio Silva, country manager of Hot Chili, an Australian junior operating in Chile: "As financial markets have not been funding many exploration projects in the last few years, the few ones that remain will be very important in the next cycle." He went on to address why greenfield projects are less favorable at the moment: "In general, drilling is very expensive and chances of success

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# Christoff Janse

Investment Promotion officer
**INVESTCHILE**

**Can you give an overview of InvestChile and the role it plays in promoting investments in Chile?**

In the mining sector we focus on mining and exploration projects and companies in the supplier value chain. Diversification of the country´s key economic sectors is a long-term strategic goal, and besides primary extraction projects, we promote projects that move up the mining sector value chain.

In what ways does InvestChile inform and support investors?

We act as a bridge between foreign companies and the public sector. We also act as a link between other agencies and services which can help the company during the evaluation of a project or the implementation phase. InvestChile works closely with CORFO (The Industrial Development Corporation) that provides subsidies for special focus programs.

**What makes Chile an attractive investment destination?**

Chile ranks highly, in the region and internationally, in terms of the ease of setting up a business and has been consistently ranked as the most competitive country in Latin America since the creation of the World Economic Forum ranking for this metric. There is still some red tape and bureaucracy companies have to go through but the government is committed to cutting red tape with a new pro-investment set of laws and accelerating projects with a new office that supports Investchile in the landing stage.

The Sustainable Projects Management (GPS) office was established by the Ministry of Economy and aims to track and streamline procedures such as permitting in order to boost large investment projects.

Chile is a world-class mining jurisdiction and was ranked 6th out of 91 jurisdictions in terms of attractiveness for investment in mining projects in the latest Fraser Institute Survey. Many of the big players in the mining sector have operations here and from a supplier´s perspective this means relative easy market entry by continuing business relationships already established elsewhere with their clients.

**Can you elaborate on the permitting process in Chile?**

The permitting process might take longer in Chile than in some other jurisdictions but remains transparent. There is a stated commitment to streamline the permitting process and many initiatives have already been launched in this regard.

**How has mining investment been in 2019, and what do you project 2020 to look like?**

The last couple of years have been slow globally, but we are starting to see an increase in mining investment. Companies that had put projects on hold have decided to move ahead with the investments. The current project pipeline for mining projects in Chile for the period 2018 to 2027 is close to US$66 billion, which is encouraging.

Considering the current social and political juncture that Chile is facing, we are confident that the country is and will continue to be a good destination for foreign investment, especially in the mining sector. There is wide acknowledgement of the importance of foreign companies in the economy and their contribution to best practices, operational efficiency and development.

**There are concerns about high labor costs and requirements around labor being a drag on profitability. In what way is the government trying to improve the situation?**

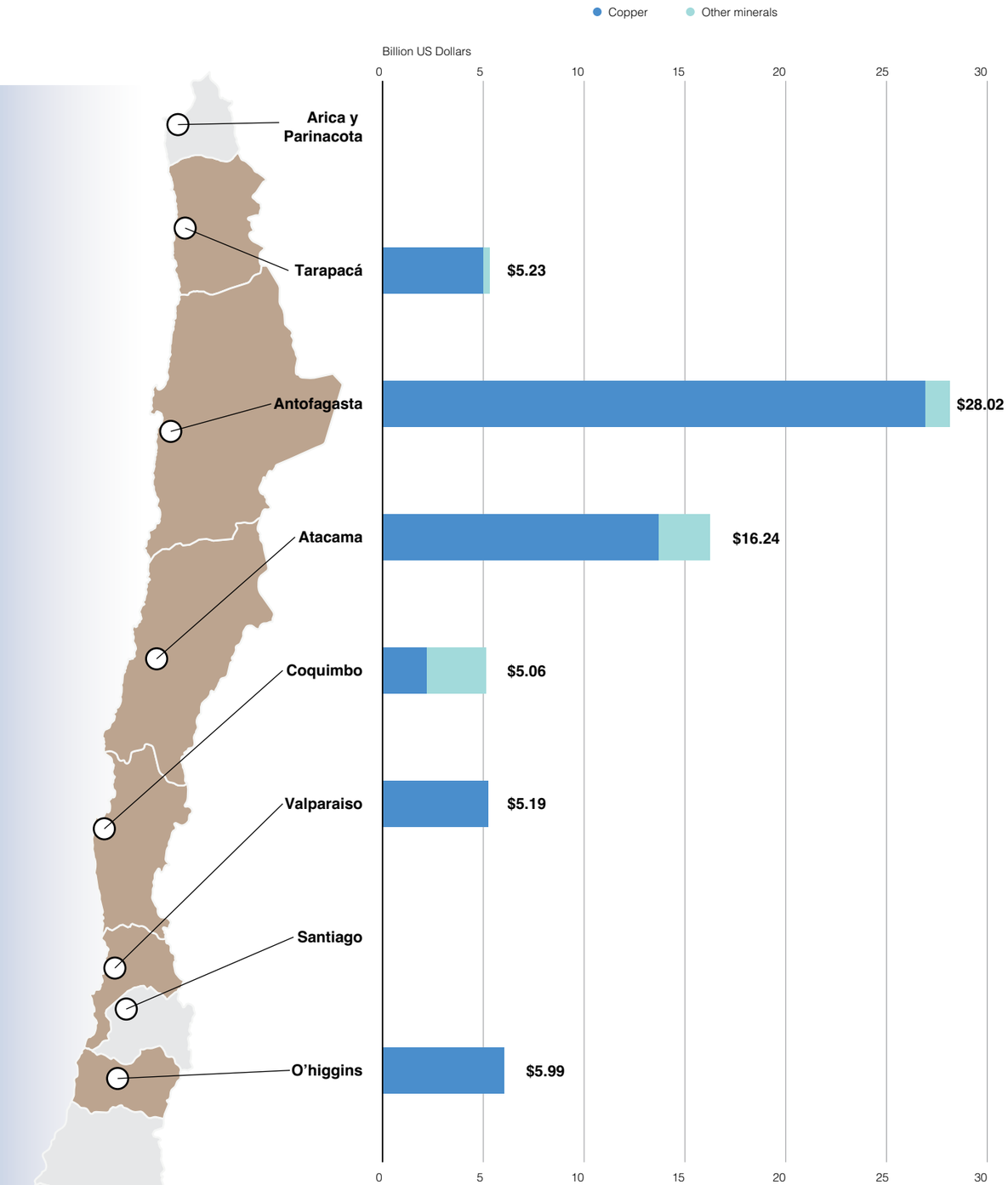
There was a significant increase in operating costs during the super cycle period due to high demand for labor and services. After this period, these costs did not decrease significantly but just leveled off. Some companies still struggle to fill positions for skilled workers, which puts pressure on the cost of labor. The government has initiatives in place to increase training and educational programs focusing on technical skills in an effort to grow the available talent pool. With 200,000 university students graduating annually and with Chile holding the top position in Latin America in the 2018 Global Talent Competitiveness Index, there is reason to believe that the issue of high labour costs is being addressed.

**How does InvestChile encourage smaller players to enter the Chilean mining market?**

InvestChile has started to focus on smaller exploration projects that do not necessarily have the visibility or direct contact with potential investors. In collaboration with the Ministry of Mining we annually publish a catalog of smaller and medium sized exploration and exploitation operations in Chile that could be of interest to bigger mining companies or investors. ■

## INVESTMENT PORTFOLIO BY REGION, COPPER MINING AND OTHER MINING

Source: Cochilco








# Antony Amberg & Fernando Porcile

AA: President and CEO
FP: Executive Chairman
**LOS ANDES COPPER**

AA

FP

**What is the history of Los Andes Copper and the evolution of your Vizcachitas project?**
**AA:** Los Andes Copper and our Vizcachitas project have a long history dating back to the 1970's. I joined the company in 2012 and, since then, we have completed two drilling campaigns; in 2015 and 2017. The results of these drilling campaigns were then used to prepare a NI 43-101 compliant Preliminary Economic Assessment, which we published in June 2019. The PEA demonstrated that the Vizcachitas project is a very attractive and viable copper project. We were able to show an NPV of US$1.8 billion and internal rate of return of 20.77% at US$3.00/lb copper after tax. We demonstrated a significantly larger resource base and have measured and indicated resources ore of 1.284 billion mt. The PEA also demonstrated that there are no fatal flaws and the project can be mined without any significant complications.
We are now pressing ahead with a Preliminary Feasibility Study for the project and to enable that, there has be a restructuring of the management team to reflect the fact that we are now a development company, with Fernando Porcile joining the board as executive chairman.

**What is Los Andes Copper's vision for the Vizcachitas project and what is the company's strategy moving forward?**
**FP:** The Vizcachitas project not only has a large resource, but also has some qualities that make it more competitive than many new greenfield projects and even some of the brownfield expansions in Chile. The ore grades are satisfactory, we have molybdenum content which improves our copper, and it is a clean ore with minimal impurities. The project is located at an elevation of approximately 2000 meters above sea level, which is very attractive in a country such as Chile, and the deposit occurs in the same geological belt as several other giant porphyry deposits.
Vizcachitas is located approximately 150 km northeast of Santiago, in the Rio Rocin Valley, an area with good infrastructure and paved roads. The port of Ventanas is located at approximately 140 km from the project site. The infrastructural advantages are very relevant for us, as we will need reduced capital investment in infrastructure to achieve a production of approximately 500,000 mt/y of copper concentrate.

**How important is it for Los Andes Copper to establish good relations with nearby communities?**
**FP:** You cannot develop a project today without social acceptance. Vizcachitas has some advantages, in that we are not located in an area with much human activity. The main social issues of concern in the community are water and tailings disposal, and we believe our project will have a positive economic impact on the community, without causing relevant disruption to the environment.

**How does the 2014 PEA differ from the PEA published in 2019?**
**AA:** The resource base has increased significantly and we have defined measured resources for 46% of the projected mill feed for the first 10 years of operations. The conditions of the Chilean power market have improved drastically from those present in 2014. The 2015 and 2017 metallurgical test work has demonstrated that we can use a coarser grind for the rougher flotation circuit, while maintaining recovery. This means that for the same capital and operating costs we can significantly increase the ore throughput.

**What are the biggest challenges Los Andes Copper sees moving forward with the PFS?**
**FP:** The challenge will be to have all the information required for an EIA prepared in our targeted timeframe. Our plan is to complete our PFS by the end of 2020 and have everything ready for an EIA. The EIA approval process can last 12-15 months. Once the approval has been granted, multiple sectoral permits need to be processed. Los Andes Copper estimates that this approval, including the sectoral permits, may be finalized by the end of 2022.

**What has been the driving force behind Los Andes Copper's increase in shareholder value in 2019?**
**AA:** I believe that the PEA has demonstrated the attractiveness of the project. We are also now going into the development phase and have brought on a very experienced management team to take the project forward. ■

# David O'Connor

Country Manager and Chief Exploration
**ABRAPLATA RESOURCE CORP.**

*As of 2020 Aethon Minerals is now AbraPlata Resource Corp.*

**Can you give a brief overview of Aethon Minerals in Chile?**
Aethon Minerals commenced trading on the TSX Venture exchange in May 2018 and was based on a series of exploration projects in the Maricunga and Antofagasta regions of northern Chile. These are early projects which have had money spent on them to focus on targets for more detailed exploration, and recently we entered into a joint venture with Rio Tinto on one of the projects in Antofagasta region.

**When Aethon partners with a major, what are the terms of the agreement?**
Companies such as Rio Tinto are looking for mega projects as they have deep pockets and long-term vision. They are thus happier to look at concepts where a mega project might develop. Aethon Minerals cannot afford to go down this route as it is too expensive for us and thus, we need to enter joint venture agreements. The earn-in agreement we announced with Rio Tinto on Arcas allows Rio to earn into a 75% stake in the project by spending up to US$25m in exploration activities over the next several years.

**What is the major challenge for Aethon Minerals for the next 12 months?**
Aethon Minerals is going to be focused in Argentina on the advanced Diablillos project. We aim to start drilling this project next month. We aim to improve the economics of the evaluation by expanding the resource and looking at an underground mining scenario which would have a much lower capital cost, but retain the amount of gold and silver production over the life of the mine, as well as improving metallurgical recoveries.

**What are Aethon Minerals' objectives in Argentina and Chile moving forward?**
In Chile, as our projects are more appropriate to majors, Aethon Minerals would like to venture out all our properties to majors to get them financed. In Argentina, we aim to expand our resource and complete a new economic assessment to improve the overall economics. ■

# José Ignacio Silva

Country Manager
**HOT CHILI**

**What has been driving Hot Chili's strong stock performance year to date?**
The Cortadera project has been and will continue to be a game changer for Hot Chili. We are now finishing the year having announced on December 4th one of the best intercepts globally (972 m at 0,5% copper and 0.2 g/mt gold from surface). Once we began reporting positive results from our project, the financial markets quickly took notice of our larger than expected resources and this explains the exceptional performance of our stock year to date.

**How is the location of your Cortadera and Productora projects strategically beneficial?**
In terms of infrastructure, I don't know of any other project in Chile with a better location. Cortadera and Productora are located 14 km from each other, at low altitude, 50 km from the coast and 20 k from a power sub-station. Additionally, there is no need for camps, because our projects are located close to a mining town called Vallenar. We have very good relationship with the people living in the town and they support our work.

**What are the benefits and drawbacks for juniors operating in Chile?**
Chile can be viewed as a good place for juniors to operate, because it has stable rule of law, a stable economy, centrist politics, good enough infrastructure, and community relations aren't as bad as in other countries. There are also many challenges for juniors, and this starts with the fact that in the mining rights system in Chile, it is very easy for majors to block juniors from acquiring title. Here there is no "use it or lose it" policy for mining rights, no "minimum exploration commitments", so majors can keep mining rights forever as long as you pay a small tax to maintain the mining right. ■





Image courtesy of Revelo Resources

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are very low. That is why it is better for junior companies to look for a project with some drilling and some results than rather than opting for a greenfield project."
Some of the juniors that are skillfully navigating the current challenging environment in Chile are Aethon Minerals, Coro Mining, Hot Chili, Los Andes Copper, Rio2 limited, Wealth Minerals, Lithium Chile and Revelo Resources.
Los Andes Copper is leading the development of the industry with its Vizcachitas project, located in the Rio Rocin Valley of central Chile. It is one of the largest advanced copper projects in the Americas not held by a major. The project is currently well positioned to continue its development as it is now in the permitting process for its pre-feasibility study. According to executive chairman Fernando Porcile: "The Vizcachitas project not only has a large resource, but also has some qualities that make it more competitive than many new greenfield projects and even some of the brownfield expansions in Chile."
His colleague Antony Amberg, CEO of Los Andes Copper, explained why their project has garnered so much attention from the mining community: "The PEA demonstrated that Vizcachitas is a very attractive and viable copper project. We were able to show a net present value (NPV) of US$1.8 billion and an IRR of 20.77% at US$3.00/lb copper after tax. We demonstrated a significantly larger resource base and have measured and indicated resources of 1.284 billion mt."
The PEA also demonstrated that there are no fatal flaws and the project can be mined without any significant complications.
Another notable copper exploration project is Coro Mining's Marimaca. The project is geologically unique in that it is an oxide deposit and is hosted by intrusive rocks, while the numerous manto deposits in the same region are hosted by volcanic rocks. With a lack of new copper exploration discoveries in Chile, it represents a new type of deposit, which challenges accepted exploration wisdom and may open up new frontiers for discoveries elsewhere in the country.
Marimaca's location on the coastal belt at low elevation close to Antofagasta and Mejillones is considered advantageous, particularly when compared to projects in the high Andes and this prime location could enable its future development at a relatively modest capital investment. "Marimaca lies in the heart of Chile's main copper producing region, surrounded by the skills and infrastructure needed to build and operate a mine. Crucially, it does not need to incur the significant infrastructure costs associated with a remote development project," said CEO Luis Albano Tondo.
At Hot Chili, its Cortadera project saw notable progress in 2019. The company's latest drill results announced are globally competitive, with 972 m of drilling and grading at 0.5% copper and 0.2 g/mt gold from surface. José Ignacio Silva described this years developments: "Once we began reporting positive results from our project, the financial markets quickly took notice of our larger than expected resources and this explains the exceptional performance of our stock year to date." Cortadera, first thought of as a satellite project for Productora, is now the companies flagship asset. Hot Chili's combined resources base is approximated at 236 million mt at 0.5% Cu equivalent.

# Lithium: Dealing With Difficult Market Conditions

The two most influential juniors operating in the Chilean lithium mining market are Calgary based Lithium Chile and Vancouver based Wealth Minerals. Most Canadian lithium explorers battled massive share price declines and difficulties raising financing in 2019. As a result of falling prices, companies reacted quickly to the deteriorating market conditions and curtailed drilling operations to prevent excessive cash burn. Globally, the Mining Intelligence Data Application revealed that in Q2 2019, drilling activities focused on exploration and resource evaluation of lithium and cobalt deposits dropped to the lowest level in two years. Also, the number of completed drillholes dwindled by more than 50% from the peak reached during Q3 2018.

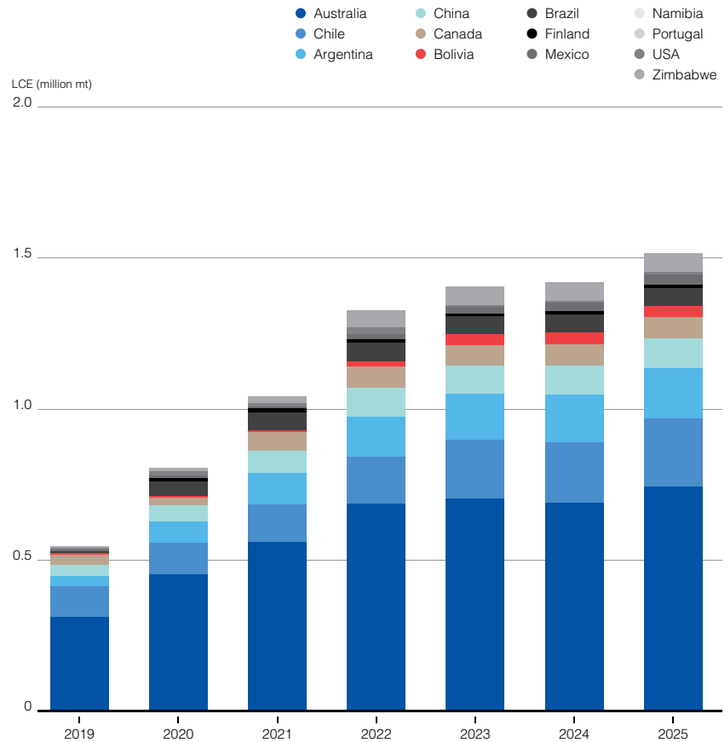
In spite of market conditions, Lithium Chile remained committed to advancing its lithium property portfolio consisting of 166,150 hectares covering sections of 14 salars and 2 laguna complexes in Chile. Lithium Chile is the largest landholder of lithium exploration projects in Chile outside of the government and SQM. In December 2019, the company announced that drilling has commenced at its Turi lithium brine project in Chile. Turi is one of six high-priority projects identified for early drill testing.

For Wealth Minerals, the announcement of a memorandum of understanding with Uranium One could lead to a Definitive Agreement for a partnership that would accelerate the development of the companies Atacama lithium project. This includes the use of Uranium One's lithium extraction technology, which potentially has big implications for more efficient use of water. A Pertinencia (or work program review affidavit) was received from the Chilean Environmental Agency for the company's Atacama project in August 2019. This key document allows for low impact exploration programs at the property.

Source: Cochilco and Ministerio de Mineria

| Project | Company | Amount |
|---|---|---|
| Planta La Negra - Fase 3 | Albermarle | US$ 300 millions |
| Ampliación Salar del Carmen | SQM Salar | US$ 180 millions |
| Producción de Sales Maricunga | SIMCO SpA | US$ 350 millions |
| Ampliación Salar del Carmen<br>Ampliación Carbonato de Litio A 180 | SQM Salar | US$ 450 millions |
| Maricunga | Minera Salar Blanco | US$ 527 millions |

LITHIUM PRODUCTION (LITHIUM CARBONATE EQUIVALENT)








# Marcelo Awad & Henk Van Alphen

MA: CEO
HVA: Executive Director
**WEALTH MINERALS**

MA

**What compelled you to join Wealth Minerals and enter the lithium industry?**
**MA:** I realized that lithium had a significant amount of potential in Chile. In the past, lithium was left as waste. Only in the last 10 years has lithium become an important mineral for the global economy. It is now clear, however, that lithium will play a big role in the energy and transportation technologies of the future. For this reason, I decided that I wanted to contribute to making Chile a leader in lithium production.

**Can you elaborate on the projects Wealth Minerals is involved in in Chile?**
**MA:** Wealth Minerals holds a number of mining concessions of which the most important is the Atacama Salar. The Atacama Salar concessions cover an area of approximately 46,200 hectares. We also have concessions in the Trinity Salar, which comprise several land positions located in close proximity to each other. Our other concession is in the very northern part of Chile in the Iquique area. In total, Wealth Minerals holds approximately 70,000 hectares across its five Salars.

**What makes Wealth Minerals assets attractive to investors?**
**HVA:** The Atacama Salar is the world's highest grade and largest producing lithium brine deposit, and currently produces approximately one third of global lithium output from two production facilities operated by SQM and Albemarle. The Atacama possesses a very high grade of both lithium and potassium, and has a high rate of evaporation and extremely low annual rainfall. These characteristics make Atacama's finished lithium carbonate easier and cheaper to produce than its peer group globally.

**What is your outlook on lithium prices?**
**HVA:** I believe lithium prices will rise because currently there is not enough production coming online. None of the salars in the lithium triangle in South America are moving forward quickly and the only country in the world that has seen an increase in production is Australia. Chile hasn't increased production much and it is much more complicated than people predicted. The process in Chile is to pump the brine and evaporate the water, and that creates lithium. Evaporating water in a desert environment isn't a popular thing to do.

**From a policy perspective, lithium was declared a strategic mineral. Do you see the status changing, and what policy initiatives do lithium producers need from the Chilean government to fully realize their potential?**
**MA:** The Chilean government has been very eager to find a way out of the fact that lithium and uranium are strategic metals according to the constitution. To make a change, the entire constitution will need to be brought back into congress for review, and we have not seen a government willing to do this. The government is currently finding ways to comply with the constitution, but they are also trying to bring more production licenses to companies to develop lithium projects. I believe that we need more clarity form the government with regards to the current lithium laws.

**Is Wealth Minerals in a position where the company has social license to operate?**
**MA:** The day we bought the mining concession at the Atacama Salar, Wealth Minerals decided to immediately meet with the communities and report our plans to them. We have kept the community very well informed from the start and we have continuous dialog with them. We will always listen to the concerns of the community, as we believe that it is necessary to involve all stakeholders in the process of developing the Atacama.

**What are Wealth Mineral's objectives moving forward?**
**HVA:** In the next two years it is very important to get a big strategic partner to move the project forward and provide us with the financial backing we need. That is our hope for the next two years. Production will take substantially longer, but as long as we are working toward that goal, we will be successful.

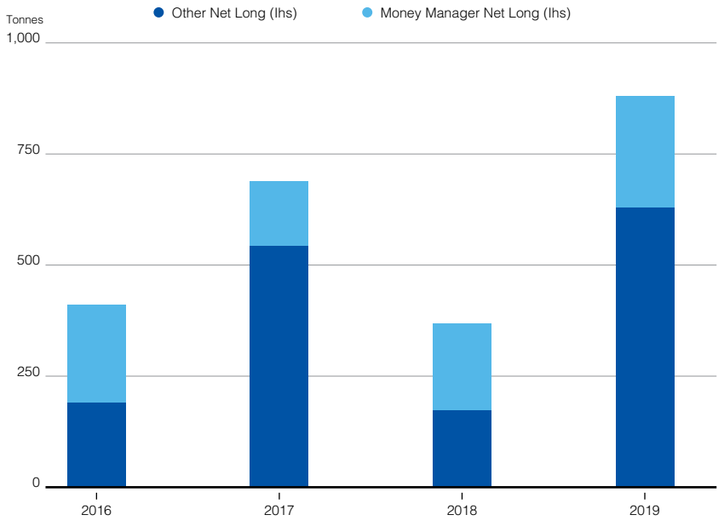
**Why is Wealth Minerals an appealing investment opportunity?**
**HVA:** As a shareholder we are trading at a 2 or 3 year low, so its a good time to start looking at companies again, because there will be a lithium shortage at some point over the next 2-4 years. ■

# Gold: Enjoying Favourable Market Conditions

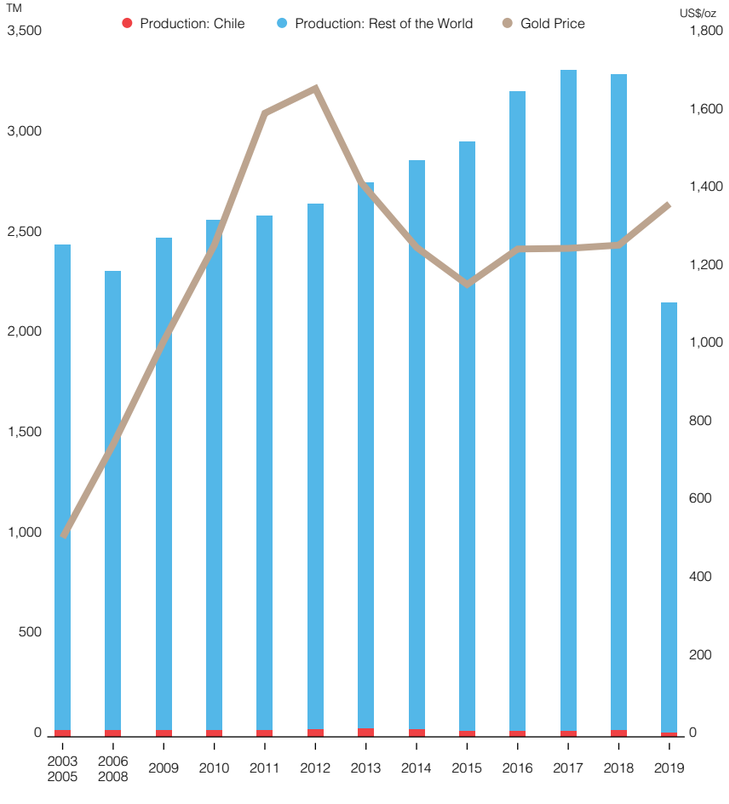
In contrast to copper and lithium, precious metals focused companies have not experienced the same level of difficulty in financing their operations. Because of this, the market for new exploration has been reinvigorated.

Rio2 is a junior led by CEO Alex Black. Black previously turned Rio Alto Mining into a new gold producer in Peru, which was eventually acquired by Tahoe Resources for US$1.12 billion. Rio2's Fenix project, located in Copiapó Province, Antofagasta region, is one of the largest gold oxide resources in the world according to the company. In 2019, it completed an updated pre-feasibility study to reveal an after-tax net present value of US$121 million discounted at 5% and an IRR of 27.4%. The study also proved that the project is capable of profitability at prices as low as US$1200/oz. According to Enrique Garay, senior vice president of geology: "Rio2's business model is to move the large resource at Fenix Gold into development and production as an open pit, gold heap leach mining operation. The strategy is to take the project into production in the shortest possible timeframe based on a staged development strategy."

COMEX NET LONG POSITIONING




GOLD PRODUCTION AND PRICE EVOLUTION




Source: Consejo Minero





# Enrique Garay

SVP Geology
**RIO2 LIMITED**

**What is the history of Rio2 and why has the company chosen Chile for its flagship project?**

Rio2 is a follow-up business to the previously successful Rio Alto Mining, which began business in 2008. Alex Black and his management team took Rio Alto Mining from a CAD$12 million company in 2009 to a CAD$1.2 billion company in 2015, which was then acquired by Tahoe Resources.

Three years later, the same team that had successfully developed two projects in five years with Rio Alto, formed the management team of Rio2. Today we are a public company listed on the Toronto Stock Exchange Venture, the OTCQX Market, and the Lima Stock Exchange. We believe that we have the experience to move advanced projects into production or manage existing mining operations and, to date, we have evaluated over 60 mining and development projects in the Americas. The Cerro Maricunga project in Chile captured our attention because it was well drilled with a sizeable initial resource. After acquisition, the project was renamed the Fenix Gold project. We then wanted to confirm the resource disclosed and drill a further 7,000 meters. The mineral resource estimate was updated in 2019, based on data collected from 91 diamond drill holes and 291 reverse circulation holes drilled on the project since 2010.

**What strategy and business model is being implemented at the Fenix Gold project?**

Rio2's business model is to move the large resource at Fenix Gold into development and production as an open pit, gold heap leach mining operation. The strategy is to take the project into production in the shortest possible timeframe based on a staged development strategy. The advantages of developing a project in Chile compared to Peru are that mining regulations are clearly defined and the social aspects of doing business in Chile are far less complex than in Peru. We are in the process of conducting an EIA on the Fenix Gold project, which will be completed in early 2020 and planned to be filed with the authorities for approval in Q1, 2020. In the meantime, we will be applying for various permits related to the project while the EIA is being assessed. We expect to receive our construction permit in Q4, 2021 and commence construction shortly thereafter, with a target date of Q4, 2022 for the start of gold.

**Can you elaborate on the permitting process in Chile?**

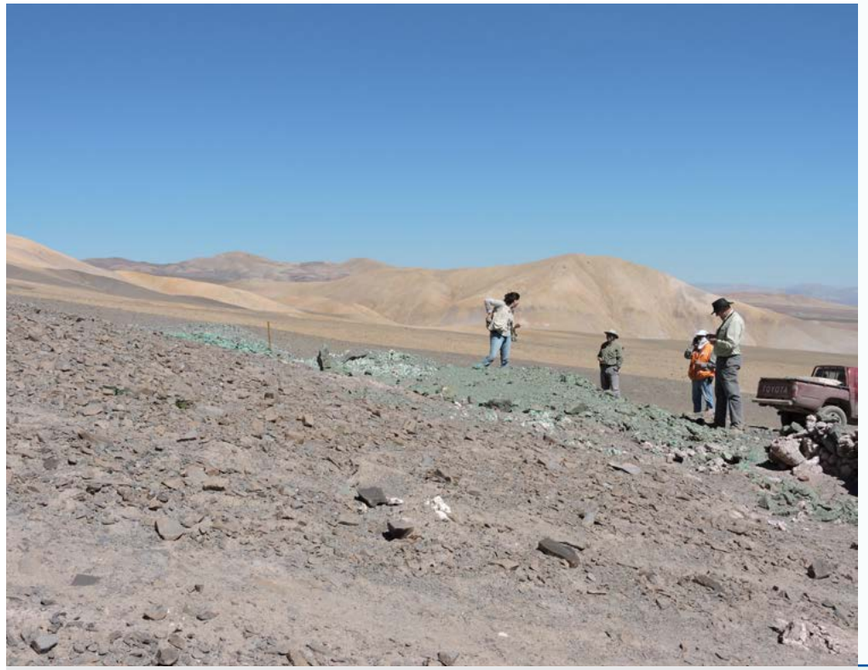
Rio2's experience with the permitting process in Chile has been positive. The process does take time as it is very prescriptive but we have a commitment to comply with all the regulations and get through the process as quickly as possible. The advantage is that we have a good sense for how long it is going to take, and the clarity of the process significantly helps with planning for the future.

**What are Rio2's objectives moving forward?**

Rio2's main objectives for 2020 will be to look for other permitted sources of water for our Fenix project and ways to optimize and lower our capex and opex for the project. We are also planning to continue our M&A activities focused in the Americas. ■

# Prospect Generating: Rare Dollars for Exploration

Image courtesy of Revelo Resources



Revelo Resources is a prospect generator and the company's CEO Tim Beale outlined its strategy: "The idea is that we generate prospects and then look for industry partners to make joint venture agreements. We are now looking to modify our strategy by continuing to look for option and joint venture agreements with mid-tier or large companies, but also by raising private finance to fund exploration – perhaps by spinning out certain projects which we will operate."

The company signed a letter of agreement with UK based BMR Group in 2019 to acquire an 80% interest in the Montezuma copper project for US$6.5 million in cash and US$1.5 million in exploration expenditures. Montezuma is located in northern Chile between the Chuquicamata and Centinela copper districts and BMR will have an option over the property, while Revelo Resources will have a retained interest through to the completion of a PEA.

As for the company's future plans, it intends to continue spending money on exploration and advancing projects: "The exploration process is the biggest step up in value creation in the whole chain of exploration, feasibility and development in mining. If we make a discovery, significant shareholder value will be created," Beale said.

## Private Equity

Junior exploration companies primarily fund their operations through liquidity generated by stock market listing. Analysis of the geographies in which these companies are listed gives a strong indication into where the capital for exploration activities in Chile are raised. The Toronto Stock Exchange (TSX), the TSX Venture Exchange (TVX) and the Australian Stock Exchange (ASX) are the principal markets, according to Cochilco. Given, funding for junior explorers dropped 25% year on year on the Canadian stock markets, and these exchanges finance over 50% of juniors operating in Chile, it is understandable why impacts are being felt so markedly in Chile.

Private equity provides an alternative to financing via the stock market and insulates companies from the volatility of public financial markets. Two of Chile's top juniors, Coro Mining and Los Andes Copper, have significant private equity backing. Greenstone and Tembo Capital own 70% of Coro Mining and Resource Capital Funds has been instrumental in helping Los Andes Copper advance its Vizcachitas project. The company financed drilling for Vizcachitas in 2016 and in 2018 provided funds to complete the preliminary economic assessment and initiate the prefeasibility study.

Criteria for private equity firms differ significantly, but often companies are flexible and adapt to opportunities in the market. According to Ignacio Del Rio, CEO of Minería Activa: "Back in the boom of 2010, it was difficult to acquire an operating company. We saw valuations at US$4 copper projections, so it made more sense to invest in exploration or pre economic assessment stages. We did this with Dominga and it proved to be successful. When we went through the crisis and copper fell back to US$2 in 2016, that is when we acquired Pampa Camarones, a copper operation that was filing for the Chilean bankruptcy process. In this case we went for a distressed opportunity with a turnaround idea. We are opportunistic and flexible regardless of what stage a company is in or what mineral they are producing." ■





# Tim Beale

CEO
**REVELO RESOURCES**

**What is the history of Revelo Resources? Why did it choose to focus its operations in Chile?**

In the late 2000's, Iron Creek Capital identified Chile as a jurisdiction with great potential and the company decided to establish a presence there. In 2014, when the last mining boom finished and the industry was in a depression, Iron Creek decided to capitalize on opportunities in the market and we started making acquisitions. We performed several stock based transactions to expand our portfolio and this included a merger with another Chile based junior named Polar Star Mining. After Iron Creek Capital acquired Polar Star Mining, we changed the company name to Revelo Resources.

**What is the business model of Revelo Resources?**

Revelo Resources has been known in the industry as a prospect generator. The idea is that we generate prospects and then look for industry partners to make joint venture agreements. Our partners then go on to explore our properties and invest more in them. We are now looking to modify our strategy by continuing to look for option and joint venture agreements with mid-tier or large companies; but also by raising private finance to fund exploration, perhaps by spinning out certain projects which we will operate. For partnerships, we are focusing on companies that do not have a presence in Chile but would like to have a presence in the country.

**In what stage of development are most of Revelo's projects? What is your biggest challenge in moving these projects forward?**

Revelo Resources has historic data on our assets and we have done surface work such as geological mapping and revision of the historical data. Some of the projects require more surface work, but most are at the drill stage. The challenge for us and many other juniors today has been financial. It is a struggle in the capital markets to get money for greenfield exploration and mining companies have not been doing many deals with juniors lately.

**Describe the interest Revelo is receiving from investors?**

Investor interest is very much dependent on what commodities the world is looking for. With the recent increase in precious metals prices, there has been an improvement in the sentiment for precious metals exploration. We have four precious metals projects in our portfolio, of which three are currently attracting interest. We are looking at a possible spinout of these precious metal projects. We also have several copper focused projects that we are promoting.

**Is Revelo Resources looking to acquire more assets in the Chilean market?**

As a junior company, Revelo Resources has a competitive portfolio of 130,000 hectares of wholly owned properties in Chile. We have 16 projects – four gold/silver assets and 12 copper assets. This is a significant portfolio to offer to investors and to companies which are not present in Chile. Revelo would be open to acquire more assets, but capital is currently a challenge. We need to advance the portfolio we have before we start making more acquisitions.

**How does Revelo Resources view Chile as a mining jurisdiction?**

Chile is a very stable jurisdiction. The legal system works, and levels of corruption are low. The geological potential of the country is huge, and despite claims that Chile is a mature market, we still believe there are significant opportunities. When compared to its neighbors in the Andean cordillera, Chile is a less complicated place to mine. There are a host of political, social, legal, environmental and security issues that are much more manageable in Chile. Some of the big mines have been mined for over 100 years and yes, grades are much lower than they used to be, but Chuquicamata, for example, has gone underground and will likely be mined for another 50-100 years. World class means long life of mine and scalability of production, and Chile has several truly world-class mines. These huge mining districts in Chile will all be mining for decades into the future. Jurisdictional risk is increasing all over the world today, and there are fewer and fewer places where you want to invest a lot of money. Chile still remains a leader in that regard. ■

**When compared to its neighbors in the Andean cordillera, Chile is a less complicated place to mine. There are a host of political, social, legal, environmental and security issues that are much more manageable in Chile.**

# Ignacio Del Río

CEO
**MINERÍA ACTIVA**

**Before construction stage, permitting is the most relevant risk in Chile. At feasibility stage, securing water supply has become a key challenge in Chile. At exploration, geololgical risk is relevant, but metallurgical issues should also be faced early on.**

**Mineria Activa has focused its investments in Chile. What about Chile is so appealing for a private equity fund?**
Minería Activa belives that being local provides an important advantage in the value we add to our portfolio companies. We know the history of our investmentments and we have the network in place to overcome challenges.

**Currently, what are your key investments in Chile?**
Our first fund was raised in 2008 with a focus on early stage junior companies. For that fund we acquired an Australian junior company that had a project called Dominga. We took the project to pre-economic assessment and had a good exit. Overall, it was a good initial fund. Last month, we sold our investment in a company called BioLantanidos. We invested 100% of the fund into the company. It required a large investment, because the company was starting a new industry in Chile and also Latin America and was important to us. We held that investment for 8 years and just sold it to Hochschild Mining. The last fund was a mining fund with two important companies; one is Pampa Camarones, which is a copper cathode producer in operation, and the other is a polymetallic project that we are taking to feasibility.

**How do you see potential for growing the rare earths industry in Chile?**
There is only one rare earths project in Chile and that is BioLantanidas. Production of rare earths has been monopolized by China. Here, we have found a deposit that is unique because it brings supply to the kind of rare earths you do not find outside of China. The answer goes beyond Chile, it is a global challenge to produce rare earths for our most advanced technologies, such as electric vehicles and motors. When you start a new kind of project in a region it brings a whole ecosystem with its growth. That has happened with lithium and SQM and we hope we are starting a story similar to that.

**What has been your experience pushing projects forward in Chile and what areas do you think can be improved from a policy perspective?**
The permitting process has evolved through time. It has become more challenging and in some ways this is a good thing, because society expects high standards for projects. It is a matter of the process and coordination of entities that makes permitting tricky. There is much improvement to be made in terms of providing more clarity on what the rules are to get the permit and then how to maintain it once it has been granted. Many projects have received permits and ended up in a court of law anyway and that is an issue.

**Is there a particular stage of a project that Minería Activa finds most attractive for its investments?**
For early stages, it needs to be an interesting opportunity with some derisking already occurring there. Today, we are finding opportunities at the later stage of the curve. Closer to operation or within operation. At this stage, margins are not that high and it is a really difficult funding environment for construction, so coming in at that stage you can find good value.

**What is your assessment of deal flow in the Chilean market today?**
In the early stage, there are a lot of projects that are frozen so there is plenty of availability. It is relatively cheap to hold projects, so many companies are waiting out the current environment. There is deal flow if you want to go and get it. The tricky thing is you need to be sensitive to the market. We like operations that are already proven and working.

**What are the biggest challenges that you face with your projects?**
The challenges in operations are related to people, plant issues, and mining costs. The biggest issue in the construction stage is visibility and permitting. In the operation stage with drilling, you have flexibility to stop or continue with the risk of exploration, which is a major step. What all stages have in common in terms of challenges is that mining is technical. Risk management and pouring capital into a company is important. Staging activity to decrease risk is how you require the least amount of capital. ■





# A decade of financing for exploration and mining projects: Is Chile only for major miners?

By **Francisco Acuña**
Mining Consultant and Entrepreneur
Senior Consultant, CRU

Chile's mining output is extraordinary. It is a world class producer of copper, molybdenum and lithium, while also producing a significant amount gold, silver and iron ore. During 2010-2018, annual mining exports amounted, on average, to 58% of the country's total export value. With this in mind, one would expect booming exploration, project development and a financial sector readily fueling the dreams of local entrepreneurs and investors looking for the next big discovery or project breakthrough. The reality is very different. In perspective, only three mining companies are formally listed on the Santiago Stock Exchange (SQM, CAP and Pucobre) and the investor base mining companies rely on has shown acute weakness. How dynamic is the financial sector for mining in Chile? What happened with local and foreign investors this last decade?

In 2012, CORFO and the Ministry of Mines achieved a great milestone; establishing the first ever risk capital funding program for greenfield mineral exploration, better known as the "Fenix Fund." Through a tender process, six fund managers were awarded a US$90 million line of credit to be spent on mineral exploration in Chile. The funds contributed a combined US$60 million from different investors. What was the result of these ventures? Did they create new projects and opportunities? Mineria Activa successfully advanced the Biolantanidos project to a prefeasibility stage; Zeus Capital and IM Trust carried a prospect generator strategy aiming to sell or partner with third parties to advance projects. After several years, however, the Fenix Fund initiative did not prove to have generated traction and attractiveness among local investors, with an overall negative - or yet uncertain- capitalization to the funds over their investments.

Large and diversified Chilean conglomerates have also entered into the mining sector during the last decade, with mixed strategies and, in many cases with yet to be seen results. Examples are Haldeman Mining, part of the Solari Group, and Alxar Mineria of Empresas Copec, part of the Angelini Group. Haldeman changed strategy drastically in 2015, with the acquisition of the copper cathode mine operation Michilla from Antofagasta Minerals for US$52 million. Before this, Haldeman's initial focus was project generation and development of small-medium gold production near Punitaqui. Alxar, on the other hand, initiated its strategy as a medium sized miner with the El Bronce mine. Alxar decided to jump into the "tier-1 club", however not as an operator but acting as a financial/strategic partner in the Mina Justa project in Peru alongside Minsur.

If capital for exploration is scarce locally, then Chile should be an important target for mining markets with better financial ecosystems such as Canada and Australia. Junior miners headquartered in these countries have been active in Chile for much of the past decade. Yet, junior mining activity is still insignificant in Chile. When compared to other mining countries like Canada, Australia and Peru, juniors make up a far smaller portion of the market. Complex access to prospective ground as a result of a mining claim system that allows for property stagnation and accumulation, and lack of quality publicly available geological data from past exploration work are generally pointed out as two factors that have led to this situation. Additionally, I would like to add to this list the lack of realistic business expectations from private mining property owners and a lack of incentives (or creativity) form larger mining companies to seek partnership for their non-core portfolio of mining properties.

The latter half of the previous decade was tough for junior miners globally, with depressed markets and access to capital. However, although Chile adds additional constraints for junior miners, there have been encouraging stories of success. An example of a success story for a junior in this decade was Exeter Resource, a Canadian company that was developing the gold-copper project Caspiche. In 2017, the company was acquired for US$180 million by Goldcorp (now Newmont). Other examples of successful financing and project development are the Australia based, Hot Chili and Canadian Los Andes Copper. Both have been able to attract capital from different sources to advance their Productora/Cortadera and Vizcachitas projects respectively. While the projects have been able to move forward, the final capitalization is yet to be seen and challenges and risk remain present.

Foreign private equity funds have also found opportunities for investment in Chile, particularly in the medium-size mining space. AMCI Capital has maintained a significant stake in Grupo Minero Las Cenizas since 2010, and Audley Capital and Orion Resources backed Mantos Copper in their bid to acquire Mantos Blancos and Mantoverde from Anglo American in 2015. Other private funds have been keener to take risks, such as Dehnam Capital, with its fully funded vehicle, Santiago Metals, that initially started as an exploration vehicle (but later switched to a small/medium size cash flow generator).

While the results of most of the Fenix-backed exploration and development ventures remain unclear, it seems that mining remains to be a bull that cannot be tamed by local investors. The relatively small junior sector is a reflection of a tough competitive environment to develop new projects and, therefore, both local and foreign investors are impacted. However, success stories have demonstrated that Chile's mineral endowment still offers opportunities. Positive lessons can be found from mining focused private equity funds that have grown in presence in Chile over the last decade. The role of the government should be to promote competitiveness, understanding that there is still untapped potential for exploration and small-medium scale operations beyond major tier-1 developments. Indirect incentives to attract capital, rather than subsidy-type instruments, should be further analyzed and positive lessons from other jurisdictions imitated. ■

# ENGINEERING AND CONSTRUCTION

**» Water management in the Chilean mining sector is perhaps the most important factor for success. Even more important than the grade of copper in the reserve. It has become a make or break issue, where if you don't secure the water for your project, the mine may have to close down or may never be built in the first place. «**

**- Mark Venning,**
**South America Regional Mining Leader,**
**Stantec**

Image courtesy of Echeverría Izquierdo

Image courtesy of Echeverría Izquierdo

# Establishing Value Through Sound Design

## CHILE MINERS LEAN ON EPC'S TO SOLVE INDUSTRY'S BIGGEST CHALLENGES

Mining is a very capital intensive business. Therefore, it is crucial that the design and construction of everything from crushing plants, to tailings dams to desalination facilities are carried out efficiently and to the highest safety and environmental standards. Chile has a diverse mix of EPC and consulting firms that bring expertise to help develop mining projects. The market includes local companies like Amphos 21, JRI Ingeniería, Pares & Alvarez, Ingenalse as well as international firms such as Arcadis, Black & Veatch, Stantec, Wood Group and Worley. These companies all possess significant knowledge and experience that makes for an extremely competitive landscape as companies bid for contracts.

Chile is such a large producer of metals that there is ample room for many industry participants, but in 2019, the market seemed crowded due to the slowed pace of project development. In the vjew of Ivan Rayo, general manager of JRI Ingeniería, a company that has been working with Codelco on the renovation of its El Salvador mine: "Because of the low copper price demand for engineering services has shrunk. There are fewer opportunities to expand the business and many engineering companies have been forced to take austerity measures to increase efficiency. It has also meant fiercer competition. Many companies are looking for opportunities outside of Chile where they can lend their expertise."

Iain Humphreys, Santiago office leader at Black & Veatch, also observed changes over the past year. "Clients want more for less, but as the grade of copper reduces, the returns are becoming even more modest, compounding pressure. More studies are going on and miners are reluctant to select a single solution very quickly. In today's market, clients are looking to ensure they are getting the best value for what they can achieve. With this in mind, we are also seeing clients taking time to ensure that projects are fully optimized," Humphreys said.

Although the slow down in 2019 hurt demand for construction, other areas such as advancement on feasibility studies continued. Jim Spenceley, senior vice president of mining at Black & Veatch added: "Currently, many miners are taking advantage of the industry's slow progression to update their prefeasibility/feasibility studies and make progress on permitting, so their definition phase timelines have not necessarily been impacted. What has been impacted is the full funds decision timing for these project." He continued: "As trade pressure reduces the copper price will rebound, the peso will strengthen, and we expect projects to progress with full funding approvals. We don't expect to see a repeat of the previous mining super-cycle as our mining clients have very disciplined and rigorous capital investment processes. We anticipate a more measured pace of project development."





# Water & Environment

The Atacama desert is the driest climate in the world. It is also one of the most mineral rich, which means securing water supply is absolutely essential to advance a project or to expand an existing one. In the high, arid deserts of South America, particularly in Chile, water is possibly the most important factor.

Historically, Chile's water code has permitted the state to grant long term and perpetual water use rights, which can be exploited with minimal regulation and without any "use or lose" obligations. Mining rights in Chile to date have therefore contained water rights, permitting holders to use any water they come across within the mining area for any purpose for the duration of the mining project. Due to the increased scarcity of fresh groundwater following a series of droughts in recent years, there has been intensifying socio-political pressure from indigenous communities fighting for prioritization of their domestic and farming water needs. The care of freshwater resources and the promotion of efficient water use have therefore become a public policy priority in Chile and, accordingly, a key risk concern for mine operators in the country.

At the same time, mining companies demand for water is expected to soar as ore grades decline, forcing them to process more material to maintain production levels.

The modern sustainability agenda, beyond regulatory compliance, is becoming critical to the sector, with both risks and opportunities stemming from environmental and social pressures.

### Desalination and Pipelines

In response to increased risk regarding the securing of water supplies, miners are building large desalination plants,and seawater use is expected to more than double through 2029, according to the latest forecast from Cochilco. Despite that fact, use of ground water at the country's giant mines is still set to increase 12% through until 2029, Cochilco said.

Although mining companies and their shareholders are more cautious when it comes to capital spending today, investment in desalination is proving to be the exception to this rule, as it is fundamental to survival in the mining industry in Chile.

BHP and Rio Tinto's Escondida joint venture has spent US$3.4 billion over the past decade as they hired Black & Veatch to build a second desalination plant on Chile's west coast, as well as a 175 kilometer pipeline that carries the desalinated water more than 3000 meters uphill to the site of the famous mine.

Additionally, in 2019, Japanese holding Marubeni won a contract for a US$1 billion desalination plant supplying state miner Codelco's Chuquicamata, Radomiro Tomic and Ministro Hales mines. Engineering, procurement and construction was to be the responsibility of Techint Chile, owner of process and equipment supplier Tenova. This plant would reduce water consumption costs by 35% and become the country's second largest desalination plant behind Escondida's, according to a report by Reuters. The BOOT (Build-Own-Operate-Transfer) tender was awarded in November, but retracted in December. Codelco identified adjustments to be made to the project, prompting a decision: "To redefine the tender, which will take place within the next 24 months," it said in the statement.

There are three plants, besides Codelco's, scheduled to begin operations in the next decade. Anglo American-Glencore's US$3.2 billion Collahuasi mine life extension, includes a desalination facility. Antofagasta Minerals' Los Pelambres Complementary Infrastructure project (INCO) will have a 400 l/s plant and Teck has announced plans to build a 1,000 l/s plant for its QBII project.

According to Jose Maria Guzman, Chile country manager at CDM Smith: "Water scarcity and drought has been a common trend in Chile in the past 10 years, but the sector is now even more pressured to come up with more resourceful ways to use water. Most mining operations rely on ground water sources, as many mining sites are located in remote areas at high altitudes. Because of the draught, the government began to reduce some of the water permits extended to mining operations and mining entities had to start looking at innovative ways to find water.

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# Mark Venning

Regional Mining Leader, South America
**STANTEC**

**Describe the dynamics of the Chilean copper market in 2019 and the effect it has had on EPCM contracts in the country?**
When I joined Stantec in January 2019, I was incredibly bullish about the year. At Stantec, we expected to double our workforce in Chile within 12 months and we expected the copper price to rise to $3.50 per pound. At that level, the mines are producing huge quantities of cash and projects are easily approved. Unfortunately by June, I was pessimistic about the market, mainly due to the US-China trade war. The fundamentals of copper are fantastic, because we have come to a point where there are not enough projects to cater to an increase in demand. I expected demand to exceed supply by mid 2019, however, that has not materialized yet.
Towards the middle of the year, a lot of projects started drying up, and we had to restructure Stantec in order to adapt to the new reality. We are fine, but the level of competition between the engineering companies has been fierce as the market and the number of projects declined. People don't like shedding staff, so instead of laying off workers, companies lowered their hourly rates resulting in lower margins.

**How can water management practices in Chile be improved?**
Water management in the Chilean mining sector is perhaps the most important factor for success. It has become a make or break issue, where if you don't secure the water for your project, the mine may have to close down or may never be built in the first place. Underground water in the Atacama does not get replenished, so everything taken out of the ground is not coming back. This is why Escondida spent billions of dollars on one of the biggest desalination plants in the world.
Desalination is expensive to build and operate, because you have to push water up to five vertical kilometres at a rate of thousands of liters per second. All the mines that can afford it are going to build desalination plants and that is very important. However, equally important is the reuse of water at the mines. Stantec is working with a number of mining companies on large projects to assess how to best reuse water. Clients can limit the amount of desalinated water they need to pump up to the mine if they can re-use already processed water effectively.

**How do you view Chile as a mining jurisdiction in light of civil unrest that has shaken the country?**
Chile is incredibly stable and has a very large and sophisticated mining industry, with hundreds of billions of dollars invested, employing hundreds of thousands of people, both directly and indirectly. The industry pays incredibly good salaries. My hope is that the current social unrest will result in a better and more socially aware Chile and that it is a wake up call for everyone in politics. Perhaps the economic model that was implemented to take Chile out of abject poverty and turn it into a growing economy, which worked very well, is outdated. They need to redesign the economic model now that Chile is a developed country and a member of the OECD. People have gotten to the stage where they simply cannot pay more for basic services. Chile has the best water treatment plants, electricity plants, and projects for renewable energy, wonderful highways and a nice metro, but that all has a cost, and the model says the people must pay for it. At the same time, salaries over the last 20 years have not risen at the same rate costs have. When the minimum wage is less that US$500 a month it is impossible to live whilst paying for first world infrastructure. So people start getting into debt at exorbitant interest rates that they will never be able to pay back.
If they change the system correctly, Chile will come out of this stronger. There is not a single worker at any mine in Chile that doesn't earn double or maybe even triple the minimum wage. The mines are good payers and they give big bonuses at the end of the year. Mining is a great industry that people love, and it supports millions of people in Chile. It is the backbone of the Chilean economy. If anything happened in the mining sector all Chileans would suffer the consequences. ■

**Chile is incredibly stable and has a very large and sophisticated mining industry, with hundreds of billions of dollars invested, employing hundreds of thousands of people, both directly and indirectly. The industry pays incredibly good salaries. My hope is that the current social unrest will result in a better and more socially aware Chile and that it is a wake up call for everyone in politics.**





# Jim Spenceley & Iain Humphreys

JS: Senior Vice President-Mining
IH: Santiago Office Leader
**BLACK & VEATCH**

JS

IH

**Why is Chile an important market for Black & Veatch? What advantages and capabilities do you bring to the market?**
JS: Chile is the largest copper producer in the world, many of the major global mining companies are represented here, and they are all committed to energy and water sustainability. Additionally, most of the mining operations are located in the Antofagasta and Atacama regions, some of the driest spots on the planet. This means that effective use of water is extremely important to be responsible and sustainable. Using seawater for mining – whether it is desalinated to produce freshwater or for seawater flotation – is definitely the direction in which the Chilean copper producers are moving. Our market strategy is to be the service provider of choice for water and energy security solutions. Understanding that holistic, integrated water management is critical for the future of mining in Chile, Black & Veatch provides the full spectrum of water management solutions, from desalination and seawater conveyance to water reuse and treatment. From an energy standpoint, Chile has a fantastic solar resource, and the government is committed to significant expansion of renewable energy for the grid. Mining companies are dedicated to expanding their use of renewable energy supply for mine power. As a full service provider of energy and water solutions to the mining industry, there are many opportunities for Black & Veatch in Chile.

**How is Black & Veatch working with companies to develop creative solutions to water and energy challenges in Chile?**
JS: We are involved with studies around ways to capture water that will otherwise be lost to evaporation or seepage. Additionally, we are studying water swapping in an effort to ensure that community water supplies are secure. Evaporation management is an important focus given the low humidity in most of Chile. There is a clear business case where using less water means pumping less water, saving energy and resources. To help solve this issue, we are studying the installation of floating solar panels on water reservoirs both to generate power and to reduce evaporation.

**What sources of energy are most in demand from miners in Chile? How do you solve the challenge of energy storage?**
JS: Energy depends completely on geography. Chile has a robust national grid system, which allows mining companies to source directly from the grid, removing the burden of having to develop and manage their own power supply.
Battery storage is not there yet, but pumped hydro storage is very promising. The pumped hydro storage process uses the sea as the lower reservoir with an upper reservoir constructed on-shore at elevation. Solar or wind energy would supply the power necessary to pump seawater to the upper reservoir, where the stored energy is run through a hydroelectric system. Additionally, a desalination plant can be integrated that uses the head pressure already present in the upper reservoir, offsetting the input pressure required for desalination. Pairing desalination with pumped hydro storage and renewables at grid scale allows the production of freshwater at a lower operating cost. We are seeing interest in these types of hybrid, integrated solutions.

**How has the low copper price affected the demands and actions of clients?**
IH: Clients want more for less, but as the grade of copper reduces, the returns are becoming even more modest, compounding pressure. More studies are going on, and miners are reluctant to select a single solution very quickly. In today's market, clients are looking to ensure they are getting the best value for what they can achieve. With this in mind, we are also seeing clients taking time to ensure that projects are fully optimized.

**What are the biggest areas of opportunity for Black & Veatch if the market were to turn up?**
JS: Currently, many miners are taking advantage of the industry's slow progression to update their prefeasibility/feasibility studies and make progress on permitting, so their definition phase timelines have not necessarily been impacted. What has been impacted is the full funds decision timing for these projects. But as trade pressure reduces the copper price will rebound, the peso will strengthen, and we expect projects to progress with full funding approvals. ■

# Juan Alfaro

General Manager
**INGENALSE**

**The environment in Chile is a challenge because the legislation is not very clear. The government is taking actions to improve the environmental impact of mining. Government Environmental Commissions were formed so that Chile will have a clearer environmental policy within a year.**

**What is the core focus of Ingenalse and what services do you bring to the Chilean market?**
We are focused on segmentation, flotation, filtering and tailings treatment. We have a specialized team of electronic engineers, mechanics and service engineers. We have two three-year maintenance contracts for all of Anglo American's mineral thickeners in Chile and we have an additional contract at Chuquicamata for tailings thickeners. Currently, we are updating and repairing Division Ministro Hales' thickeners. Ingenalse has 15 years of experience in the country and we recently opened offices in the south of Chile to gain market share in the water treatment sector.

**What opportunities are there in Chile regarding tailings?**
Ingenalse has been working for 10 years at Minera Valle Central, where the tailings of El Teniente mine are being treated. The fresh tailings that the mine throws away are reprocessed in Minera Valle Central and the tailings gutter is squeezed out.
We are participating in mining flotation projects at Chuquicamata and Candelaria and we have just been awarded a contract to make improvements in flotation cells at Tranque Las Tortolas by Anglo American.

**Which of Ingenalse's services have been most in demand in 2019?**
We work with large companies directly. We have repaired Centinela's thickeners. We have also repaired and updated some thickeners in Division Ministro Hales. Ingenalse has worked on developing its own thickeners this year and they have already been installed in Chuquicamata.

**What have the biggest changes been in terms of technology and sustainability being incorporated into the mines?**
The big changes have been mostly electronic. There have not been many mechanical or structural changes in recent years. What was done 30 years ago is still being done, but the control has been improved.

**How is being a local company an advantage in the Chile?**
We are a small company competing with large international companies. We have the experience and we are cheaper and faster. We have integrators that incorporate the control panels and structural engineers who are dedicated specifically to mining in Chile. That is what sets us apart from other companies. We have a group of engineers who have worked together for many years. We have the recognition of the international market and that is why we are competitive against large companies. We have also developed and patented our own equipment that leads to process improvements. Ingenalse has a lot of experience in the mining sector and we have an intimate understanding of how the mines work.
Ingenalse helps mining companies boost their productivity and lower their costs because the development time of our projects is less than with other companies. We are experts in our field and we deliver improvements in recovery, flotation and the optimization of resources for clients. The requirements of each mining company are different and engineering solutions should not be duplicated. We provide specialized solutions.

**What is your view on Chile as a mining jurisdiction today?**
The environment is a key topic in Chile today. It has slowed the development of large projects, and the community is more aware of the impact of mining activities now. Legislation is slow because there are people who want to take advantage of the natural resources, the towns and the people. The environment in Chile is a challenge because the legislation is not very clear. The government is taking actions to improve the environmental impact of mining. Government Environmental Commissions were formed so that Chile will have a clearer environmental policy within a year.

**What are the biggest opportunities to grow Ingenalse moving forward?**
Ingenalse's focus is in the water sector as it is very important for mining. Therefore, our teams must be able to recover and reuse more water and it in the process. We would like to be part of a great company. The opportunities we have today are very good, but we could grow more if we had more support. This support may come from Chile or other countries. ■





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The best alternative option has always been desalination, but the challenge is pumping water to the mining site can sometimes be more costly than the water treatment itself." In this context, it is essential to get pipeline design right,as it can lead to significant cost overruns if done poorly. "Many of the mines in Chile are at 3000-4000 meters of elevation and around 100-200 kilometers from the sea, so transporting water via pipeline requires a lot of energy. These systems must be designed the right way, particularly because they are operating at high pressures, so the design can be very sophisticated. There is significant permitting that comes with this process and mistakes can be very costly," said Spenceley of Black & Veatch.

## Reuse

Because desalination is exceedingly expensive and logistically difficult when mines are located in the high Andes, it is imperative that companies adopt smart reuse policies. "Companies may spend billions of USD to build a desalination plant and spend a fortune on electricity alone. Any reuse that you can do at the mine will translate into big cost savings. Water is expensive, but for some mines water is the limiting factor of production. If they don't get a lot of snow in the mountains in winter and it does not melt in summer, that is the limiting factor. Ultimately it costs them in copper production. Desalination and increased reuse is fundamental to the Chilean mining industry," said Stantec's Mark Venning.
Another way of limiting water resources is to first have a deep understanding of the details of the resource and how to create the most efficient design to exploit it. Amphos 21 is a company that is involved in the process of providing precise data on the availability of water. According to CEO Juan Castaño: "The first thing producers need to know when starting a project is how much water they have at their disposal and then they must plan an efficient management strategy that allows for secure and resourceful consumption. This means clients demand help with the construction of new underground wells, defining conceptual models of how groundwater behaves at a mining site and implementation of numerical models that allow us to predict groundwater flow. The goal is to create a sustainable operation that minimizes its impact on groundwater balance."

## Tailings

Mines are the pillar of Chile's economy, but their byproducts, which accumulate in ravines, mountain areas, river beds and reservoirs, and which are often used to create tailings dams, pose a handful of problems for surrounding inhabitants. Apart from the environmental threat, the recent collapse of two Brazilian dams that killed hundreds of people has triggered renewed concern in Chile.
Mine tailings are produced when mined rock is finely

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# Juan Castaño

CEO
**AMPHOS 21 CHILE**

**How is Amphos 21 enhancing water security for its Chilean clients?**
Mining in Chile is very water intensive and Amphos 21 offers services that enable efficient consumption and reuse of water. We provide precise data on the availability of water for our customers. Whether it be rivers, streams or aquifers, Amphos 21 has the capacity to identify where the water is located and how to best exploit it, while minimizing the environmental impacts of mining on water. Additionally, we are able to advise clients on the amount of water needed to carry out their operations and how to size systems in an appropriate manner.

**Which of Amphos 21's services has been most in demand in 2019?**
The first thing producers need to know when starting a project, is how much water they have at their disposal and then they must plan an efficient management strategy that allows for responsible and secure consumption. For Amphos 21, this means that we have to help and supervise the construction of new underground wells, define conceptual models of how groundwater behaves at a mining site and develop and implement numerical models that allow us to predict groundwater flow and groundwater chemical behavior. Our purpose is to create a sustainable operation that minimizes its impact on groundwater balance.
Companies also have also been looking at Amphos 21 to provide sustainable reuse and feasibility analysis of water resources. We are working to implement circular economy parameters and principles in water resources, by reusing water that has already been processed for other purposes of the industrial/mining operations. One of the objectives of the government and of Amphos 21 is the treatment of sulfate contaminated water to control and minimize sulfates and metal contents in groundwater and surface water so that the quality of the environment is preserved.



**What is the opportunity in tailings today and how is Amphos 21 positioning itself to capitalize on this trend?**
Much progress is being made in minimising the water content of tailings. The aim is to avoid subsoil contamination due to leakage / infiltration from tailings, as well as economize the extension occupied by mine tailings. We are also working to extract water from tailings and reintroduce it in the process.
The Dirección General del Agua de Chile (Directorate-General of Water) is becoming a leader in Latin America in terms of water regulations. Amphos 21 has a deep knowledge of the regulatory framework in Latin America, as we have developed projects in many countries. The Directorate-General of Water regulations encourage companies to use alternatives to groundwater, and obtaining groundwater exploitation and usage permits is increasingly difficult. I am convinced that the use of water is very well regulated by the government in Chile and mining companies have to make efficient use of water resources. This has pushed the miners to self-regulate their use of water.

**What would Amphos 21 like to achieve for the next few years?**
We are very ambitious. This year, we will bring in US$3.5 million in revenue. We would like to double that figure in the coming years. We plan to do this by incorporating new services such as engineering into our business model. This will allow us to offer a more complete service portfolio to our clients and ensuring a responsible use of the water resources as a guarantee for the development of current and future generations. ■





# José María Guzmán & Juan Eduardo Coeymans


JMG


JEC

JMG: Chile Country Manager
JEC: Business Development Manager
**CDM SMITH**

**What specific services does CDM Smith offer to the Chilean mining industry and which of these services are most in demand?**
JEC: CDM Smith offers consulting, engineering, and construction management services. The main mining related projects we are involved with in Chile are related to tailings dams.
JMG: Chile has multiple tailings dams that will have to be carefully dealt with when decommissioning and remediating. CDM Smith is experienced in providing geotechnical remediation and water recovery services to the market.

**2019 has been one of the driest years in Chile on record. How has this put pressure on the mining industry?**
JMG: Water consumption in the mining industry was already stressed before the drought. Most mining operations rely on ground water sources, as many mining sites are located in remote areas at high altitudes. Because of the draught, the government began to reduce some of the water permits extended to mining operations and mining entities had to start looking at innovative ways to find water.
The best alternative option has always been desalination, but the challenge is pumping water to the mining site can sometimes be more costly than the water treatment itself. We continue to look at ways of using water more efficiently in the mining sector. The reuse of water is also a viable option, but one has to keep in mind that the mining industry needs a certain quality of water and innovative solutions must be implemented to ensure that you do not lose too much quality when treating water. The most common water treatment method used in the mining industry is reverse osmosis.

**In what ways is CDM Smith incorporating innovative solutions to help relieve pressure on the mining industry with respect to water consumption?**
JMG: One of the needs in the market is the reduction of energy consumption when treating water and we provide solutions to help our clients in this regard. Reuse is the future of water supply. We're here to help clients conquer the regulatory, operational and communication challenges that come with leading the way. Whether we're pioneering technologies to improve performance or researching comprehensive monitoring approaches, we are committed to achieving water supply innovation through reuse.

**In what direction do you see water management policy moving?**
JEC: In terms of water policies, there needs to be a definitive guideline which sets clear standards for reuse. The reuse of water is a hot topic of discussion and policy makers should be transparent and clear when establishing regulations. The government should also think about how they can incentivize the establishment of desalination plants in Chile.

**What logistical and engineering challenges does pumping water to remote locations present to the mining industry?**
JMG: Pumping water to mine sites can be very challenging as one has to lay a pipeline that goes through many different properties. It is difficult to align all landowners to be part of the project and this can take a significant amount of time. Another challenge is that there are different projects going on at different times and each has its own independent infrastructure. Therefore, potential synergies are lost that otherwise could be present if multiple projects were combined into one water supply project.

**Can you elaborate on CDM Smith's involvement with BHP?**
JMG: BHP has decided to outsource operational water supply through a BOOT (build – own – operate - transfer) contract, where a third-party oversees the design, construction, financing and operation of the water conveyance system, all the way from the desalination plant to the mine site within a certain period. CDM Smith has supported BHP on the identification and evaluation process of world-class joint ventures. We are responsible for the construction management of the 23-million-gallon-per-day seawater reverse osmosis plant, marine works, 95-mile-long desalinated water conveyance system, and a power supply system. We have also been involved in preparations for BHP's environmental permit application.

**What are CDM Smith's strategic objectives moving forward?**
JMG: CDM Smith aims to assist our clients in finding new water sources for their projects. Our goal is to expand our service portfolio in Chile and provide a wider range of services and solutions to the market. We have the objective to continue growing our company moving forward. ■

Image courtesy of Gold Fields

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ground and mixed with water and sometimes chemicals to separate minerals and valuable metals. As more water is needed to process more material just to maintain production rates, the challenge of tailings management becomes more pressing. Looking at the two biggest environmental risks, contamination of ground water and tailings dam failures are the biggest environmental hazards associated with mining. Chile has 740 tailings deposits located in 10 regions, which creates important challenges for the mining industry, according to the national geology and mining service.

"Throughout the history of mining, tailings have not been a big focus. Recently there have been very dangerous examples, such as Brumadinho, which we cannot repeat. Chile has not had this type of accident and our technicians, engineers and geologists say that our tailings are very different and safer, but we need to improve our standards even more so that we can give the local communities safety and certainty that an accident will not happen," said Mining Minister Baldo Prokuriça.

In response to heightened environmental concerns regarding tailings, companies are developing solutions that make tailings less risky. "Tenova developed technology to use dry stack tailings and it now filters or uses a thickener to filter and transport by conveyor, so that the deposit is close to dry material. This mitigates the risk of a dam collapse. Today's market is much more environmentally conscious. It is telling companies to not waste water and to not contaminate," said Christian Cavagnaro, managing director at TAKRAF Tenova.

Companies like Wood are being retained by clients to be the Engineer of Record (EoR) for their tailings facilities in Chile and to provide assistance to them in the development of safer operation protocols and tailings disposal alternatives, such as dry stacking and thickened tailings. According to Dave Lawson, president of mining and minerals at Wood Group: "Globally, the industry has had dam failures, which have raised safety issues related to operation and design of tailings facilities and, because of this, we are spending a bit of time finding solutions for these challenges."

One safety measure companies are taking in Chile is to thicken the tailings. Operating costs are higher for thickened disposal due to the associated dewatering costs. However, there are significant advantages to thickening tailings. Perhaps the most important is that higher volumes of water can be recovered and the seepage and evaporation losses from the tailings storage facility can therefore be minimized. Sustainable water use in tailings is becoming increasingly more important and firms like Ingenalse are able to capitalize on the trend. The company has two three year maintenance contracts for all of Anglo American's mineral thickeners in Chile and has an additional contract at Chuquicamata for tailings thickeners. The company is also updating and repairing Division Ministro Hales thickeners. "What was done 30 years ago is still being done today, but the oversight has improved. Thickened tailings and paste solutions are now very much in favor," said Juan Alfaro, general manager of Ingenalse.

Companies are now implementing these new solutions into their mines, not only for safety purposes, but also because they conserve water. Yamana Gold, for example, has stated that its focus at El Peñón is on "increasing reuse and recycle rates and minimizing overall raw water consumption." To that end, the company has implemented a dry stack method of tailings storage at the mine, which allows 80% of the water contained in the tailings to be recovered.

At Gold Field's Salares Norte mine, according to country manager, Max Combes: "A lot of effort and money was invested into creating a sustainable design that ensures water use is kept to a minimum. In terms of tailings, we have an environmentally stable design. We have introduced filtered tailings that will allow us to recover most of the water and produce a dry tailing that will be moved with trucks to be compacted."

Juan Castaño, CEO of Amphos 21, posited: "Much progress is being made in minimizing the water content of tailings. The aim is to avoid subsoil contamination due to leakage and infiltration from tailings. Companies want to be able to extract water from tailings and reintroduce it in the process. The price and the scarcity of water is highlighting the need for these good practices."





# Fernando García & Claudio Martínez Z.

FG: VP Operations Chile
CM: Commercial Director
**WORLEY**

FG

CM

**Can you give a brief overview of Worley and the company's operations in Chile and Latin America?**

**FG:** Worley Chile is part of the Americas region, and we are the largest mining office in the region. Since acquiring Jacobs ECR, Worley Parsons has now been rebranded as Worley and we have all the capabilities of WorleyParsons and Jacobs ECR. Our footprint in Latin America is spread across Chile, Argentina, Colombia, Brazil, Peru and Mexico, but only our Chile and Peru offices are focused on mining, whereas the other offices are focused on construction and oil and gas.

**How does Worley provide cost savings for its clients?**

**FG:** Worley has assisted clients with ore sorting technologies, which can reduce the footprint of their processing plants. This innovation does not only significantly reduce the amount of energy and water required, but also maximises the efficiency and quality recovery of valuable ores.

Digitalization is another element that leads to increased productivity and lower operational costs for our clients. We implement material tracking where clients have traceability of all their materials through the entire process.

**Can you elaborate on the permitting process in Chile?**

**FG:** The mining sector in Chile is very cognizant of their social and environmental responsibilities and takes all steps necessary to comply. Although the permitting process takes some time, companies will still follow the right path to start operating in the country, usually having higher standards than those requested by the regulator or the communities

**From a policy perspective, is Chilean law clear enough so that the country will be able to realize its potential as a leading lithium producer?**

**CM:** The government has the objective to become a leading lithium producer and they have been putting in the effort to reach this goal. The status of lithium has been changed to open and regulations and policies are being revised. ■

# Hugo Andrade

General Manager
**ARCADIS CHILE**

**What is the history of Arcadis and their operations in Chile?**

Arcadis is a leading global Design & Consultancy firm for natural and built assets, including mining. Based in the Netherlands, the company was founded in 1888 and currently we are 27,000 people, active in over 70 countries. In Chile the company was founded in 1981 with offices in Santiago and Calama.

When we started, our initial work in Chile was mainly associated with geotechnical studies, as Arcadis acquired a Chilean company that was founded by geotechnical professionals. Today, we work on mining projects to fulfill the needs of our clients providing services throughout the entire value chain – from strategic advice, planning, licensing and permitting, project studies (conceptual, pre-feasibility and feasibility), detailed design and implementation, through to maintenance, operation, optimization and decommissioning.

**Can you elaborate on some of the projects Arcadis is involved with in Chile?**

80% of Arcadis's business in Chile is dedicated to the mining industry. Arcadis is involved in the key projects of the major players operating in the Chilean mining market such as Codelco, BHP, Anglo American, Antofagasta Minerals and Teck among others. We can proudly say that our firm has been involved in many phases of the design and/or operation of more than 70% of the tailings dams of all major mining projects in the country.

**How does Arcadis distinguish itself from competitors?**

There are many complexities in mining, and we have the full suite of capabilities and capacity to combine and consider all factors in delivering a successful project in line with the clients' objectives. Our global network enables us to bring our knowledge and experience of projects worldwide and apply that expertise to specific local situations and needs duly implemented by industry reputed Chilean professionals. ■

# Energy and Technology

## Energy

With ore grades progressively in decline in Chile, companies now have to extract large and growing volumes of mineral in order to maintain their expected fine copper production levels. This, in turn, means an increase in electricity consumption in processes such as crushing and milling. It also necessitates miners to dig deeper and, to fuel that effort, they need vast amounts of energy.

Miners are now switching to renewable sources of energy in Chile, where solar and wind power is becoming more cost competitive. The country has little in the way of fossil fuels, leading it to rely on imports and making electricity there extremely expensive. In 24 of the last 30 years, the country's energy prices were higher than the world average; at its peak in 2011, the price per kilowatt-hour reached US$150.90, almost double the global average, stated a Bloomberg report.

In response to risks of high energy costs and efforts to lower carbon emissions and solidify license to operate, companies are now looking to transition to renewable energy to power mining operations. In 2019, BHP signed four renewable energy contracts to supply all of its Chilean copper operations with wind and solar energy beginning in 2021. The company anticipates this will help cut energy costs by 20%. Anglo American also has committed to using only renewable power at its mines in Chile from 2021 onward. "Compared to 100 years ago, we are consuming double the water and about 10 times the energy. We can't continue in this vein. We have to do something differently," said Aaron Puna CEO of Anglo American Chile.

## Technology

Mining companies and contractors have been aided in cost and schedule forecasting with the evolution of technology. The big data, automation and electrification buzz is not just confined to the operational phase of mining, it also has relevance in design and build. Automation is now considered at all stages of project development and the productivity and efficiency gains afforded by automation and digitization help de-risk or improve return on investment. Currently, in Chile mines are being designed to enable advanced data and analytics processes and to facilitate autonomous equipment or a combination of manned and autonomous equipment.

Wood Group sees opportunities to influence and design project data with recent technology improvements. Wood's Dave Lawson pointed to a recently awarded PFS contract award with Antofagasta's Minera Centinela SA division as a good example of how the company was leveraging these technologies. The project will support the studies of centralization of monitoring and control for its mining operations in Chile through a technologically advanced integrated operations center. This includes cloud-based data storage and information management for the company's operations.

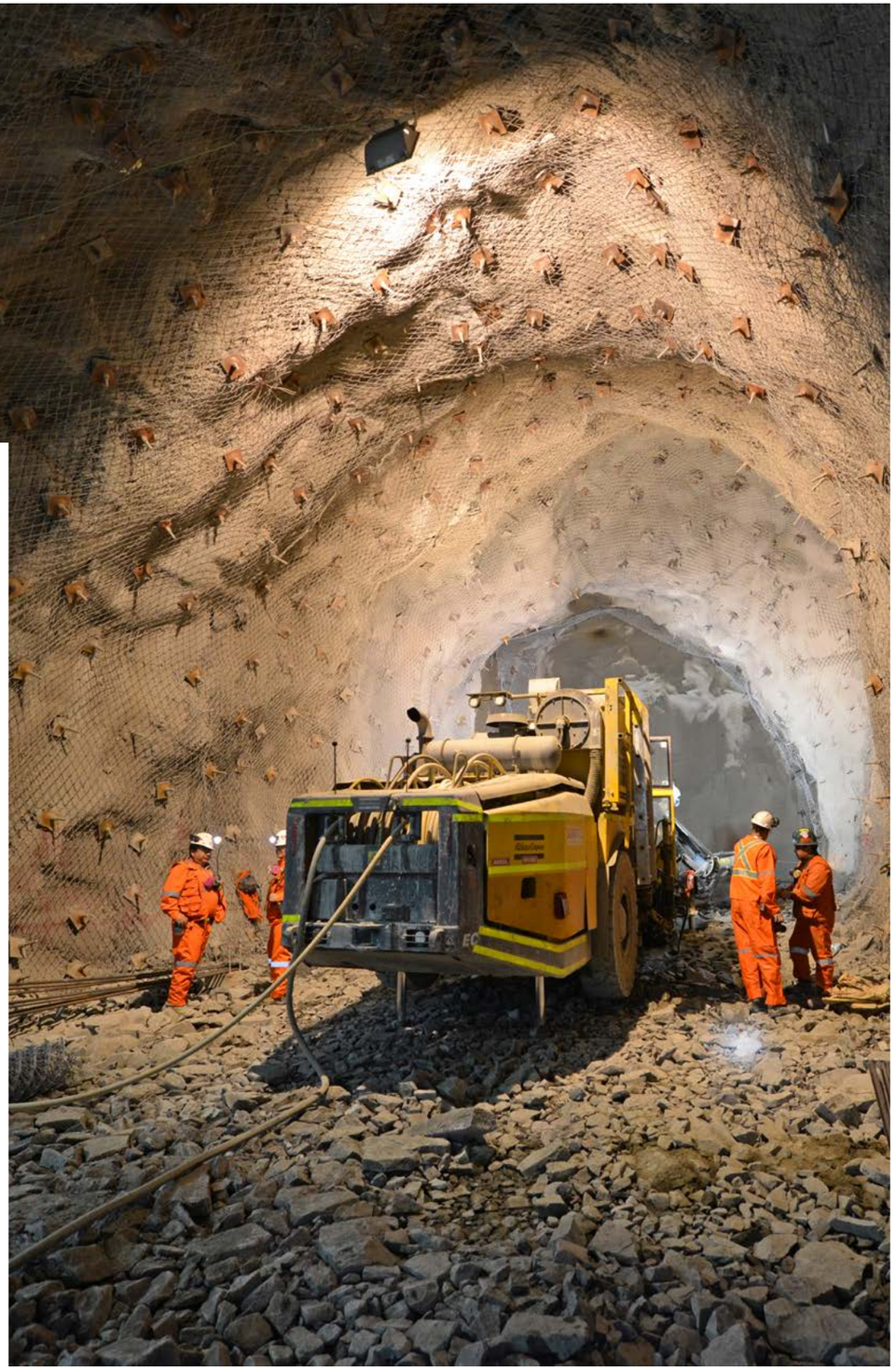


Image courtesy of DSI Underground

# Underground Mining

When Chuquicamata commenced its underground operation in August, after 104 years in operation as an open pit mine, it represented a paradigm shift. Chile's transition from open pit to underground mining is now fully in progress, as many of the most noteworthy mines and expansions are being developed underground. Although open pit mining still yields 90% of the country's copper production, this number will change significantly in the coming decade as Chuquicamata underground ramps up production and El Teniente's new mine level project is advanced. The expansion of Los Bronces is also planned to go underground.

Underground mining brings many benefits as it has less impact on the surface. Places where there are glaciers or vegetation can remain intact and, in addition, it generates less dust. These expansions are also a great opportunity to introduce technological changes in the field and have more machinery that is remotely operated, leading to improvements in safety and efficiency.

The paradigm shift toward underground mining presents a big opportunity for EPC firms, because the design of the mine, equipment and logistics differ significantly from open pit mining. Chile already has several underground mines, so there are firms with expertise. However, today it is clear that most engineering firms are looking to improve their competitiveness in the space.

Worley is working with two clients on large brownfield and greenfield projects and its involvement is mostly focused on underground, processing and infrastructure development. According to the company's commercial director, Claudio Martínez: "We are seeing big opportunities in underground mining."

Worley is also in the process of completing three studies for clients looking to operate underground. These new mine developments underground require detailed design for the underground infrastructure, maintenance facilities, dewatering facilities, mine air heating, ventilation systems and electrical power distribution systems, amongst other project requirements.

The collapse of the main ramp into the San José mine in 2010 collectively instilled in Chilean miners the importance of safety in underground mining. Today safety remains paramount. The most effective way to reduce risk is by incorporating safety into the design, which is a large focus of what companies like Stantec, Wood Group and JRI Ingeniería do.

## Niches Underground

In addition to engineering firms, Chile's underground developments are attracting contractors and subcontractors with experience providing products and construction that make mining safer and more efficient. DSI Underground is a German company that is providing bolts and resins to the Chilean mining market that help ensure the safety of workers. According to Carlos Leigh, the company's CEO of Latin America: "Any mine that is deep or located in a country with seismic issues, needs bolts and systems with dynamic capacities that can absorb energy, not just those that go to the maximum resistance and break. Therefore, it is important to develop products capable of providing support in those conditions."

DSI has been responding to client needs to lower opex by introducing a liquid resin that allows clients to install and get resistance for bolts in 6 minutes; much faster than the 24 hours needed with traditional cement.

Another example of a company looking to expand their presence in Chile due to the promising future of underground mining is Herrenknecht, a company with experience in mechanized tunneling. It took took its understanding of tunneling for civil works and applied it to mining to develop innovative machine concepts for a variety of applications underground, such as vertical access or production shafts, inclined vehicle access ramps, ventilation shafts and transport routes. "The challenge is to design the right equipment that meets the clients expectations. With Chuquicamata and Teniente new mine level there is huge potential and greater need for underground equipment," said Michael Weinhold general manager, Latin American mining at Herrenknecht.

# Juan Pablo González

President
**IIMCH**

**Some projects are going to increase their production, but I do not think this will be as easy and fast as they have planned. Mining projects are long term and are taking increasingly long to develop due to processing issues, technical challenges and a difficult environment for financing.**

**How has the *Instituto de Ingenieros de Minas de Chile* evolved over the course of its history?**
The Institute of Mining Engineers of Chile (IIMCh), is a private nonprofit law corporation that was founded 89 years ago by professionals who led the mining industry. The purpose of the institute is to strengthen links between mining professionals and the related arts and sciences.
We provide technical and professional cooperation to any initiative, work or activity - public and private - that tends to the development and progress of the mining industry. As a group, we are focused on scientific, technological and management changes in the mining industry and we seek to train and educate members associated on developments in the market.
We also give technical opinions when there are interesting issues regarding the mining industry. Our opinion is not affiliated with any political party, mining company or particular interest, because technical and academic matters support our actions. We care about the development and growth of mining in Chile.
We have many professionals specialized in a variety of topics and we have been supporting the mining industry since its inception. We host several conferences, seminars and courses throughout the year to educate our members.

**What are the most important challenges that the mining industry in Chile must overcome?**
The main challenges are environmental and community related. They are a result of the bureaucracy of the system. Companies have become more proactive in addressing environmental issues, because of the need to develop the concept called social license. This means that they must find a new way of connecting with the community in order to carry out their projects. Regarding the environment, Chile has some of the highest standards in the world, however the bureaucracy has caused regulations to become somewhat burdensome and long, but now government is trying to introduce simplification mechanisms, while still maintaining high standards.

**What initiatives could the government adopt in order to quicken the length of the permitting process?**
An internal committee was created within the Ministry of Mining in order to oversee the large mining projects in Chile. This serves as a platform to generate better response times in the processing of permits. Administrative and political issues must be improved, so that there are no contradictions in the permitting rules. What I know is that the mechanism and the processing platform are being improved to streamline processes and minimize response times.

**What are the benefits of underground mines as opposed to open pit mining?**
In the case of Chuquicamata, the ore is very deep, so the mine was deep. This condition has geo-mechanical and structural complications. It also means high transport costs, because of transport distances are too long. This led to an increase in the operational costs. Underground mines can be much more profitable, in this specific case. In general, the underground mines have higher costs, but the difference in transforming an open pit mine to underground is that it opens the possibility of mining greater mineral resources and extending the life of mine.

**Do you think there will be a limit on how much Chile will be able to produce in the future?**
There are some mining projects in Chile that only plan to continue producing the same amount of minerals, but other mines plan to expand in the coming years. Chile seeks to reach 7 billion mt of copper production. Some projects are going to increase their production, but I do not think this will be as easy and fast as they have planned. Mining projects are long term and are taking increasingly long to develop due to processing issues, technical challenges and a difficult environment for financing. ■





# Carlos Leigh

CEO of Latin America
**DSI UNDERGROUND**

**Social demands are being made and it is giving Chile the opportunity to solve them and move forward. Chile was never considered, in our recent history, a populist country and I still believe it will not become one.**

**What is the history of DSI Underground and what capabilities does the company bring to Chile?**
DSI Underground is based in Germany and the company covers four regions – Europe, Asia Pacific, North America, and Latin America. We are involved in mining and tunneling. Latin America is especially strong in mining. As a system supplier to the industry, we offer our clients the largest product range globally available and we offer a team of strong service professionals to meet all customer demands.

**What challenges associated with underground mining can DSI Underground's products and services solve?**
The core focus of our products and services are related to safety. We emphasize safety while improving efficiency in our client's operations. Our products help speed up production cycles, which leads to a lot of operational savings We do this by mechanizing the process in order to make the site safer and the production faster.

Can you elaborate on DSI Underground's product portfolio?
DSI Underground supplies various steel products as well as fiber glass solutions. We supply products such as anchor systems, injection resins, pumpable injection chemicals, fore poling systems, the largest range ground support products in the market.

**Where does DSI Underground see the best opportunity for growth moving forward?**
Latin America is a growing region and there is still significant opportunity for growth. We have achieved great success in other regions and aim to do the same in Latin America. We aim to continue growing our company and market share moving forward.
Do you see civil unrest in Chile materially affecting project development?
It is important to remember that mining investments are very long term, so I believe companies will continue moving forward with the development of their assets, despite the current unrest. Social demands are being made and it is giving Chile the opportunity to solve them and move forward. Chile was never considered, in our recent history, a populist country and I still believe it will not become one. The silver lining of the crisis is that those social issues will now find the space to be incorporated into the law. The most important matter it is to implement the critical issues sooner rather than later and we can move forward as a country.

**What are some of the most exciting innovations in underground mining today?**
DSI Underground has developed products for dynamic rock conditions or rock burst, this is a great opportunity for us and our customers. Any deep mine or mines located in countries with seismic issues need bolts and systems with dynamic capacities that can absorb energy, not just go to the maximum resistance and break. Therefore, we are very involved in developing products to support in those conditions. We have a dynamic product that works with resin and cement and it has been very well received by the market.

**With the price of copper being below expectations, has there been a greater push towards automation?**
Fluctuations in the commodity price have increased demand for automation. Some companies have paused or slowed down their operations, but others adopted technologies and innovations in order to improve efficiency and productivity. The only way that some companies can deal in difficult markets is to improve their operational costs and therefore there is an increased demand for products and services that will assist them in achieving these goals.

**What are DSI Underground's objectives moving forward?**
DSI Underground Latin America has a challenging company growth over the next three years. We aim to expand our presence in Latin America, Central America and the Caribbean. We would also like to consolidate the efforts we have been making in new countries of local operation over the last three years. In some markets we are still seeing old methods of underground support, including wood and some mines even less than that. There is a lot of room to improve safety conditions in underground mines across Latin America and DSI Underground wants to be a part of making industry safer for workers and more efficient for our customers. ■

# Iván Rayo

General Manager
**JRI**

**Can you give us an overview of JRI and the company's business offerings to the Chilean mining industry?**
JRI is a Chilean engineering company and has been present in the construction and maintenance of the country's most important mining projects, either as the main contracting company or a subcontractor. The company has a market share of approximately 8% of the total engineering activity related to mining in the country.
Our company has four main business branches: design of underground mine; building of treatment plants; design of pipeline systems for water and mineral transportation and the fourth is tailings dam design.

**How have depreciations in the copper price affected JRI's business and the demand for the company's services?**
When the copper price was booming, there was a large market of new mining projects and the demand for engineering services was very high. Nowadays, the demand for engineering services has shrunk. It has also meant fiercer competition. Many companies are looking for opportunities outside of Chile where they can lend their expertise.
Unlike other companies, JRI business model was less reactive to market influences and therefore it has responded more robustly to the changes. It has been increasing its market share in Chile. Since, 2017 we have experienced 20% per annum growth.

**What are the biggest challenges for the Chilean mining industry?**
The industry is seeing significant changes in how mining operations are conducted and the challenge lies in adapting to the technology requirements that come with them. For example, we are seeing a trend away from open-pit mining and towards underground mining. Engineering companies must provide solutions to changing needs.
Another challenge is with industry regulation. There is stricter regulation on tailings and companies must be able to adapt their operations accordingly.

**What are some of JRI's achievements that you are most proud of?**
I am most proud of the company's growth. We have successfully increased our market share and are participating in larger and important projects. For example, we are involved in large structural projects for Codelco.

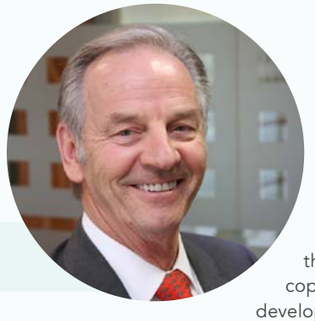
**What are some areas of opportunity for JRI geographically?**
We want to increase our presence in Peru. There have been fluctuations in mining permits and requirements and that has impacted our ability to penetrate the market.
The challenges for mining in Peru and Chile are different. Mining in Peru tends to be smaller scale and more selective while Chilean mining is characterized by large rates of extraction and considerably larger mining sites. The location of the operations also poses different challenges. In Chile, the majority of the projects tend to be located in the desert away from local communities while mining in Peru is done in the close vicinity of the inhabitants and far away from the ports. ■







# Dave Lawson



President Mining & Minerals
**WOOD GROUP**

**What is the core business of Wood in the mining sector and what are your most promising areas for growth?**
Wood has approximately 1,000 employees here in Chile, with most of them devoted to mining. In the engineering area, Wood's complete services adds value across the mine life cycle. Wood´s service lines handle mineral resource and project evaluations, mine planning and design, mineral processing and metallurgy, engineering design and project management, environmental permitting and water management services, automation and control, and construction. The automation and control group directly supports our clients in leading their digital and technological transformation efforts towards operating the mine of the future.

**Can you tell us about the opportunities you see for Wood in tailings and your offerings in that area?**
Wood´s environment and infrastructure group assists our clients in the tailings area. Wood has been retained by several of our clients to be the Engineer of Record (EoR) for their tailings facilities here in Chile, and we are assisting them in the development of safer operation protocols and tailings disposal alternatives such as dry stacking and thickened tailings, to lower the chances of a dam failure.

**Can you elaborate on any lithium projects that Wood is working on?**
Globally Wood is involved in several lithium projects. In Chile, currently we are working on the La Negra project, located close to Antofagasta. We are executing an EPCM contract for the construction of a lithium carbonate plant that extracts the mineral from the Salar de Atacama. We have a similar lithium project in Australia.

**What is the role that automation, data analytics and robotics will play in the future of mining?**
We are working with clients in Latin America to implement new technological innovation strategies that will allow them to incorporate big data into their decision making. Currently, we are conducting a study for a major mining company in Chile to build a command center in Antofagasta that will allow them to remotely control their plan operations using artificial intelligence and automation, thus minimizing their operational cost and increasing their safety.

**What does Wood aim to achieve in Chile over the next 2-3 years?**
Our vision for the company is to assist clients in two areas. One is in energy transition materials. We want to be involved with anything dealing with electrification. That means copper, lithium, nickel, and cobalt and we are developing our expertise in all of those areas. The second area is sustainable building, which is about helping in water and energy, which are the main building blocks in Chile going forward.

**What are your views on the Chilean mining market in 2020?**
I am optimistic about 2020. We have had some troubling times in the last few months and I hope that it does not impact the mining industry in Chile. Chile has been a success story in mining because it has been a stable and transparent place to do business. We know what to expect in terms of taxes and laws and, as long as those remain stable, then this is a great environment. If any of those start to move then people will start thinking twice about their investments. ■

# Construction and Logistics

With mines increasingly moving underground and to high altitudes in the Andes, construction and logistics can be extremely challenging. Both Bertling and Echeverría Izquierdo are specialized in working at high altitudes, a great advantage in Chile because many of the mines are located high up in the Andes mountains.

Bertling, a logistics company dedicated to delivering specialist cargo to challenging and remote locations, went through a difficult period during the downturn as it went from 62 employees in 2014 to 10 at the end of 2017. Today, it is back at 50 employees and the resurgence in hiring came as a result of a ramp up in projects. These include Teck's Quebrada Blanca, BHP's Spence Growth Option, and a project from Codelco. As these projects develop, Carlos Reveco, managing director at Bertling, has observed some of the challenges of performing logistics for mines in Chile: "The issue we face is that the size of the equipment is growing. Designs for electrical rooms, for example, were 16 meters long in the past and they are now 20 meters long. A lot of manufacturing occurs in Santiago and moving from Santiago to the north can be difficult due to the distance to the mine site. Also, many of the mines are located at very high altitudes and the maximum height for transport is 5,000 meters,"

Echeverría Izquierdo is a holding company involved in different stages of construction projects. It works closely with the engineering teams and develops construction projects and facilities based off of designs. According to Dario Barros Izquierdo, general manager of Echeverría Izquierdo's Industrial Assembly unit, the market for construction is very competitive in Chile and therefore, "Keeping costs low is key." This can be especially challenging in underground mining. Izquierdo continued: "Echeverría Izquierdo has the challenge of constructing and erecting complicated equipment on site in the underground environment. Surface construction and underground construction are completely different. Underground construction can often be more complicated as there might be condition and site access challenges. You can not use combustion equipment during underground construction and electrical equipment is required."

The company is also involved in construction of a lithium facility and Izquierdo likens it to that of a chemical plant. "We have to provide solutions that are tailor made for the lithium business. The processing plants for lithium are much smaller compared to copper. There is a significant amount of investment made into the lithium market which provides great growth opportunities," said Izquierdo. ■







# Darío Barros Izquierdo

General Manager
**ECHEVERRÍA IZQUIERDO MONTAJES INDUSTRIALES**

**What is Echeverría Izquierdo's focus in terms of mining, and how important is the mining industry to the company's overall business?**

Echeverría Izquierdo is a holding composed of nine companies, which are involved in different construction areas. Currently, we are operating in Chile and other parts of Latin American with active participation in the mining, pulp and paper, energy and petrochemical industries. In Chile our focus is mining. It is a very big market and we continuously try to find and develop new projects. We have been involved in some of the main mining projects in Chile such as Collahuasi, Quebrada Blanca 2 (QB2) and the Albemarle lithium project. Echeverría Izquierdo is specialized in working at high altitudes, which is a great advantage in Chile because many of the mines are located high up in the Andes mountains.

**What specific services does Echeverría Izquierdo provide to the mining industry?**

Echeverría Izquierdo is involved in the different stages of construction projects. We work closely with the engineering teams on projects and we develop construction projects and facilities according to their engineering designs.

**What are the challenges for Echeverría Izquierdo in working at high altitudes and how does the company overcome these challenges?**

It is paramount to find an experienced team that will be able to live and work at high altitudes. Health and safety can sometimes be a challenge for this kind of project. Logistics might also be a challenge.

**Does underground mining pose challenges for a construction company such as Echeverría Izquierdo?**

Echeverría Izquierdo has the challenge of constructing and erecting complicated equipment on site in the underground environment. Surface construction and underground construction are completely different. Underground construction can often be more complicated as there might be condition and site-access challenges. You can also not use combustion equipment during underground construction and electrical equipment is required. Underground mining is the future of Chile and Echeverría Izquierdo is focused on finding good solutions for the challenges this presents.

**Can you elaborate on the size of investments that are currently being made in the market?**

Teck is making big investments into its QB2 project, but they are in the minority. There are far more small to medium sized investments being made than big ones. Small investments are not good business for Echeverría Izquierdo because these projects are served by small contractors. Medium sized mining projects are important, and that is where the development is occurring in Chile. El Espino (Pucobre) and Santo Domingo Project are important medium sized projects.

**What has been Echeverría Izquierdo experience working in the lithium space, and what is your view on the potential for Chile to be a top lithium producing country?**

Lithium mining in Chile is a good business and the country's lithium is high quality and cheap to produce. Construction of a lithium facility is similar to that of a chemical plant. We have to provide solutions that are tailor made for the lithium business. The processing plants for lithium are much smaller compared to copper. There is a significant amount of investment made into the lithium market, which provides great growth opportunities for Echeverría Izquierdo.

**Is Echeverría Izquierdo completely focused on the Chilean market or is the company looking to expand into other markets?**

Echeverría Izquierdo is a Chilean company and it is mainly focused on this market. Approximately four years ago, the company entered the Peruvian market, where we were mainly involved in projects in the energy sector. Our focus will remain in Chile as it is a huge market with a substantial amount of opportunity. Nonetheless, we will consider expanding into markets where we see great potential.

**What are Echeverría Izquierdo's objectives and vision moving forward?**

Echeverría Izquierdo aims to continue to grow its footprint in the Chilean mining market. We want to get involved in all the major mining projects and want to remain a preferred construction partner in the market. We are continuously looking for opportunities where we can offer solutions to our customers. Echeverría Izquierdo has seen significant growth over the years, and we aim to continue onward. ■

# EQUIPMENT AND TECHNOLOGY

**» Adoption of innovation and auto- mation in Chile is a massively important topic. In our research we read a lot about Chile wanting to be lower cost in order to increase competitiveness. When we talk about automation, artificial intelligence, robotics, there really is not an option to not participate. Businesses will have to accept adoption as a cost of being in the marketplace. «**

**- Chris Knowles,**
**Global Marketing Manager,**
**Maclanahan**

Image courtesy of Komatsu

# Equipment:
## Innovation that Offsets

DISRUPTIVE TECHNOLOGIES ARE COMPENSATING FOR DECLINING ORE GRADES

Thanks to George Lucas and his Star Wars franchise, as a society our most popular image of a robot is R2D2. For a small number of visionary thinkers, however, robots are more than science fiction; they are a critical enabler for a safer and more productive mining future. Marco Ruiz, general manager of ENAEX Robotics, is one of the thinkers attempting to bring disruptive change to the mining industry. He said: "We recognized that as ore grades decline, there is a need to facilitate access in difficult to reach deposits while protecting the safety of operating personnel."

Within the mining industry robotics may be considered niche and unready to immediately replace traditional methods, but their development and presence is indicative of a broader trend in which companies are investing heavily in technology. According to a KPMG survey, the highest level of investment in the mining technology space is occurring in data and analytics tools, autonomous vehicles and robotic process automation.

One local Chilean company that is growing its presence as a regional leader in automation for mining is MIRS, a subsidiary of HighService Corp. Their president, Hugo Salamanca, characterized industry enthusiasm for robotics saying: "We believe that the industry is more receptive to technology today than it has been in the past and that presents a big opportunity. The mining industry is facing many challenges and the importance of robotics in mining is now widely understood. We need technology in Chile especially because productivity is low and production costs are high. Robotics can help boost competitiveness, improve productivity and reduce costs."

The company develops robotic applications in the concentrate sampling process and in the plugging of flash furnaces. Its robots are active at Codelco's El Salvador operation and in the smelters at Chuquicamata.

Technologies such as this will also have big implications for increasing safety in the mines. When asked about the biggest risks associated with teleoperation and autonomy, Brian Larocque, general manager of Hard-Line Chile, a leading supplier of automation, teleoperation and remote control technology, responded: "The most prominent risk is in companies taking too long to adopt the technology available. The pace of technological adoption in mining is accelerating at an unprecedented rate and mining operations must partner with support companies to ensure the acceleration in adoption is implemented effectively."

An equally important factor encouraging companies to adopt new technology is the relatively high cost of production. Chile had some of the highest energy costs of any major metal producer for much of the 2010's. Toward the end of the decade, this began to change but companies had already signed long term contracts at nearly US$100 per MWh, based off of Consejo Minero data. Furthermore, the cost of labor is on par with the world's most developed jurisdictions like Canada, US and Australia, but productivity is lower. Finally, permitting times are long, so there is greater risk of cost overruns. In order to negate some of these risks, particularly associated with labor, companies must consider all options to reduce headcount inside the mine and boost efficiency.

Technology seems to be the preferred vehicle to deliver these results. Chris Knowles, global marketing manager at McLanahan, a provider of engineered process solutions for mining, shared his view: "We read a lot about Chile wanting to be lower cost in order to increase competitiveness. That means lower energy, labor and much lower transport costs. This plays into electric instead of diesel trucks, robotics instead of humans, smart conveyers instead of trains and tracks. They do not have an option not to go that way," he said, adding: "We as manufacturers must make sure we can deliver as many sensors and as much condition monitoring technology as possible to be able to feed that into the market. They will not want to pay for this tech but, in order to be globally competitive, they will have to adopt these technologies."





**Autonomous Mining and Teleoperation**
*OEM's blaze path forward*

It is no longer an uncommon sight to see a mine truck cabin empty as it is being operated remotely or fully autonomously. Trucks that drive themselves can spend more time working because software does not need to stop for shift changes or to take a lunch break. Miners throughout Chile are putting their faith in driverless trucks and unmanned drilling rigs, while they oversee their operation from offices thousands of kilometers south, in Santiago. According to Komatsu Cummins Chile CEO, Darko Louit: "Autonomy is the future of mining and the future of mining has now arrived. All major mining operations are considering automation or autonomous fleets on the haulage side." Louit continued: "If you think of automation on a scale, with 1 being no automation, 5 being fully autonomous, the haulage fleet is likely a 4-5 in Chile, while other equipment is still at level 1. The road from 1 to 5 for different families of equipment goes from assisted operation to semi-autonomous operation, to operation not fully integrated with the rest of the fleets, to system-wide automation."

Today, there are several convincing signals that automation, remote monitoring and productivity boosting technologies are becoming essential to miners in

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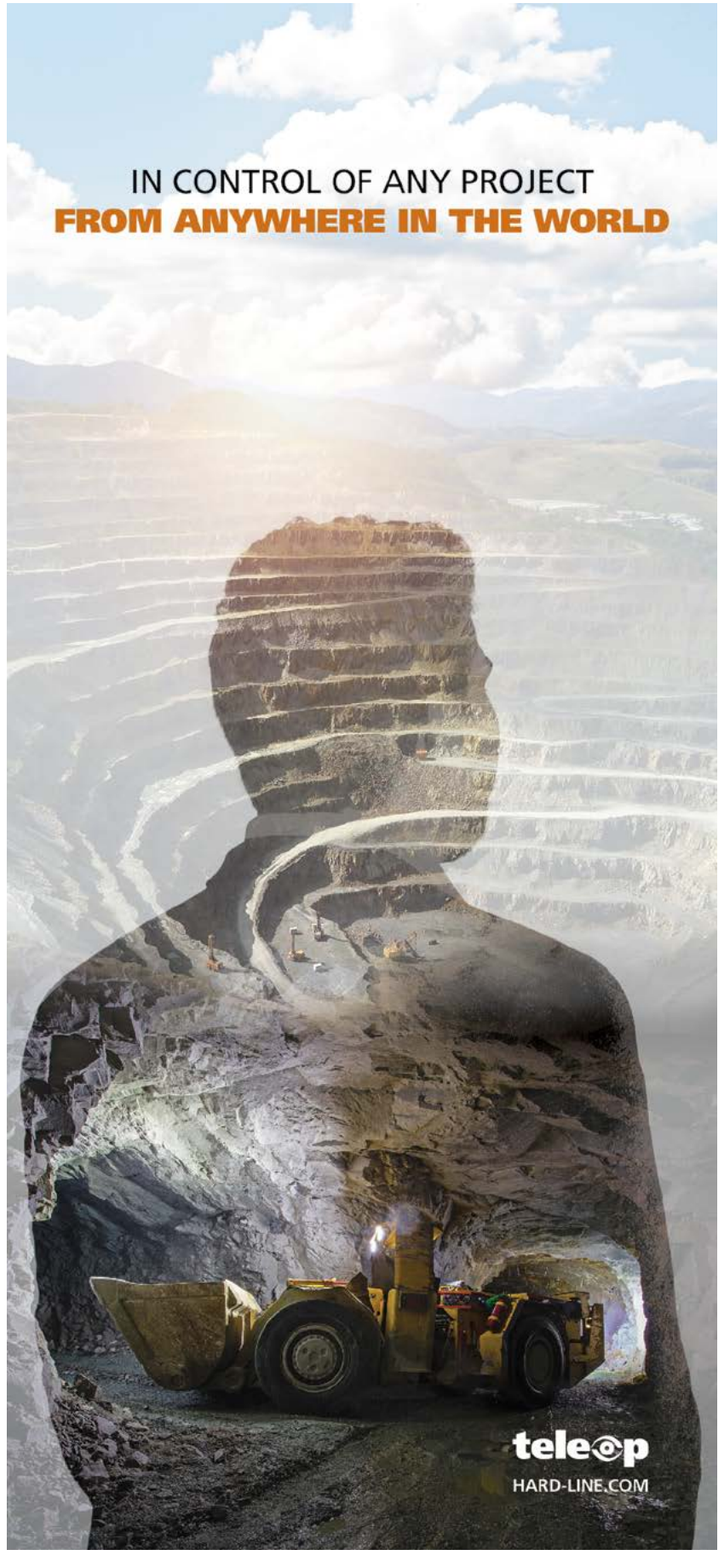

# Darko Louit

CEO
**KOMATSU CUMMINS CHILE**

**How has Komatsu's acquisition of Joy Global helped expand its mining capabilities?**
In 2018, we integrated the management from both companies in Chile. There is a great deal of synergy in the support functions of the business. We have combined our facilities, all logistics, warehousing operations, transport contracts and services. Joy Global is now called Komatsu Mining Corporation (KMC), and in combination with Komatsu we offer more products and services for open pit and also underground mining.
We have a trial of our hybrid LHD, a new product for the underground, and a new market for Komatsu here in Chile. We have integrated the equipment and diagnostics efforts, and we are working heavily on data analytics. Globally, in terms of joint development, there is a lot going on in terms of platform development for mine optimization.

**How has Komatsu's investment in remanufacturing added value to its Chilean operation?**
Komatsu invested US$33 million in a remanufacturing facility in Santiago in 2017. It has increased our capacity for remanufacturing components, applying new technologies, reducing time, and improving quality control. We recently announced that we will build a new remanufacturing facility in La Negra, Antofagasta and we are in the process of finalizing the investment of over US$20 million.

**How does Komatsu view the trend toward underground mining?**
We believe that mining will gradually move to underground in the future. That is one of the reasons why Komatsu invested in Joy Global. Joy Global is a market leader in soft rock underground, and also participates in the hard rock underground market. For us, Chuquicamata underground and the El Teniente new mine level project are huge opportunities in Chile. Our aim in the underground is to enter the market with new technologies. For example, our Hybrid 18 ton LHD is diesel powered, but it has an electric drive system. This will reduce emissions inside the mine, while also providing faster acceleration for the machine. We believe the future of underground mining is continuous excavation, with no drill & blast, and relying on fully electric, fully autonomous machines.

**How do you defend your market share in autonomous mining in Chile?**
If you think of automation on a scale, with 1 being no automation, 5 being fully autonomous, the haulage fleet is likely a 4-5, while other equipment is still at level 1. The road from 1 to 5 for different families of equipment goes from assisted operation to semi-autonomous operation, to operation not fully integrated with the rest of the fleets, to system-wide automation. Komatsu is on a journey to advancing to system-wide mine optimization, and autonomy is a critical building block.

**How can these new technologies drive environmental sustainability and lower energy costs in the mines?**
In the future, you will have electric machines, hybrid equipment or reduced emissions technology applied to all mining equipment, underground or surface. Likely, there will be alternative fuel usage on large mining machines like hydrogen fuel cell technology. There will be hybrid, trolley assisted, battery-based and more efficient engines. For example, there is something called contention management. You have many trucks that are running around and you know that a truck will reach an intersection, and there is another truck that will also reach that point. What you don't want to have is any of these trucks stopping, it is inefficient in terms of energy use, because by starting and stopping, you use more energy and cycle time increases. If all the machines are autonomous, the system knows where everything is and it can predict when they will reach the intersection. When you have mine-wide optimization in real-time, you can dynamically interact with the equipment so that they reduce power and speed to make it a more fluent operation.

**How has demand been for Komatsu's products in 2019? How are you projecting 2020 to look?**
I can say that 2019 has, so far, been in line with our projections. 2019 was our second year under joint management of the Komatsu and KMC businesses, and we have seen more benefits from the integration. We reintroduced P&H drills in Chile and have closed some interesting deals with customers for new autonomous fleets, while at the same time continued to strengthen our services operations for mining customers. We are projecting 2020 to remain stable and similar in volume to 2019 in the mining sector. ■

# Brian Larocque

General Manager, Chile
**HARD-LINE**

**What is the history of Hard-Line in Chile and what capabilities are you providing to the market?**
Hard-Line was established in 1996 in Sudbury, Ontario. In 2014, Hard-Line decided to invest in Chile because it saw opportunity in remote control technology specialized for mining. Since Hard-Line has opened the company, there has been a lot of technology development from the line of sight remote control technology to fully automated loaders where we take people completely out of the mine site. Also, in the open pit we can now operate trucks and bulldozers from kilometers away.

**What projects are you specifically involved with in Chile?**
Hard-Line is mostly involved in large mining projects in Chile. We did a very large project 4-5 years ago, where we tele-operated three trucks, a shovel, bulldozer, wheel dozer and a water truck. The idea was to test a new mining method using tele remote control in case of a collapse. Due to rising costs in open pits, the mining industry needs to do more vertical wall mining.
Tele-op LHD was used in an underground application to move the production LHDs to the work area through a seismically active area.

**Why are expenses rising for miners and how does Hard-Line technology address this issue?**
The cost of doing business is on the rise, generally, however the most prominent risk is in taking too long to adopt the technology available to the industry. The pace of technology adoption in mining is accelerating at an unprecedented rate, which increases productivity and improves safety, both priorities for all mining operations. Mining operations and support companies are learning to create partnerships to ensure these accelerators are implemented effectively. Hard-Line's technology addresses the shift towards automation and tele-operation, but we also strongly believe in the development of strong partnerships with the clients we serve. We have a highly skilled team in-house to research, develop and implement custom solutions for the unique challenges mining companies are facing.

**How do the services that you offer in open pit differ from those in the underground?**
Tele-op technology is transferable to a variety of environments. It has been used for both underground and surface mining, as well as in other industries, such as construction and military ordnance clean up. The interface that we install on the equipment is customized to the equipment being operated. It is designed and manufactured in Canada and we implement it here on-site with our technical team located in Chile.

**How has demand been for Hard-Line services in 2019?**
It has been affected by the need to get people away from potentially dangerous environments. Safety has become the most important concern of our clients. This is even taking precedence over value.

**One of the challenges with technology in underground mining is reliable connection. Is this an issue for Hard-Line and what solutions can help overcome this challenge?**
It all depends on the mine. Often IT people want a closed network and they don't want other people to gain access to the information. We can overcome that by installing our own Backbone Network that delivers both power and connectivity to the mine.

**What are the biggest challenges with your business?**
Getting mining companies to understand the need to integrate this technology into their operations is a big challenge, along with working through the barriers to tech adoption. This goes back to the importance of working as partners to support the process in every way to ensure that the shift is effective and efficient in all areas of business.

**What metrics can you point to that would convince someone of the benefits of tele-operation?**
The understanding that this is where the industry is heading is widely accepted. Tele-operation keeps operators out of harm's way, it allows continued production during shift change (which can account for a significant amount of time, sometimes upwards of 6-7 per day), and decreased maintenance costs when utilizing collision avoidance.

**What are the goals of Hard-Line in Chile over the next 2 to 3 years?**
Hard-Line is forecasting continued growth over the next few years in Chile and our other offices. We continue to develop and improve technology to help mining operations meet their objectives. ■

# Dale Clayton

Managing Director
**LIEBHERR**

**How has Liebherr's business been in Chile since 2017?**
Liebherr's overall Chilean business has remained stable since 2017. Our excavator fleet has grown from 20 to 32 units. After 18 years, we finished our contract with Chuquicamata in July 2019 as a result of their transition to underground mining. However, we are in the process of moving these trucks to a new project. In 2020, we are involved in the ESTRS trial at Escondida for BHP that has great growth potential for our business.
Our strategy has been to continue with our maintenance and service contracts while we wait for the market to pick up. Companies are extending the life of their assets and eventually that will get to the point where the cost to repair is uneconomical and they will have to look for replacement equipment. We still want to have our employees in place and develop more talent. As a family company, employees are a huge part of our business and we need to make sure that when the market does pick up we have the people ready so we can react quickly and fill our management and supervision positions internally.

**In your opinion, how much of the talk about innovation is noise and how much has substance?**
If you look at the technology now and the data that is available, from Liebherr's point of view, it can only get better in providing more information from our machines. Our LNDS system allows us to remotely monitor the vital information on our trucks and manage the maintenance accordingly.
Another technology development that Liebherr will have for our excavators is our "Assistance Systems", which allows us to increase the levels of safety and productivity of our equipment, reducing operating costs, through different tools such as: the application of a truck loading assistant to continually measure the bucket payload, a self-diagnostic system, an onboard system that automatically computes the KPIs about machine productivity and an application severity detector. This aligns with increased safety, productivity and ultimately lower cost per tonne.
We believe in terms of mobile mining equipment, there is still quite a way to go with some very exciting advancements that we are continuing to develop that will further improve our overall equipment performance.

**How far along is Chile in the transition to autonomous mining?**
At our testing grounds in the United States, we have a truck running without operators with some advanced features like obstacle detection. We are looking for a partner to start mine site trails in 2020 with our trucks or to retrofit an existing Liebherr truck fleet.
Liebherr has chosen an open protocol system that means we can use any fleet management system, as we believe the industry will look for this flexibility in the future.

**How does Liebherr Chile deal with the challenge of retaining talent?**
We identify our high potential people and tailor training to that person´s and the company's goals. We also have a policy where when positions become available we try to promote internally from our existing staff. For all our employees we sponsor further studies where we see a benefit for both the company and our employees. We also use our affiliate companies and factories for training and experience sharing.

**Is your Chilean office driving expansion elsewhere in South America?**
Yes. We have a separate management team in Peru, but we are relying heavily on our planning and technical support experience from Chile for the initial start-up while we develop our in company capacity.

**What would you like to achieve at Liebherr in Chile by 2022?**
We want to expand our excavator and truck fleets and introduce our mining bulldozer range. Chile is an amazing mining country and we want to continue to be part of the mining industry. We also aim for the successful completion of the ESTRS trail at Escondida and expanding our strong relationship with have with BHP in other regions especially Australia.
We believe that with our flat management structure that allows our customers have direct access to our senior management team and our factories is a huge advantage. We are willing to work with clients directly to provide the solutions they need to get maximum production at the lowest TCO. ■

# Charlie Ekberg & Rodrigo Izzo

CE

RI

CE: General Manager
RI: Business Manager
**EPIROC**

**How has Epiroc's presence in Chile evolved over time?**
**CE:** Atlas Copco has been present in Chile for 60 years. In 2017, Epiroc split out as a separate unit to devote itself to mining and civil infrastructure. Now, Epiroc is a completely separate business, with branches in Calama, Copiapo, Antofagasta, and Iquique.

**What challenges does Epiroc face that are unique to the Chilean market?**
**CE:** Chile is a very long country, and that puts Epiroc in a challenging situation in terms of supporting customers whose operations are far from the capital. For the mines in Chile, the challenge is declining in ore grades. For us this is not necessarily negative, but for the customer it means that they need to be much more productive and efficient to keep their costs in line. That is where we come in, being able to add value with the machines we are offering. Epiroc's drills, loading machines and hauling machines are all devoted to boosting efficiency, safety and productivity for the customers.
Other challenges in Chile include energy, water, and according to our customers, time to get mining permits. The lengthy process means customers have to make big investments before they even get the permits. It is nothing new but it seems to be a really big challenge at the moment to start a new operation.

**Describe the opportunity that Chuquicamata underground represents?**
**CE:** This is one of the biggest underground projects in the world and it is going to be extremely important for years to come. It is also one of Epiroc's biggest projects and prospects. Epiroc is very much focused on being part of Chuquicamata's development and it is a wonderful opportunity to display our capabilities underground.

**How is data and analytics transforming mining in Chile? What specific metrics are customers looking for?**
**CE:** Normally what we look at is drill meters per hour, drill meters per operator, precision in where you need to drill the hole, and fuel consumption, etc. All things that people didn't really know previously, and now they can see that these metrics having a big value.

**RI:** Real time data is extremely demanding in performance, because of its transparency. When you have real time info and you can send out reports, no one can hide. If operations don't arrive with a drill pattern on time, it will show. In this environment, every area feels they have to step up to the challenge to insure optimal use and increase the production time for the equipment.

**What kind of improvements can clients expect by investing in new technology?**
**CE:** In underground mining, the machines clients purchase are utilized on average 25-30% of the time. These are expensive machines, and when customers recognize they are underutilizing their investment, it is clear how much potential there is to improve.
Before these innovations were introduced, in surface operations there was one operator per machine. Now you can run up to three machines simultaneously, and the operator is no longer in harms way. This yields higher utilization on the rig, increased meters and much higher productivity.
Word of mouth is very important in Chile. When Los Bronces was successful using our equipment people started to ask, hey can I do this? Then we got several other big projects.

**Does Chile have the potential to become an innovation hub for mining?**
There are several Chilean owned startups developing digital software for handling big data. The challenge for them is how to become a global player. The knowledge, production and customers are here, Chileans are very entrepreneurial but funding is likely an issue. It will be interesting to see what they can do.

**What is Epiroc's strategy moving forward?**
**CE:** The main cornerstone of our strategy is to convince our customers that the new technology and products we offer are going to be good for them. Our vision is to be the best productive partner. Not just to sell machines and parts; we are selling a commitment for the life of the equipment and we want to make sure our machines are delivering what we promise. Today business can be very focused on the short term, but for customers it is about a long-term partnership. Partnership alliances will be even more important in the future. ■





# Felipe Cabrera

Country Manager
**EMERSON**

**Because of our results in Escondida and Minera Los Pelambres, clients around the world are now interested in the technology we produce here in Santiago. We developed technology for mines in Chile and we are now selling it all over the world.**

**What is Emerson's history in Chile and what capabilities do you bring to the Chilean market?**
Emerson started operating in Chile six years ago. Prior to the establishment of our mining center here in Santiago, there was no specific focus on mining within the company. However, this office was specifically opened with the intent of growing our presence in mining. Since arriving, Emerson has developed technology specifically for mining in copper concentrate plants, solvent extraction plants and electrowinning. Our approach was to first listen to the big mining companies operating in Chile and they stressed to us their need to increase productivity, reduce costs and lessen environmental impacts. Emerson then developed technology and sensors to solve these challenges for them. We were given the opportunity to pilot our technology and it proved to be successful. Because of our results in Escondida and Minera Los Pelambres, clients around the world are now interested in the technology we produce here in Santiago. We developed technology for mines in Chile and we are now selling it all over the world.

**What are the biggest benefits of automation for miners in Chile?**
When we talk about automation we are talking about a lot of sensors where everything is connected to a control system. Emerson technology covers the full spectrum of client needs in this regard. Automation is the name of the game, because sensors are replacing people who otherwise would be exposed to extremely dangerous parts of the mine. This has big implications for worker safety. Automation can help solve some of the most complex issues in mining today and Emerson technology can help companies achieve their goals by enabling the monitoring as well as the operation of parts of the mine remotely. We have long term service agreements with big miners and that allows us to invest and tailor innovative solutions.

**How do you see the future of automation in Chile playing out in terms of adoption and jobs?**
There are a lot of risky places in the mine where people are still operating, and we should be replacing them with equipment. There is a common belief that this will create unemployment, but at the same time, we need people to monitor, maintain, configure and program the equipment. It's a different kind of job, but we need people to develop skills to fill those jobs. In that regard, universities need to do a better job at preparing people for the jobs of the future. Today automation is well received in the market. I helped start the movement toward automation in Chile in the 80's, and back then it was hard to demonstrate the advantages and benefits. Today that is not the case. The benefits are too obvious and the trend toward autonomy is unstoppable.

**What goals would Emerson like to achieve in mining over the next 2-3 years?**
Emerson customers are all asking us to aid them in their path toward digital transformation. This is because they recognize that they have a lot of data, but are not using the data in a way that increases productivity. Use of data in a more efficient way will produce better results and that is why Emerson is focused on becoming a leader in data analytics. Our digital transformation business unit is devoted to solving these issues for customers, and we are devoted to growing this unit.
Furthermore, our mining center has grown by double digits every year since it was created and we want to sustain this growth over the next three years. Our other goal is to expand into the important mining markets globally such as Australia, USA and Peru. Emerson already has the technology, solutions and experience. The next phase for us is about convincing the mining community to embrace change. The value proposition is very clear. In mining one percent more copper recovery per year equates to millions of dollars. If the equipment fails we loose millions in hours. Customers are aware of this and are focused on preventing these big failures. Emerson has the solution that they are looking for. ■

# Pedro Damjanic

Senior Vice President
**FINNING**

**What is Finning's growth strategy for South America and Chile?**

We have three key strategies. First is to focus on new equipment and technology, this includes an autonomy package. The second strategic point is we are reinforcing our focus on our aftermarket products. We have a new product line that is more comprehensive, so customers can use Finning equipment for the full spectrum of their needs. The third aspect of our strategy is service.

**How is Finning's implementation of autonomous mining beneficial to its customers?**

Our technology and innovation allows our customers to operate in very high altitude mines. Prior to the adoption of these new technologies, the costs and risk were very high. We are now able to dramatically reduce the number of people and the amount of risk in the operations.

**Are you seeing a change in the demographics of the mining industry?**

We have put a lot of emphasis on including women and disabled people in our operations. Unfortunately, numbers have not changed dramatically yet, but this will likely change, because with new technologies, all the planning engineering, programing and supply chain logistics will be moved to our Knowledge Center in the cities. Additionally, we are working with the community in Mejillones, where we are training welders and encouraging women to join the mining workforce. Recently we received "Best Mining Supplier" by the Women In Mining group.

**How do Finning - CAT's products help miners operate more efficiently?**

The new equipment is faster, safer and operates at a lower cost. A large amount of additional ore is accessible for mining because of the technological breakthroughs and new equipment performance. We are exploring opportunities in autonomy both for open pit and for underground. One example is our operation of a semi-autonomous model with CODELCO in the El Teniente mine. With this technology, El Teniente is able to access a very high-risk part of the mine and we eliminated the risk of sending people into a dangerous area. ■





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Chile. In 2019, Finning-CAT was awarded a contract by Teck to deliver new equipment and product support to their QB2 operation in Northern Chile. Finning will supply an initial fleet of Caterpillar 794AC electric drive off-highway trucks and other large mining machines to the copper mine. In addition, Finning will provide Caterpillar's 794AC AHS (Autonomous Haulage Technology) kits and ancillary kits to enable autonomous operations as QB2 ramps up to full copper production in 2022. "Prior to the adoption of these new technologies, the costs and risk were very high. We are now able to dramatically reduce the number of people and the amount of risk in the operations," said Pedro Damjanic, senior vice president at Finning. He continued: "The routine and risky processes will be done by machines and the focus can now turn to planning and new design of the operation. This will aid companies in capturing ore's that were previously uneconomical and or inaccessible."

Epiroc is developing a digital platform alongside Pucobre in Copiapó. They have their own control room and are able to monitor their machines in real time. "This is a huge change from manual paperwork. Many machines are running in the mine somewhere and, to be able to see where those machines are and plan the traffic of those machines, where to put them, and what is going on with the machine is a big advantage for customers," said Charlie Ekberg, the company's general manager in Chile.

Liebherr is also advancing its technology offerings and is looking for a partner to start mine site trails in 2020. The company has chosen an open protocol system, which means it can use any fleet management system. According to managing director, Dale Clayton: "Innovation comes in many forms and technology is changing the way we manage equipment and our business. If you look at the technology now and the data that is available, from Liebherr's point of view, it can only get better in providing more information from our machines. Our LNDS system allows us to remotely monitor the vital information on our trucks and manage the maintenance accordingly."

Since 2017, the company has grown its excavator fleet from 20 to 32 units, while its trucks business has remained flat. This has led Liebherr and nearly all the other OEM's operating in Chile to prioritize maintenance and service contracts while the market continues its slow recuperation. "Companies are extending the life of their assets and eventually that will get to the point where the cost to repair is uneconomical and they will have to look for replacement equipment," said Clayton.

In the meantime, aftermarket service and remanufacturing are playing an important strategic role for OEM's. Epiroc, for example, employs 500 people in Chile, 400 of which are devoted to aftermarket services. At Komatsu, the company invested US$33 million in a remanufacturing facility in Santiago in 2017 and is now in the process of finalizing an investment of over US$20 million to build another new remanufacturing facility in La Negra, Antofagasta.





**Ancillary Equipment**

One of the added benefits of the wave of investment into automation is that it encourages innovation from suppliers. As there are several new autonomous and technologically advanced trucks being introduced to the market today, companies such as American Air, which supplies air conditioning, Motion Metrics and even tire manufacturers like Bridgestone and Michelin are incentivized to tailor innovations to complement new fleets. According to Joel Araujo Strul, commercial manager at American Air: "The challenge (of automation) is that there are not enough qualified people in the industry who are prepared for this rapid change. We are developing the most automated AC unit on the market and it will require minimum work on installation and maintenance."

Additionally, American Air is developing a predictive maintenance system for air conditioning units to be launched in 2020.

Motion Metrics is using machine learning to help mines implement predictive maintenance for shovels. The company provides tooth wear monitoring for all mining shovels and excavators so that tooth change-outs can be predicted and scheduled without the need for manual measurements. Worn teeth are inefficient because they require increased cutting forces to penetrate material, which results in lower overall productivity and increased energy consumption while causing premature wear to other sacrificial components like adapters. According to José Oliva Peralta, general manager of the Chile office: "Chile was an appealing country to open a satellite office because most mines are concentrated in Atacama region, leaving at least 13 possible candidates that could adopt systems."

Today the company has six contracts with miners operating in the region.

Beyond vehicles, there are also autonomous solutions for other segments of the mining process. Technosteel subsidiary Polimet, for example, has developed a technology that can transmit information to a remote operator, which eliminates the need for inefficient manual inspections. Its other subsidiary, Safedrill, developed a 100% hands-free rod handling operation in drilling. Technologies such as these will have big implications for increasing safety in the mines.

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# Joel Araujo Strul

CEO
**AMERICAN AIR**

**What is the history and mission of American Air?**
American Air is a family business established approximately 40 years ago. The company specializes in light vehicle, medium duty and heavy truck air conditioning systems. Our mission is to provide technical support to our distributors and service workshops, also making available all the equipment, service tools, and spare parts they may need.

**How did American Air become involved in the mining industry?**
American Air realized that there was a lack of local suppliers, knowledge and expertise with regard to air conditioning within the mining industry. Given our staff of qualified technicians, we saw a need in the mining market and we started supplying the industry with our products and aftersales support. We were one of the first air conditioning companies to start supplying the mining industry in Chile.

**What products and services does American Air provide to the mining industry?**
American Air has a complete line of compressors, evaporators, condensers, expansion valves, accumulator filters and everything that the industry of mobile air conditioning needs in one stop. We also have the components to remanufacture compressors and tailor-made hoses for any model of vehicle included in our inventory. Also, we develop and build air conditioning units for standard and special types of duties. We have the highest standards in compressor repair, and we can guarantee the best reconditioning service to our customers. OEM parts are, as a rule, present in our inventory, which we provide to the automotive and heavy machinery sectors. We both distribute products and tailor make products our self.

**Does the emergence of the electric vehicle market provide new opportunities for American Air?**
With the emergence of the electric vehicle market, changes are happening quite rapidly. The challenge is that there is not enough qualified people in the industry to be prepared for this rapid change, so we are developing the most automated AC unit that will require minimum work on installation and maintenance.

**How do fluctuations in commodity prices affect American Air's ability to price products?**
American Air has good margins on specific items such as our compressors. This is the core of our business. We are thus able to absorb some of the fluctuations in commodity prices. We source approximately 90% of our products from the US and 10% from Asian countries. We have very good relationships with our suppliers and can use the credit that they extend to us instead of using bank credit.

**Do you have a final message for our international readership?**
American Air places emphasis on education and the transference of knowledge. We believe that the more people we can educate, the better it is for the air conditioning field. Our objective is to keep growing our business and continue to be the leading supplier within our field. We are in the process of developing predictive maintenance systems for air conditioning units and hope to have these systems built and launched by 2020. ■







# Guillermo Crevatin

General Manager Chile, Bolivia and Peru
**MICHELIN CHILE**

**Michelin's aim is to excel in the fields of innovation, performance, strength and longevity. A longer tread life, the tread pattern and the choice of rubber compounds perfectly suited to mining environments and the speed capacity of our tires have a direct impact on the mine's productivity.**

**How has Michelin's Fenner acquisition in 2018 impacted operations in South America?**
Michelin's acquisition of Fenner is part of our strategy to diversify our business into new areas such as mining and sustainability. Our company has a 130 year history in the tire space, but we feel that there are great opportunities for our business to expand.
We aim to help mining companies become more productive in their work and we want to offer services and solutions that boost efficiency. Our strategy is to develop high technology materials for the mining industry, and we are adding to our capabilities by making strategic acquisitions. Fenner has a great presence in the mining industry as well as good knowledge technology materials. The acquisition of Fenner will help Michelin expand its capabilities to offer the best services and solutions to the mining market.

**What are the biggest strategic priorities for Michelin's business?**
Sustainability is the core focus of our strategy. We have to innovate in order to reduce the amount of material we use to manufacture the same tire with the same capacity. Older tires do not necessarily have to go to waste, but can be reused through regrooving and repairing, to give more life to the tires. When the life of the tire comes to an end, we have the responsibility to recycle its materials. We can then renew by reusing recycled materials in producing new tires. We also have to do R&D work to find renewable materials that can be implemented in new products. We are in a strong position in Chile, because it will be one of the first countries to implement regulations for the recycling of mining tires and this is well aligned with our strategy.

**Can you elaborate on Michelin's efforts to introduce innovation and sustainability into its tire business?**
We aim to make tires lighter by using less material. We also have the goal to produce tires that are 100% recyclable and renewable. Michelin continues to innovate with regards to the construction of our tires in order to offer more to the client in terms of tire life. We are developing technologies which improve our tires and assist customers in how to best use their tires. We can improve performance as connect technology keeps customers constantly informed of the position, pressure, temperature and status of each tire. Sensors fixed inside each tire can monitor the tires and give precise measurements.
Michelin's aim is to excel in the fields of innovation, performance, strength and longevity. A longer tread life, the tread pattern and the choice of rubber compounds perfectly suited to mining environments and the speed capacity of our tires have a direct impact on the mine's productivity and these are big advantages we have over our competitors. Tires used in the mining industry are subject to very challenging conditions operating in extreme terrain. Through innovation, our tires are designed to give the highest levels of reliability, safety and performance.

**Ore grades in the Chilean mining industry are declining and more mines are going underground. How is this changing the way Michelin is developing technologies for the mining industry?**
Michelin's product range covers both surface and underground mining. Our connectivity developments are very important especially in the underground environment. Machines are faced with the most extreme working conditions in these scenarios. To stand up to fallen rock debris, flooding and heat encountered in the extraction of minerals, tires must be 100% reliable. They also have to be able to withstand greater loads to keep pace with the increased productivity demanded. Mindful of these demands, we have developed a hi-tech tire range, capable of handling these various stresses and strains and carrying even more load.

**What are Michelin's objectives and vision moving forward?**
Michelin aims to provide the best products and services to our customers so that they can reach success in their projects. Moving forward, our focus will remain on sustainability and efficiency. Our goal is to be the preferred tire and solutions provider for the mining industry worldwide. ■

# The Future of Labor

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Salaries in mining are 70% higher than the country average and mining makes a direct contribution of 3% to Chile's employment, according to Consejo Minero. Mining companies may be keen to implement technologies that lower labor costs, but that does not mean that workers and surrounding communities will also embrace changes coming to the industry in Chile. Inevitably, as automation and artificial intelligence become more widely adopted, certain well paying jobs will cease to exist. Many of the OEM's, for example, have remote operated equipment where one person can now operate three rigs simultaneously. In the past, the same task would have required three people.

Unions already play an important role in the functioning of Chile's mining industry and have caused operations to miss production targets in the past. In conversation with Andres Guzman, VP of Yamana Gold, he proclaimed: "In Chile, expectations for benefits sharing as well as local hiring and procurement have increased and this sometimes manifests in protests that can delay production… Yamana has largely avoided these tensions by engaging respectfully, transparently, and continuously with its community partners and by investing heavily in local development, quality of life, education and culture."

However, it is difficult to imagine a scenario under which unions are not, at least in some way, part of a conversation to help preserve jobs in the face of technological change. The mining industry understands this dilemma and is focused on new areas in which jobs will be created. "We believe that autonomous mining will employ the same amount of people but with a different skill set. The challenge will be finding and training local communities to take these positions. It is important for companies to look to hire locally in Chile, so we are staring to investigate how we can start in an area and train a local workforce to support an autonomous fleet. This is good for our social license and that of our client," said Dale Clayton of Liebherr.

Felipe Cabrera, Emerson's mining sales director, asserted: "It is a common belief that automation and remote operation will create unemployment, but at the same time, we need people to monitor, maintain, configure and program the equipment. It is a different kind of job, but we need people to develop skills to fill those jobs. In that regard, universities need to do a better job preparing people for jobs of the future."







# Data and Analytics

Coupled with development in autonomous mining, data analytics is also quickly becoming an essential tool for operators. Predictive maintenance solutions that address problems before they occur are one of the biggest benefits that digital technologies can offer the mining industry. Maintenance in mining often occurs on a time-based schedule, rather than as needed, leading to a lot of wasted time and money.

In Chile, there are several companies that specialize in helping customers leverage their use of data through software. Although data and analytics tools are still in their infancy in Chile, they represent a significant opportunity because data has the potential to unlock value in nearly every aspect of the mining process. EY has been working closely with the large mining companies in Chile on ways in which they can better use the vast amounts of data they collect. In one case the company provided advice that increased recovery in the flotation plant simply by using data analytics to understand the optimal settings on different pieces of equipment. These subtle changes boosted copper recovery by 3%, which translates into significant cost savings.

In underground mining the machines that clients purchase are utilized on average 25-30% of the time, so companies are focused on assisting clients in using data more efficiently. "These are expensive machines and when customers recognize they are underutilizing their investment, it is clear how much potential there is to improve," said Charlie Ekberg general manager of Epiroc.

According to Juan Vega, co-founder of eBooting, a company with expertise diagramming and integrating data flows: "We have access to a significant amount of data today, but it does not mean anything if there is a ton of data and no way of using it to become more productive. We see opportunity in distilling and adding context to the vast swaths of data mining businesses collect. If they use these tools properly it will increase their bottom line. "

**Sanhattan Valley?**

With so much focus on technology development in mining, Santiago has become an important regional hub for many of the leading global technology firms. According to Pascual Veiga, president of APRIMIN: "Chile is being used as a laboratory for experiments with new technology because it offers great diversity and variation in style of operations, height of mines and rock types."

Another reason technology companies find Santiago appealing is because the city has some of the most well educated and well trained workers, an entrepreneurial culture and a good climate for investors – characteristics the city shares with other international hubs for the development of disruptive technology such as Silicon Valley.

Because Chile is a country where vast geological potential mixes with a well educated workforce, it is able to pilot and test cutting edge technologies in its mines. Companies with experience in Chile can then look to apply their knowledge to other less technologically advanced markets. One such company is Technosteel: "Chile is a mature mining market. Therefore, Chilean companies have an opportunity to contribute in introducing world class technologies into less experienced markets, like Bolivia and Panama. The technologies we introduce are new for them, but have often been in use for some time in Chile," said Tomás Buttazzoni general manager of Technosteel.

**Underground Equipment**

As Chile's mines increasingly move underground there will inevitably be big opportunities for technology and equipment providers to tailor products that boost efficiency and safety. Chuquicamata underground, for example, will rely heavily upon new technology to reduce fuel consumption by 80%, while automation will increase workers productivity by 40% according to Bloomberg reporting.

Companies in Chile are swapping diesel fueled drills, loaders and utility vehicles for equipment powered by lithium ion batteries. They are looking to reduce emissions and eliminate exhaust fumes that pollute the underground air, creating health hazards for workers.

Beyond vehicles and drills, there are also autonomous solutions for other segments of the mining process. Normet, for example, has developed a smart scan technology. Senior vice president of sales, Marcelo Anabalon Del Campo, said: "This improves the quality of the sprayed concrete, securing the concrete in the mine, which supports the tunnel and therefore mitigates the risk of tunnel collapse."

Another area of opportunity is in conveyor belts. TAKRAF Tenova built the world's most powerful conveyor belt system for Chuquicamata. The belt system will deliver copper ore from the underground mine directly to the concentrator plant 13 km away from the mine site. According to the company's managing director, Christian Cavagnaro: "Chuquicamata needed the strongest conveyer belt in the world because in order to move such large volume and capacity you must have strong equipment. The mines are getting deeper, the ore grades are going down and you need large volume, which implies large equipment." He continued: "The advantage of belt conveyors from an operational point of view is that it lowers opex. The focus in mining generally is capital investment, but today, the challenge is opex. The opex in Chile is too high and, to reduce it, companies must lower energy costs by minimizing the quantity of energy used by investing in more efficient equipment."

# Hugo Salamanca

President
**HIGHSERVICE CORP.**

**HighService was looking for a global partner for its service business because we had reached an important level of development in Chile. We felt that we still had the potential to continue growing and we wanted to expand our global reach and look for new business opportunities in other countries.**

**What value will HighService's service division bring to Metso after the acquisition?**
Metso is gaining a business that is a leading company in integral, mechanical, electrical and instrumentation maintenance services for mining. The company has operations in Chile, Argentina and Brazil, and 1,300 employees. HighService was looking for a global partner for its service business because we had reached an important level of development in Chile. We felt that we still had the potential to continue growing and we wanted to expand our global reach and look for new business opportunities in other countries. We had previous experience working with Metso, where we carried out the maintenance of the crushing plant at Minera Gaby in northern Chile. This was a very positive experience and was important in building the mutual confidence needed to execute the acquisition.

**What is the strategy for HighService Corp´s different businesses?**
We have three different segments: engineering and construction (HS E&C), robotics (MIRS) and an incubator of technological enterprises (HS Tech). Our strategy is aimed at developing robotic technology in mining and the development of robotic applications worldwide. We believe that the industry is more receptive to technology today than it has been in the past and that presents a big opportunity. The mining industry is facing many challenges and the importance of robotics in mining is now widely understood.
The other strategic focus we have is to strengthen the engineering and construction company to make it a medium to large company.

**In what ways are robotics being applied in the process of mining?**
We develop robotic applications in the concentrate sampling process. The robot moves through a lineal rail in order to reach every possible sampling area tailored to the customer's specific requirements. MI Robotic Sampler is being used in world class operations like Impala Terminals Callao, Glencore Antapaccay & Matarani and Codelco's El Salvador. We are also focusing on the passage's tapping and plugging for flash furnaces. The melting furnaces have tap holes where the mineral is discharged in a liquid form and we develop the method of opening the furnace walls to avoid the risks of accidents and contamination. The system is operating in Codelco Chuquicamata Smelter and we are working at the engineering phase for smelters in Europe and Australia. Another example of the application of robotics is the SAG Mill's trommel maintenance, which has totally innovated the way in which maintenance activity is carried out at BHP's Escondida mine. Our robotic arms have benefits for safety and productivity, because workers are removed from potentially dangerous situations.

**What are the biggest projects in Chile that you participated and are participating in?**
We worked in Codelco's *Smelter project (Ventanas)* and Asarco refinery project (Amarillo, Texas), where we made a great application of a robotic system that allows the stripping of copper cathodes. The cathodes and starting sheets stripping process requires a lot of effort, that exposes staff to high risk, but we managed to do it with robots. In the coming months we will start robotic application tests for mill lining replacement. These mills have metal parts that lift the ore and grind them. These must be replaced very often. In order to replace the metal part, the equipment must be stopped for many hours, which generates losses. Our proposal is to robotize this whole process to avoid accidents and reduce maintenance times. This is being implemented in operations like Minera Los Pelambres, BHP's Escondida mine and CODELCO El Teniente.

**How is the technical know-how of Chile as a country?**
We must build technical capabilities. There is a good level of technical training in the Chilean mining industry, but we need to develop a better relationship with the universities so that they train specialists in robotics and artificial intelligence. There are not enough technicians or professionals who understand how to work with artificial intelligence. We can address these issues with the support of specialists from United States and Europe, but it is better if Chile is able to develop its own local workforce with the capacity to work in robotics and artificial intelligence. ■





# Tomás Buttazzoni

General Manager
**TECHNOSTEEL**

**What is the history of Technosteel, and what services do you provide to the market?**
Technosteel was created from a contract to produce exploration rocks for Atlas Copco in the early 2000s. Over the last 10 years, we decided to diversify and, as a result, we created two companies: Polimet, a company that focuses on the design and construction of conveyor belt equipment and its components, and SafeDrill, a technology company that designs and manufactures equipment for exploration. We realized that we needed to dramatically increase the safety for operators in exploration drilling and found that, while the automated feeding of rods into the platform is a challenge that has been faced by several companies around the globe, no one had achieved a 100% hands-free solution over the entire cycle of rod feeding. We took the challenge of creating 100% hands-free technology and we are now close to achieving that goal. We are also focused on reducing the area of the platform, because today mining companies are facing increasing challenges for space available for exploration. Lastly, we have created mud plants that will allow the recovery of mud and will save up to 30% of water consumption on each platform.

**Does Technosteel have anything currently in its R&D pipeline?**
At Safedrill, we have recently achieved inner tube handling, allowing us reach the 100% hands-free goal in the rod handling operation in drilling. Technosteel is developing a shock absorber for the blasting and drilling process, which is a new model that will allow mines to exchange parts of equipment on-site to streamline the maintenance and repair process. At Polimet, we are working toward making conveyor belt equipment actively send information to an operator to eliminate manual and visual inspections.

**Are there other markets where you see opportunity?**
We already operate steadily in Peru. The other markets we are looking at in Latin America are Bolivia, Colombia and Panama. Similar to Chile, Bolivia has been developing its mid-size mines.

**What are the biggest opportunities for your business, and where are you growing fastest today?**
In general, automation of processes and digitalization are the fastest growing areas in mining. We see very good potential of growth driven by the need of tailor made solutions for each exploration campaign and mining plant, and we are able to efficiently provide for that need.

**Over the next 2-3 years, what objectives would you like to achieve for Technosteel?**
Technosteel would like to become an important player in technology for automation and digitalization in our specific segments and to establish partnerships with global companies to become their local partner for the South American market. We want companies to look to us for customization of drilling platforms, and rods. We also are looking to potentially become an OEM for big brands in the rock drilling segment, in the drilling equipment segment, and with idlers and conveyor belts. ■

# Marcelo Anabalón Del Campo

General Manager Chile
**NORMET**

**What is the history of Normet and what capabilities does it bring to the Chilean market?**
Normet started as an equipment and service supplier in Chile late 2008, and later added a new business line focused on construction chemicals. The success of this business has helped Normet grow its market share year after year and led us to open new business opportunities in equipment and service in addition to construction chemicals. Normet has brought to the Chilean market strong support to customers to ensure process efficiency, especially in sprayed concrete and scaling. Normet Chile works to create a balance between each of our business lines.

**Currently what are the biggest projects Normet is involved in?**
At the moment El Teniente, Alto Maipo, El Peñon, HMC Gold, Santiago Metro and Chuquicamata are Normet's biggest projects and they are our biggest focus as well. A new stage of development will begin at Chuquicamata and we hope customers will choose us again. We are also supplying new spraying machines and concrete transport machines for the El Teniente project. Normet is involved in is Candelaria. Here we are working very closely with Zublin and Lundin mining in bolt resin injection.

**What are some new technologies Normet is introducing?**
Normet is now promoting our smart drive offering (battery vehicle) and some new tools. We have sold our smart scan system to a few contractors in El Teniente and this allows the customer to scan the surface of the tunnel in order to understand the thickness of the concrete. This new technology has been very well received thus far and has great potential.

**How do these innovations make underground mining safer for workers?**
Having electric vehicles inside the mine creates a healthier environment for workers because these vehicles do not produce harmful emissions, and keep maintenance cost on lower level as well. Furthermore, Normet's smart scan technology improves the quality of the sprayed concrete, therefore the risk of tunnel collapse is mitigated.

**How does Normet help its customers achieve cost savings?**
We are not solely focused on selling equipment or chemicals, but instead we are focused on adding value for our clients on select processes such as sprayed concrete, scaling and explosive charging. We have strong capabilities in those three processes and we are ready to support our customers to improve their efficiency by adding new tools such as simulators and process training.

**Normet is present in both Peru and Chile. How does underground mining differ between countries?**
Peruvian and Chilean mining are similar. The Chilean mines request more safety accessories to the equipment and demand a higher level of support from their suppliers. In Peru mines are normally above 4,000 m altitude, which adds an extra challenge to the workers and equipment. Therefore, underground operations are similar, and both have to add mechanizations for certain process, like explosive charging.

**Is automation and technological change leading to a change in the demographics of the mining sector workforce?**
Absolutely, as soon as you start adding new technologies in the mining sector new skills will be needed. The industry is now beginning to create different kinds of jobs dealing with data, robotics and software and in the future you will see far more women working in the sector.

**What differentiates Normet from its competitors?**
Normet's principal aim is to support its customer by adding value to their processes. We have a wide portfolio not only in equipment, but we are also very robust in service and construction chemicals. We are essentially a one-stop-shop and we can provide a complete solution to meet all of our clients needs. More and more mining contractors are looking for partners to externalize the more complex processes. This is where we are most focused on providing support.

**What goals does Normet want to achieve over the next two years in Chile?**
Normet wants to continue penetrating the market with scaling and mechanization. Today, the industry is still too reliant on manual charging processes and Normet is focused on mechanizing this. We also want to introduce our scanning system on a wider basis than we have today. ■





# Comminution and Material Handling

Image courtesy of Metso Chile

Until about 1900, nearly all breaking facilities were labor intensive. The removal of impurities was done by hand, usually by breaker boys between the ages of eight and 12 years old. The mining industry has come a long way over the past century. Today, advancements in comminution and material handling allow miners to process exponentially more complex ores. This is important for Chile because it has been the worlds leading copper producer for much of the past two centuries and therefore, most of the easily accessible, high grade projects have long been exploited. A decade ago, 10 g of copper were extracted for every mt of rock processed. Today that average has fallen to about 6 g/mt of copper according to Consejo Minero figures. This means producers must crush and treat almost double the amount of rock to get the same amount of copper they did 10 years ago.
In many cases comminution is not only the largest energy consumer in mineral processing, it is also the largest capital expense and operating cost. Today, new deposits are being found in more remote areas and are trending toward harder ores and finely grained minerals. These factors have major implications for both capital and operating costs. Add to that today's growing concern about the environment on the part of stakeholders, and it explains why companies are focusing their investments on technology and equipment that reduces energy consumption and leaves a smaller environmental footprint.
Andrés Costa González, president of the South America division at FLSmidth, an engineering firm that supplies productivity enhancing equipment, has been observing this influx in investment and is positioning his company to capitalize on the trend. He commented: "The future of mining is going to be tough. Deposits are getting deeper and costs are rising. Mining operators need to maintain productivity in order to be competitive. With technologies and technical support, our clients can offset the degradation of ores and increasing costs."
Metso is another company that has been very active in solidifying their competitiveness in order to take advantage of opportunities. In 2019, the company made a series of acquisitions of companies such as Outotec and HighService corp's service division. "Metso is very strong in the process of crushing and processing of dry minerals and Outotec is more focused on the wet processing segment of mining. This union makes a lot of sense and it allows us to combine equipment and processes. This is a very good way to grow," said Eduardo Nilo, general manager Metso Chile.
The combination will enable the company to strengthen its capabilities in technology and R&D, product and process excellence, and increasing its global footprint. Metso's acquisition of HighService Service is also important, because it is indicative of a broader trend in Chile, wherein companies are very focused on developing stronger service offerings. As a result, Metso and FLSmidth are building remote monitoring centers. Metso's first performance center began its operations in Santiago in 2019 and is expected to soon move to new customized premises. It employs experts who analyze data and derive insights to help customers optimize their processes remotely. It uses new remote monitoring capabilities for gearless mill drives, obtained as part of Metso's acquisition of HighService Service. FLSmidth also has a digital collaboration center in

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# Andrés Costa González

President
**FLSMIDTH SOUTH AMERICA**

**Can you give a brief overview of FLSmidth and the company's operations and capabilities in South America?**
Within the mining space, FLSmidth covers the entire value chain from in-pit crushing and conveying to tailings management. Our clients have access to a full flowsheet of productivity enhancing, mineral processing and material handling technologies and equipment.
FLSmidth also has digital initiatives that it is inaugurating. We are currently developing a digital collaboration center in Santiago where we can connect to the mine site and remotely assist our customer in performance and predictive maintenance, which allows us to improve reliability and availability. From Santiago we can now address all our customers needs across South America.

**Can you elaborate on FLSmidth's ability to provide solutions in areas that are increasingly difficult to operate in?**
We know that the future of mining is going to be tough. The ore grades are declining and deposits are getting deeper. Mining operators need to maintain productivity in order to be competitive. With technologies and technical support, our clients can make their operations more efficient. FLSmidth provides technologies that can increase recovery, reduce energy consumption, make transport systems more efficient, and decrease the need for spare parts. Implementing optimizing technologies into the mining process has the potential to offset the degradation of ores and increasing costs.

**How willing is the South American market to adopt new technologies and innovation?**
Over the last two years, FLSmidth has noticed a switch in the mindset of the market in terms of adopting new technologies. The mining market has always been conservative and a little reluctant to adapt, but this is changing as mining companies are starting to realize that they will have to adapt in order to survive in the future.
Today FLSmidth is developing innovations among our customers. We are developing technologies that will change the way we handle materials in the future. Currently we are working on flotation cells capable of reducing energy consumption by approximately 50% while also improving recovery. We are also jointly developing new ways of deploying dry tailings. We have an industrial operation in Mexico where we are testing an innovation that has the potential to eliminate the tailings dam.

**Do you have a message for our readership?**
It is the industry responsibility to make people in South America understand that a future is not possible without sustainable mining. FLSmidth is a leading supplier of production facilities, equipment and service solutions, which improves productivity, drives down costs and reduces the environmental impact of operations. We see ourselves as a dedicated partner to enhance our customers' productivity. ■







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Santiago, where it can connect to the mine site and remotely assist a customer in performance and predictive maintenance, thereby allowing it to improve reliability and availability. "From Santiago we can now address all our customers needs across South America," said Andrés Costa González.
McLanahan, a provider of all equipment for crushing, feeding, sizing, screening, washing, sampling and water management has had its own service capability in Chile since 2015. According to Jean Peirre Mery, general manager of McLanahan: "The idea is to produce equipment in Chile and that is our main challenge for the next two years." His colleague Chris Knowles added: "Growing our capability in Chile ultimately gives us a foothold into the Latin American region from which we could potentially expand to other countries."

## Conclusion

The reality in the Chilean mining industry is that, as a result of being the leading copper producer globally for over 30 years, many of its most productive mines are mature. Therefore, in order to spur future growth and maintain production levels, technology must be implemented and used to its full capability. The potential to achieve big breakthroughs is now within the industry's reach and companies have begun to embrace digital and technological innovations that are transforming key aspects of the industry. Technologies that have long been in the works are now available and affordable enough to become operational at scale. This transformation is being experienced at varying degrees depending on the producer, but it is without a doubt happening in Chile. Codelco and Lundin mining are incorporating autonomous fleets into their operations, miners are signing agreements to digitize their operations in Chile and Antofagasta Minerals is investing US$40 million to strengthen its technological platform in the country. As long as these investments prove that they are saving money for clients and making the industry safer, businesses will increasingly move to adopt technology at an even greater pace in order to replicate results.
The technological applications include building a more comprehensive understanding of the resource base, optimizing material and equipment flow, improving anticipation of failures, increasing mechanization through automation and monitoring performance in real time. Alone, each of these opportunities has real potential. Together, they represent a fundamental shift in both potential safety outcomes and how value can be captured. 65% of large mining companies in Chile invest in improving what they have, while 21% invest in doing things differently and 14% in radical changes according to Deloitte. These numbers will need to shift if Chile intends to remain the worlds leading producer of copper for another 30 years. ■

# Christian Cavagnaro

Managing Director
**TAKRAF TENOVA**

**Our spectrum as a company today is very wide because we can go from the pure mining industry as an equipment and service supplier to providing process and that is the future.**

**How is Tenova structured in Chile and what have been the biggest developments in Tenova's business over the past three years?**
The Chile office is Tenova and Tenova is owned by the Techint group. Tenova is the process and equipment supplier. Tenova mining has three companies. TAKRAF, which is dedicated to material handling, Delkor, which specializes in solid liquid separation, and Tenova Advanced Technology (TAT), which is Israeli and dedicated to process for the mining industry. In Chile we have three areas where we provide services, equipment or plants.
One accomplishment we are very proud of at TAKRAF is that we were very successful in finalizing Chuquicamata underground, where we built the largest conveyance system in the world. From a technological point of view, we used gearless technology and the strongest belt in the world called ST 10,000. In our Delkor segment, we have supplied large thickeners for Peruvian operations, and TAT is entering into the lithium business. Tenova recently finalized the design and supply of the boro removal plant and site services for Albemarle. We developed that in Chile, but we are now designing and providing supplies and site services for the plants at an Argentinian project which will be one of the biggest lithium projects in the world. Our spectrum as a company today is very wide because we can go from the pure mining industry as an equipment and service supplier to providing process and that is the future.

**Lithium is a developing industry in Chile and there is a need for solutions that use less water. What is your experience working with lithium in Chile?**
To process lithium, you extract the brine, put it in a pond, and leave it there while the sun evaporates the water. What you get is salt, which you later process. That method requires good radiation and a large area. TAT developed a technology so that you can get the brine into a plant and this plant is not any bigger than 100 by 100 meters. Therefore, the footprint that you need is smaller. Secondly, all of the water that is processed in the end is reinjected into the ground and can be reused. These are the types of innovations that are needed to ensure the sustainability of operations in Chile.

**How is Tenova contributing to increasing tailings safety?**
Tenova developed technology to use dry stack tailing and now we are in a position where we filter or we use a thickener to filter and later on transport by conveyor, so that the deposit is close to dry material. This mitigates the risk of a dam collapse. Today's market is much more environmentally conscious.

**What are the biggest complications with desalination?**
Some of the major challenges are the differences in altitude from the sea up to Quebrada Blanca, and up to Collahuasi the difference is 4,300 meters. Plus you have to cross the Andes mountains, so it is a big investment and the opex is huge. There are no other possibilities, because if you do not have water you cannot operate.

**What are some of the clearest ways Tenova helps lower opex for clients?**
In Chile, some decisions are based on information that will not be made with all the testing needed to make an informed decision. A lot of money gets spent and often companies still do not reach their desired results. If a company spends US$2 billion and expects to produce 100,000 mt/y of copper, and after a couple of years it only produces 50,000 mt/y, they end up spending much more money than anticipated. Today, the investors analyse carefully all of the different aspects of an operation.

**How do community relations differ in Chile and Peru?**
The communities in Chile are not close to mine operations. Collahuasi and Quebrada Blanca are located at 4,200 meters of elevation and the communities surrounding are close to zero. In Peru, if you are in Quellaveco, the mine is underneath the river, and that river is used by farmers downstream. The distance between the community and the mine are much closer and the impact has the potential to be much more severe. If, for example, mining activities contaminated the water, it would undoubtedly affect farmers downstream. This is less of an issue in Chile. ■





# Eduardo Nilo

General Manager
**METSO CHILE**

**We made important acquisitions this year and this has given us strong growth and positioned us well for the future. We seek to increase and diversify the products and services we offer. Our growth plan has exceeded expectations.**

**What is the core focus of Metso in Chile and what products and services do you provide to the Chilean market?**
We have strong market share in mills, filtration and crushing products. In terms of services, we develop tailored engineering for our clients. We opened two equipment repair centers in Antofagasta and Arequipa a few years ago. There are two plants that manufacture the lining of the machines in the region and all underground crushing protections are provided by Metso.

**How do Metso´s products and services help facilitate greater operational efficiency?**
Our clients demand optimization from an economic standpoint and from a resource consumption perspective. The mining industry has increasingly focused on more sustainable and efficient projects in terms of energy and cost. We take these customer requirements seriously and develop new technology that solves these issues. One example, is our vertical mill, which manages to efficiently process minerals with 25% less energy. Metso has started to implement equipment that conserves energy and water in the filtering process. For this reason, we are developing new roller crusher technology that increases energy efficiency and serves a double bottom line in that is has great ecological impact and major economic value. Optimization processes are a critical factor in the price of copper production and generate benefits for the entire community. Metso is building a performance center that will improve processes and establish maximum efficiency through technology.

**When it comes to water and safety, how does Metso Chile see the opportunity in resource management?**
We are going to launch a new filtration product in Brazil that seeks high efficiency and greater water reuse. One of our challenges is that there is not much water available at the mines, and water resources in Chile in general are scarce. Companies have had to start using water desalination and they are looking closer at optimizing water consumption. Metso is looking for alternatives such as the use of mills that do not need water.

**How do you see the dynamics of the Chilean mining market moving forward?**
Metso is closely linked with the mining industry and the region has grown a lot in recent years. We have grown every year. Our business structure is based on equipment but also on services. Our development in services has been positive and we expect that to continue. We made important acquisitions this year and this has given us strong growth and positioned us well for the future. We seek to increase and diversify the products and services we offer. Our growth plan has exceeded expectations. The expectation next year is also very positive. The mining industry remains very stable.

**How does the acquisition of Outotec improve Metso's positioning in the market?**
Metso considers this to be a merging of capabilities more than an acquisition. Metso is very strong in the process of crushing and processing of dry minerals and Outotec is more focused on the wet processing segment of mining. This union makes a lot of sense and it allows us to combine equipment and processes. This is a very good way to grow. We like the natural growth we have had throughout the years, but this deal gives Metso even stronger positioning in the market.

**What does Metso want to achieve in the next two years and what are the biggest challenges you must overcome?**
We would like to solidify our positioning as the number one company in the coming years and continue to be validated by our customers. We want to introduce new products with new technology that allows us to continue developing our presence in the region. Chile is one of the most important mining regions.
One of our biggest challenges is having the right workforce to sustain the development and growth we are looking for. New products require training and we have a workforce of 3,000 in Chile, so we opened a training centre that has allowed us to develop and train our people locally. We seek the highest safety standards in our factories and in the technical personnel in the field and our aim is to continue to develop our people. ■

# Chris Knowles & Jean Pierre Mery V

CK: Global Marketing Manager
JP: General Manager
**MCLANAHAN**

CK

JP

**What is the history of McLanahan in Chile?**
**CK:** We selected Chile because it has a strong history in mining and minerals, good infrastructure and highly technically skilled workers. Also, Australia and Chile share a strong connection through their minerals technology, and there is a free trade agreement, which increases ease of doing business in the Chilean market. Growing our capability in Chile ultimately gives us a foothold into the Latin American region from which we could potentially expand to other countries.
**JP:** We serve the broader Latin American market. The idea is to produce equipment in Chile and that is our main challenge for the next two years. Since 2015, having our own service capability has meant that we can develop a direct sales model within the country that provides greater support to our customers both in Chile and in the broader region.

**Can you give us an example of how McLanahan's equipment is suitable for Chilean mining conditions?**
**CK:** We intend to grow McLanahan's dry processing brand recognition and it will be supported through low-cost manufacturing. Currently there is more opportunity in wet processing and our team in Chile has particular expertise in sampling and wet processing.
What is driving the demand for McLanahan's sampling systems in South America?
**JP:** The Chile team also has in-house capability for design and service. Having new focus on engineered for spec sampling systems has improved outcomes for clients. We distinguish ourselves by understanding the clients' processes and understanding the engineering design of how to put a sampling system together to an iso-spec.

**Can you elaborate on McLanahan's acquisition of Anaconda?**
**CK:** In minerals, every deposit is unique and has a different process to evaluate. The Anaconda acquisition can be valuable in places like Peru where you have many SME's that don't have the cash reserves that big players do. They are looking for things like in-pit mobile modular systems that allow them to get into their resource and deliver cash-flow and value. Or they have a smaller, more complicated reserve that does not lend itself to large infrastructure. So low cost modular track mounted equipment suits smaller players well.

**To what extent would you say Chilean mining companies are receptive to new technology?**
**CK:** Adoption of innovation and automation in Chile is a massively important topic. In our research we read a lot about Chile wanting to be lower cost in order to increase competitiveness. When we talk about automation, artificial intelligence, robotics, there really is not an option to not participate. Businesses will have to accept adoption as a cost of being in the marketplace.
Looking at the larger picture, the 4th industrial revolution will be about how we deliver greater productivity. That means lower energy, labor costs, much lower transport. This plays into electric instead of diesel trucks, robotics instead of humans, smart conveyers instead of trains and tracks. That plays right into where Chile wants to be as a low cost producer. They do not have an option not to go that way. Manufacturers must make sure we can deliver as many sensors as possible, as much condition monitoring technology as possible to be able to feed that into the market. They will not want to pay for this tech but, in order to be globally competitive, they will have to adopt these technologies.

**Do you have a final message for the audience of Global Business Reports and Expomin 2020?**
**JP:** McLanahan works together with customers at the beginning of a project. The company has extensive international experience in servicing the mining market, the best quality tools and equipment, as well as a competitive price point and top quality US and Australian manufacturing standards. McLanahan needs to build brand recognition in South America. Our key focus is to connect the Mclanahan brand strongly in Chile with the technological capabilities that the group possesses.
**CK:** You do not get to stay in this market unless you are capable of collaboration with your customers, unless you are able to support them closely, and unless you are bringing the newest and most cutting edge technology to the marketplace. ■





# José Oliva Peralta

General Manager
**MOTION METRICS**

**Can you give a brief overview of Motion Metrics and the company's operations in Chile?**
Motion Metrics specializes in developing advanced monitoring solutions designed to improve safety, efficiency, and productivity in the mining industry. Our Chile branch was Motion Metric's first satellite office and has helped the company to grow significantly.
Which of Motion Metrics' technologies are best suited for the Chilean market?
Motion Metric's missing tooth detection system has been in the market for quite some time, and the product is still in demand. We are known as the shovel dentists and the system can prevent crusher downtime by monitoring shovel teeth. Over the years, we have diversified our product portfolio and today our fragmentation analysis system which determines blast effectiveness in real-time is also in demand.

**How is Motion Metric's technology cost effective over time?**
Our solutions can save costs for our clients through missing tooth detection preventing crusher downtime or damage to conveyor belts; optimizing tooth change outs by monitoring tooth wear; preventing costly equipment collisions with proximity detection and blind spot reduction technologies; and maximizing productivity with bucket-by-bucket payload monitoring.

**Motion Metrics uses artificial neural networks rather than computer vision. Why is this method better for mining?**
Neural networks are algorithms consisting of millions of simple processing nodes. To train a network, each node is initialized to a random weight and data is passed through the network in one direction. The network output is then compared to a ground truth, and the weights are adjusted until the network closes the gap. Through this process, the network 'learns' to correctly label input data. With neural networks, you don't have to manually decide which features are important – the machine does the work for you. ■

# Carlos Carmona

General Manager South Cone
**HEXAGON MINING**

**What specific technologies does Hexagon Mining provide?**
Hexagon has five portfolios of business. A planning portfolio that focuses on integrated solutions for exploration, modeling, design and scheduling; an operations portfolio focused on fleet management and machine guidance; a safety portfolio with collision avoidance, vehicle intervention and fatigue monitoring technology; an enterprise portfolio that connects processes and converts data into real time information to support good decision making; and a survey and monitoring portfolio for slope monitoring and measurement solutions. In Chile, Hexagon's biggest focus is on fleets of mining equipment because that is where the large investments in Chile's mining sector are. We are mainly focused on providing smart solutions for trucks and support equipment.

**How does Hexagon Mining technology help lower costs and increase productivity?**
The difference between Hexagon Mining and other applied technology companies is that we are able to increase a companies productivity because of our ability to integrate a variety of different product suites into one single system. We seek to help companies occupy less machinery and use it efficiently by making the experience between operator and technology seamless. We deliver solutions that allow users to manage and control information, which ultimately leads to cost reductions.

**How is Hexagon Mining technology improving workers safety?**
We have anti-collision technologies and systems that prevent accidents caused by operator fatigue. Our technology also protects against blind spots and poor visibility conditions.

**What strategic goals does Hexagon Mining wish to achieve over the next two years?**
Hexagon's regional strategy is aggressive in terms of its growth targets for the coming years. We want to increase sales and position ourselves and our products as industry leaders. We plan to achieve this by consistently demonstrating successful outcomes proving the value of our technologies. Hexagon also needs to educate and develop the skills of those in mining so that people understand the importance of technology in improving an operations productivity, efficiency and safety. ■

# DRILLING AND BLASTING

**» The focus of the mining market since 2013 has been for majors to move toward improving efficiency and productivity and away from increasing reserves. Further- more, there has been little-to-no capital for greenfield exploration nor any appetite for it from a timeline and permitting perspective. The current trend is for compa- nies to do expansions of their existing operations. One of the ways in which the industry is confronting the problem of permitting and not being able to develop new projects is by drilling deeper at their existing operations. «**

**- Stephanie Ashton,**
**CFO and Corporate Development,**
**Griffith Drilling**

Image courtesy of Ministry of Mining

# Drilling

## BUILDING RESILIENT BUSINESSES THROUGH TOUGH TIMES

Copper runs through the veins of Chile and cities such as Antofagasta and Calama have risen out of the desert fuelled by exports of the red metal. Underlying Chile's success as a leading metals producer is a robust ecosystem of service providers. Drilling contractors are an essential element of achieving the country's high level of production. Consejo Minero estimates show 6,300 companies in Chile qualify as mining suppliers, with 25% headquartered in mining regions outside of Santiago. That inevitably means regional economic success is highly correlated with the price of copper and the performance of the industry's service businesses. In Antofagasta, mining contributes 54% of GDP, Tarapacá 37% and Atacama 38%, based off Chile's Central Bank data.

Unfortunately, when commodity cycles are in a down phase, service providers are susceptible to tightened margins, falling utilization rates and less ambitious planning for greenfield projects.

According to Stephanie Ashton, CFO of Griffith Drilling, a diamond drilling company capable of operating at 2,300m depths: "There has been little capital for greenfield exploration nor any appetite for it from a timeline and permitting perspective…. The current trend is for companies to do expansions of their existing operations. One of the ways in which the industry is confronting the problem of permitting and not being able to develop new projects is by drilling deeper at their existing operations."

Despite the lack of greenfield investment, Chile's service sector remains robust and continues to appeal to global operators. For example, Master Drilling, a company based in Australia, has been drilling at El Teniente for over 20 years. The company also has contracts at Chuquicamata underground and, as of 2019, the company had 14 rigs in operation in Chile, with a utilization rate of 65%. Christoff Janse of invest Chile pointed out: "Many of the big players in the mining sector have operations here and, from a supplier´s perspective, this means relative easy market entry by continuing business relationships already established elsewhere with their clients. "

Another positive for the industry is that Chile is upping its potential to become a logistical hub for service drilling. "Increasingly the country is becoming more connected internationally and regionally. There has been a sustained increase in flights linking Chile to neighboring countries and internally. From a

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# Stephanie Ashton

CFO and Corporate Development
**GRIFFITH DRILLING**

**What is the history of Griffith Drilling and what capabilities does it bring to the Chilean market?**

Griffith Drilling was established in 2011 and is a private diamond drilling company based in La Serena, Chile, with a branch in Mendoza, Argentina. Boyd Griffith, my co-founder, has worked in diamond drilling since the early 80s, first in Canada, and since 1991, in Chile . He came to Chile with a company called Connors Drilling. I come from the investment and financial side and have been involved in many junior mining companies and exploration operations. The best company I hired for drilling services while in Chile was Connors Drilling, and that is how I met Boyd. When the opportunity presented itself, it was a no brainer for me to invest in forming Griffith Drilling. Griffith has reproduced the Connors business model, which encompasses very high quality diamond drilling services. We are able to provide drilling services where other companies cannot, such as at high altitude, in complicated ground, and to 2300 m depths.

**How does Griffith Drilling help companies increase the efficiency and productivity of their operations?**

The focus of the mining market since 2013 has been for majors to move toward improving efficiency and productivity and away from increasing reserves. Furthermore, there has been little-to-no capital for greenfield exploration nor any appetite for it from a timeline and permitting perspective. The current trend is for companies to do expansions of their existing operations. One of the ways in which the industry is confronting the problem of permitting and not being able to develop new projects is by drilling deeper at their existing operations. Griffith Drilling is particularly good at assisting clients with hole completion and core recovery, and we drill to depths that clients require in order to expand their operations or justify an operation that is being developed. By being able to reach lower depths of exploration we expand the life of a project and this creates a better return on investment.

**Does Griffith Drilling see opportunity in other markets?**

There is a magic size for us in any one market and, once you get beyond that, you start losing your marginal benefit of adding more work and people. Our sweet spot is between 20 and 25 rigs in any one market. We thus have a plan to expand into other markets such as Peru, but only if there is a demand for the specific type of drilling we specialize in. We also like the North American region; permitting has been streamlined so that has opened up opportunity.

**Given the current market conditions, how has demand been for diamond drilling in Chile?**

In 2012, there were approximately 650 rigs in Chile, but this number has significantly decreased today. There was a small uptick and then a substantial drop in capital investment in 2018 and the demand for drilling has significantly fallen as a result. In 2019, we estimate that approximately 20% of total rigs available were operating in Chile.

**Is Griffith Drilling positive about the future and what is the company's vision moving forward in Chile?**

On the macroeconomic side, I am very optimistic for the future. Electrification of cars and energy renewable growth is an unstoppable wave and the transition will require a lot of metals. On the microeconomic side, there are some regulatory, labor and social challenges, which make operating in Chile more difficult. There is the trade war and all of this has contributed to a weak sector in the short term. A project that used to take 10 years from start to finish for a new mine is now taking 20 years, so we hope to see movement towards an improved streamlining of the process.

Looking toward the future, Griffith Drilling would like to grow to be a 25 rig company that provides both surface and underground drilling. We aim to continue delivering a very high quality of service to our clients and we want to be the drilling company of choice within the market. ■

# Jorge Maldonado & Osvaldo Carmona Morales

JM: General Manager
**SUPEREX**
OC: General Manager
**PERFOCHILE**

JM

OC

**What is the role of Superex and PerfoChile in the Chilean mining industry?**
**JM:** Superex and PerfoChile are separate companies but work as a team to promote the highest standards of operational excellence, safety and sustainability. We concentrate mostly on greenfield drilling, but we service a mix of different projects. Superex has a workshop in Coquimbo and PerfoChile has one in Antofagasta. We have worked closely with Anglo American for years here in Chile, along with many other customers, especially mid size companies and juniors. We are small but we are experts in drilling, so companies want to do business with us.

**How have political developments in Chile affected your business?**
**OC:** Regulations have hurt business activity in mining. PerfoChile is small but very strong and well managed. We have cash reserves to invest through good and bad economic and political climates.
**JM:** Four years of Michelle Bachelet was very difficult. During this time, clients left for more business friendly countries. Sometimes Chile forgets how vitally important a strong mining sector is to the health of its broader economy.

**What are some of the risks to the future growth of mining in Chile?**
**OC:** The Bachelet government changed the rules, which had served miners in Chile well in the past. She made Chile a less attractive place for investors because the policy for mining permits became legally ambiguous. This opened the doors for special interest groups to come in and lobby for reinterpretation of laws and some projects never even began. As a result, the uncertainty has been detrimental in attracting foreign investment in Chile.
**JM:** The rules are not clear. We do not have big communities in the north, but a few people are creating big problems for business. If we are giving permits, then the rules should be clear. Policy uncertainty discourages investment. Companies want to invest but the rules are not clear enough and the security situation is worsening. Rules and permits must be clear and not be influenced by politics. Mining is not political.

**How are you leading Superex and PerfoChile into the future?**
**OC:** PerfoChile has strong expertise in delivering geological samples that allow our clients to clearly analyze the mineral content. This encourages a more sensible strategy for extraction. In the future, regulations will force companies to be smaller in order to become more flexible. More specialization and automation are inevitable and business models need to change along with new technology. We intend to remain at the cutting edge.
**JM:** In the past, Chile was very attractive but now it is getting expensive. The future is unclear and could even be dark if policy does not adjust. I fear policy is becoming an impediment to growth in the Chilean mining sector. We are considering expansion into the US, but we will remain well positioned to capitalize on any upturn in the Chilean mining market. We are confident in our ability to drill in a variety of different projects.

**What advice would you give a foreign company coming to Chile to mine?**
**JM:** There is a light at the end of the tunnel. Companies can still do great with small projects, if they take care of communities and the environment. However, the bigger the footprint the bigger the problems. Today, there are few benefits for juniors trying to explore. That is why the Chilean market is so concentrated toward majors. Hopefully this will change.
**OC:** Medium size projects have less regulation, so there is an advantage in staying small. Chile can be a good place to invest, but companies should be careful with worker safety. Small footprint operations that are well controlled are the future in Chile. ■





Image courtesy of Hot Chili

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logistics point of view it has become attractive to set up a business here that serves as a hub for providing equipment and services to the region," said Janse.
One of the biggest drawbacks for service providers in Chile is that regulations are too tight and that cuts into profits. According to Jorge Maldonado, general manager of Superex, a provider of sonic and diamond drilling solutions: "The rules are not clear. We do not have big communities in the north, but a few people are creating big problems for business. In Dominga they have not been able to begin because of environmental regulations and community issues. If government is granting permits, then the rules should be clear."
Ashton of Griffith Drilling also pointed to policy issues complicating operations: "From a cost efficiency perspective, we have to comply with a significant number of standards, which has increased our operational costs over time. The same amount of work that we used to perform with three crews now requires four to meet the current labor regulations."
In 2012, there were approximately 650 rigs in Chile, but this number has significantly decreased today. There was a small uptick and then a substantial drop in capital investment in 2018 and the demand for drilling has significantly fallen as a result. Asthon continued: "In 2019, we estimate that approximately 20% of total rigs available were operating in Chile. Some of the projects we were supposed to be working on have been postponed due to a variety of issues including both community and market related. We see a lot of requests for bidding jobs, but it has yet to take off in 2019."
Fortunately for companies like Griffith Drilling, Superex and PerfoChile, they possess capabilities that allow them to operate in many of the difficult, far flung areas in which much mining project development is planed over the next decade. Griffith offers diamond drilling services, where many other companies cannot, such as at high altitude, in complicated ground, and to 2300m depths. By being able to reach lower depths of exploration these companies expand the life of a project and create a better return on investment.

# Blasting

## PRECISION AND SUSTAINABILITY DRIVE THE MARKET

The market for blasting services is highly competitive in Chile and this competition is producing some of the most cutting edge technology in the business. Maxam, Plasma 4th, Enaex, Dyno Nobel and Orica all are all developing products that make blasting safer, more efficient and more environmentally friendly. By investing in the appropriate explosives, the way these explosives are positioned and stabilized, the accuracy of the blastholes drilled and the detonation procedure, companies can make a material difference to their bottom line.

As energy costs are high in Chile, one way to save energy is by blasting more and crushing and grinding less. Effective blasting will ultimately lead to reductions in feed size before primary crushing, therefore increasing throughput and reducing the energy required for comminution. Blasting is the most cost efficient means for ore size reduction. If companies design a blast pattern that maximizes the use of cheap chemical energy in a safe manner, it will have significant impact on the electrical energy required to complete the size reduction process.

Angello Passalacqua, business manager of Dyno Nobel Chile, sums up this realization in saying: "Great benefits can be obtained by adopting new technologies especially given the increase in the cost of labor, inputs and the variability in the price of commodities." He continued: "There is a huge opportunity to improve the drilling and fragmentation processes, minimize exposure of people involved and reduce the amount of equipment used. Optimization of the process of blasting, fragmentation, transport, grinding and supply of the plant can lead to huge cost savings."

This savings opportunity was the driving force behind the development of Dyno Nobel's differential energy technology, which ensures customers deliver the right amount of energy to different layers of rock within a blast. This produces better fragmentation, thus reducing the overall mining cost. In Chile the company currently has a production plant where it manufactures initiation systems and will soon add bulk explosives. It will also finish the construction of a new matrix manufacturing plant in 2020.

Maxam is also investing heavily in new technologies that will optimize the blasting process. The company has performed a significant portion of the blasting at BHP's Escondida, and recently invested approximately US$30 million in expanding its capabilities to serve the Chilean market. In 2019, the company was selected by Lomas Bayas, an open-cast copper mine in Chile operated by Glencore, to provide its bulk explosive, Rioflex, along with other solutions. "This product is sensitized on site and is flexible enough to be produced in multiple densities, so we are able to adapt blasting solutions to different rock types."

In addition, Maxam has developed a blasting modeling and simulation software, Rioblast. "This is technology that can be integrated with our loading equipment and allow us to pump the right quantities of product and deliver the right blast. Hazards and inaccuracies are therefore minimized," said Maxam's director of Latin America, Diego Rodriguez Christensen.

2020 will be an important year for blasting companies because there are several big tenders on the horizon. According to Passalacqua: "There is an opportunity to participate in different projects that represent more than 20% of the explosives market.

### Beyond Blasting

While some companies are focused on optimizing the results of blasting, Plasma 4th, a subsidiary of Enaex, is focused on eliminating the need for blasting altogether. Francisco Portilla, general manager of Plasma 4th, noted that the benefits of plasma are far reaching. Blasting is often unpopular with nearby communities and is also considered harmful to the environment. Portilla said: "To develop a project near a community, you need technologies that are minimally invasive. Blasting creates a lot of pollution, a lot of noise and a lot of vibration. Often this can lead to resistance from communities and the risk of a project being blocked."

In order for any new technology to be adapted, however, the product must be cost effective. Portilla noted that one kilogram of plasma is more expensive than one kilogram of explosives. However, there are other costs to consider. These include community resistance to blasting and the high cost of evacuating the mining site when blasts occur. With Plasma 4th technology, only those within a 150 meter radius of the fracture are required to be evacuated. This guarantees operational continuity and limits downtime.

### Conclusion

There is no denying that Chile's mining service industry is one of the most dynamic in the world. The sector is full of entrepreneurial local businesses competing with well established global firms for contracts. The service workforce is well educated and qualified and, for these reasons, Chile has been able to reach record production levels, despite the maturity of its market. 2019 has been a year that began with great optimism that new investments would be pushed forward and suppliers would benefit from higher margins. However, uncertainty around the global macroeconomic climate and political chaos at home caused projects to dry up. As a result, the market for services remains extremely competitive, with companies lowering their hourly rates and operating on low margins in order to keep from shedding staff.

In spite of this years' struggles, much optimism remains surrounding opportunities that may come from the country's substantial project portfolio. There are still billions of dollars of investments coming online in the next few years that will keep demand for services strong. Regardless of fluctuations in markets and politics, Chile's mining service providers have proven their resilience and are built to weather turbulent market conditions. ■

# Angello Passalacqua

Business Manager
**DYNO NOBEL**

**What is the history of Dyno Nobel and what capabilities do you bring to the Chilean market?**
Dyno Nobel is one of the largest explosives companies in the world. We were founded by Alfred Nobel and we have a 150 year history of innovation in explosives. Dyno Nobel has a presence on all continents, and currently Chile is our hub for Latin America. Dyno Nobel Chile was acquired by Orica in 2006. Eventually in 2010, Dyno Nobel returned to Latin American and installed a plant for electronic initiation systems in Coquimbo. Dyno Nobel is the only company that offers a full suite of products and services associated with blasting. Dyno Nobel owns several companies, such as Tradestar Corporation, which produces mobile production equipment; Detnet South Africa, which participates in the manufacturing of electronic detonators, and DynoConsult that provides technical advisory services. Our business is devoted to improving efficiency and productivity in all aspects of the blasting process for clients.

**What is Dyno Nobel's strategy for the Chilean market?**
We work with initiation systems, but we also want to provide blasting services, implement the sale of bulk explosives and grow our technical assistance capacity in order to optimize processes within mining.
Currently we have a production plant where we manufacture initiation systems, and we are planning to add bulk explosives. We also manufacture emulsion to implement new technologies such as differential energy, a new product we created and refer to as Delta E. We are currently finishing construction on a new explosives manufacturing plant and plan to open it in 2020.

**How is Dyno Nobel competing in the current market and growing its market share?**
Dyno Nobel has a 15% market share in the initiation systems business. We expect to grow within the next few years by a constant rate annually in the explosives market. We are active participants in all bidding processes in the explosives market today, and the tender of several mining companies is about to begin, so there is an opportunity to participate in different projects that represent more than 20% of the explosives market. Our market share in Chile is around 1% and Dyno Nobel is determined to expand rapidly moving forward.

**What are Dyno Nobel's biggest advancements in innovation today?**
The main technology we are working on right now is called Differential Energy. Delta E ensures customers deliver the right amount of energy to different layers of rock within a blast, producing better fragmentation and reducing the overall mining cost for the customer. Customers using Delta E have benefited from increased safety, significantly reduced mining costs, and a reduced environmental impact. This product also works in a variety of mine conditions: hard rock, soft rock, buffer blasting, holes with water, dry holes, reactive ground and hot holes.
Another one of our technologies is the Commander System to program and shotfire our electronic detonators Digishot Plus 4G. This technology is being implemented in Chile and it increases the programming speed of the detonators by seven times together with a friendly operative system.
In addition, during 2019, Dyno Nobel released the EZshot. This Nonel initiation system gives the customer the ability to use electronic precision for improved perimeter control, helping them to increase safety, save even more time and lower overall production costs. Furthermore, EZshot does not require new training, allowing the customer to quickly move forward on all projects.

**What is the biggest area of opportunity for Dyno Nobel today?**
There is a great opportunity to minimize environmental impact, improve the drilling and blasting processes, increase the safety minimizing the exposure of people on the field and reduce the amount of equipment used.

**What goals does Dyno Nobel wish to achieve in the next two years?**
We seek to implement Differential Energy Technology and the Digishot Plus 4G Commander System in Chile. In order to achieve that, we have to build the trust of our customers and make them understand that they will see outstanding benefits. Our goal is not to compete in terms of price, but rather to demonstrate that our products generate the most value in the short term. Another goal of ours is to continue diversifying our workforce. Currently women make up 38% of our operations and we intend to continue growing this number. ■





# Francisco Portilla

General Manager
**PLASMA 4TH**

**What is the science behind Plasma 4th's cutting edge technology?**
Our product is made up of a mix of metallic salts and the rock fracturing process is initiated by equipment that accumulates 4,000 volts of electricity. That electricity goes into cartridges wherein each cartridge has an initiator that creates a spark, and that spark creates a reaction. This process is called ionization and it produces a very high temperature. Then, because of the high temperature and the expansion of the gases, we are able to break the rock.

**In terms of environmental impact, how is Plasma 4th's non-explosive technique an improvement over traditional blasting methods?**
Gas emissions are far less than with normal explosives. Also, Plasma 4th technology produces close to zero waste. Lastly, our technology is 80% quieter than traditional blasting methods. Often mines are located very close to communities, so we offer a solution that can improve community relations by lessening the environmental impact of mining.
To develop a project near a community you need to use technologies that are minimally invasive. If you are blasting near a community it creates a lot of pollution, a lot of noise and a lot of vibration. Often this can lead to resistance from communities and the risk of a project being blocked. With Plasma 4th, anyone more that 200 meters away will not even hear a blast go off.

**How reliable and cost effective is Plasma 4th's product?**
So far, we have three million cubic meters of experience with no accidents and zero misfires. We have consistently executed at a very high standard, so Plasma 4th is proving to be extremely reliable.
In terms of cost effectiveness, a kg of plasma is more expensive than a kg of explosives. However, companies that use our technology don't just focus on the cost per kg. There are other costs to consider in the equation. These include community resistance due to the negative effects of blasting, and the high cost of evacuating the mining site when blasts occur. With Plasma 4th you only evacuate 150 meters. This guarantees operational continuity and limits downtime, which leads to cost savings in the long term. We are undoubtedly the cheaper option when you take into consideration the side effects of blasting.

**What is Plasma 4th's growth strategy?**
Currently we are certified as a non-explosive product in seven countries: Chile, Peru, Brazil, Colombia, Argentina and most recently India and South Africa. The next three countries that we initiated the permitting process in are Mexico, Australia and France. We are prioritizing countries where ENAEX is already present so we can leverage that position in order to grow faster and on a bigger scale.

**How receptive has the Chilean market been to Plasma 4th's product?**
In the beginning, it was very difficult, but because strong community relations are so important to the success of mining projects, slowly we have been penetrating the market. Now we are working with Inco, which has one of the biggest mine expansion projects in Chile, and also with Amsa, which is another large project where our product is being used. They chose Plasma 4th specifically because they had concerns over their projects being blocked and they knew our product would improve their chances of getting approval.

**What is Plasma 2.0? How will this phase in your development help Plasma 4th achieve its long-term goals?**
Plasma 2.0 is the next phase in our development and it means that we need to develop our technology so that we can be helpful in a broader range of scenarios. Plasma 2.0 is about proving that plasma is a better choice for most of the mining tasks that in the past required blasting. We want to be involved in full production, and for that we need to be more cost effective. Plasma 4th has a vision to become the leading rock fracture company in the world using non-explosive technologies. We have a unique solution for mining and it should be implemented around the world. Our technology is an important part of a mining future that is more socially and environmentally sustainable. We can achieve this while still remaining cost effective and productive. ■

# Marco Ruiz

Manager
**ENAEX ROBOTICS**

**Why was there a need for ENAEX to establish a strong robotics presence?**
In 2014, ENAEX saw new challenges in the mining industry where robotics and automation were going to play an important role in the future. Increasingly, mines could not operate in some areas and were limited in their ability to expand or proceed with operations because the environment was deemed too risky, sensitive or harmful for workers. To tackle this challenge we partnered with institutions like SRI (Stanford Research Institute) and together we created RobominerR with the skills needed to assemble the explosives, the Mine-iTruckR an automatized MMU (mobile manufacturing unit) that could manufactures 20 mt of explosives on site, without people on board.

**How far along is Robominer in its development?**
Robominer is currently being used in mining operations. In 2019 we performed the first fully remote blast in the world in a mine and the system is now fully approved and operative. The next phase of development for Robominer is focused on boosting its ability to generate more productive outcomes for clients. Because our technology eliminates the need for humans in the field, companies have the option to operate in new ways, for example the loading of explosives at night. Currently no mine in Chile does this. However, there is great potential for productivity gains if technology can be put to work overnight. Another example is the interoperability with the drilling process. Normally both processes are isolated, but technology enables a safe and coordinated operation where you can work collaboratively and move at a much quicker pace.

**What is needed in order for robotics to fundamentally shift the economics of mining?**
The biggest challenge is making robots more productive than humans and to accomplish that, we must improve their effectiveness and speed through automation and artificial intelligence. When the technology develops to the point where robots can take autonomous decisions in field it will be extremely beneficial for improving productivity for a company's operations. ■







# Patricio Picero

General Manager
**ORICA CHILE**

**What are the biggest Challenge mining companies face today and how does Orica help solve these challenges?**
The mining industry is faced with a number of challenges today such as low commodity prices and increased regulation. In the current environment, companies must improve in areas of profitability and efficiency. Orica is helping companies solve some of these challenges by bringing wireless initiation and automation of drill and blast to the market. We believe this has the potential to greatly improve safety and profitability for companies. Orica is also working on an integrated information platform for real time decision making. This allows the entire process of drilling and blasting to be viewed online.

**How are you innovating?**
Throughout its history, Orica has been a visionary company that has adapted to changes in the market. We are currently adapting again as we transform ourselves from an explosives and mining services company into a leading technological innovation company.

**Orica recently introduced BlastIQ and SHOTPlus technology. What are the benefits of these products?**
We have been very successful in the implementation of these technologies. We have incorporated BlastIQ into the process of many of our clients, and feedback from them has been supportive. BlastIQ is a cloud solution that provides real time information on drilling and blasting. This information allows users to plan, make decisions and monitor the entire process. This integration will generate a lot of value once clients adopt this system. It has been very well received in Latin America, especially in Chile.

**What are Orica´s goals for 2020?**
Particularly in Chile, Orica wants to maintain and grow its contract base. There are many bidding processes occurring in 2020, so there is ample opportunity to grow. Orica will continue to advance technology. Orica is undergoing a global transformation to standardize our processes, systems and organizational structures in such a way that we are able to deliver the same quality of service globally. ■

# Diego Rodríguez Christensen

Director of Latin America
**MAXAM**

**Can you give an overview of MAXAM and the services the company offers to the Chilean market?**
MAXAM is a global technology firm which specializes in energetic materials and blasting solutions. The company was founded in 1872 in Spain by Alfred Nobel. Today we have a physical presence in 50 countries and distribute our products to approximately 100 countries worldwide. We have been operating in Chile for approximately 10 years, but have significantly expanded our footprint in the country over the last three years. Our main customer is Escondida/ BHP. Our Chilean office has grown from 50 people to approximately 260 people. The Chile office is our headquarters for Latin America, from which we serve operations in Chile, Peru, Bolivia, and Panama.

**MAXAM is known for its innovative technology. Can you give an overview of the company's key products?**
New tools backed by emerging digital technologies integrated across the mining process are driving mines to be more sustainable and better able to withstand volatile prices while reducing their impact on the environment. Among our portfolio, we account for the highest energy bulk explosive in the market, Rioflex. This product is sensitized on site and is flexible enough to be produced in multiple densities, so we are able to adapt blasting solutions to different rock types. In addition, we have developed a blasting modelling and simulation software, Rioblast. This technology can be integrated with our loading equipment and allow us to pump the right quantities of product and deliver the right blast. Hazards and inaccuracies are therefore minimized. ■

"Copper in Chile is a very important material. However, we must not lose sight of the opportunity in lithium, because Chile has the largest lithium deposit in the world. Lithium has been in great demand in recent years, and this demand should grow exponentially as the demand for electric vehicle grows."

**- Abel Villafuerte Rozas,**
**Commercial Manager,**
**Haug**

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"In Chile, there is demand for pumps that can tolerate very aggressive fluids and thus special materials are required. We also have the task to make operations more efficient and digitized so that the pumps can be remotely controlled from anywhere. Factories in Chile demand pumps that have a higher head capacity, as mines are deep and need very high heads for pumping."

**- Alejandro Abud,**
**Country Manager Water Solutions,**
**Xylem**

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"We are generally encouraged to design projects which require less manpower for construction as the high altitudes and complexity of mine sites, make the working environment very challenging. Many times, we have to rely on pre-cast solutions where equipment is fabricated on site."

**- Víctor Contreras Cordano,**
**CEO,**
**Pares y Alvarez**

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"I lived in Peru and my experience was that the environmental regulations and permitting process is more difficult there than it is in Chile. Because the Chilean mining industry is starting to move more underground, I believe that environmental problems will be easier to avoid."

**- Fernando Vivanco,**
**General Manager,**
**Master Drilling Chile**

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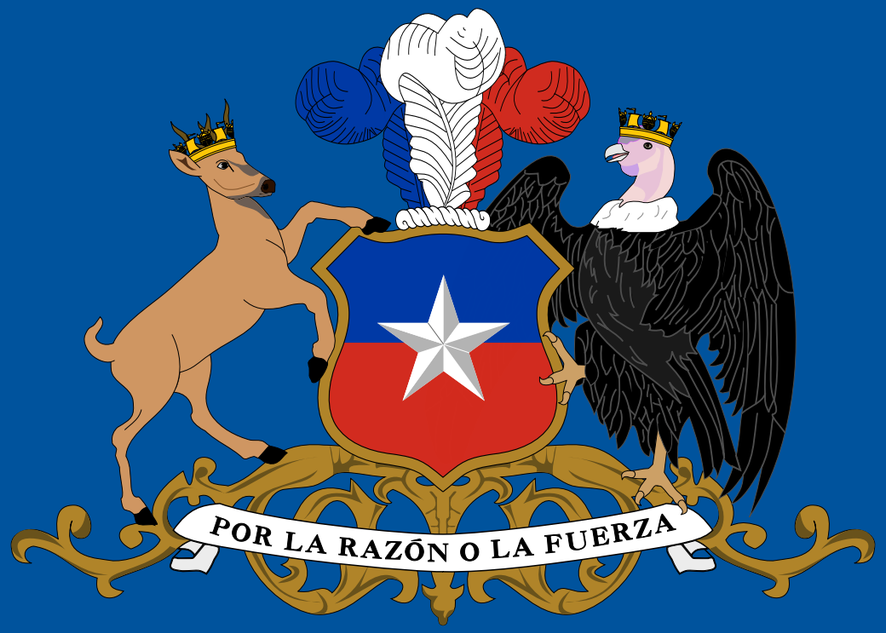
"At Codelco's El Salvador mine, the main site was expanded and they had to remove and demolish a lot of elements of the mine in order to execute their expansion. In Chile there are some very old structures and demolition can pose a big safety risk. There aren't many companies that have the ability to execute demolition of these structures with the safety and efficiency."

**- Michel Chait,**
**General Manager,**
**Flesan Minería**




"There are many regulations and standards mining companies need to adhere to concerning waste, if they want operational permits. The requirements today are much more demanding than what they were in the past, in this day in age the mining industry has to be a lot more sustainable and this poses a great challenge for the mining industry."

**- Matías Lagos,**
**General Manager,**
**Grupo Disal (Chile, Perú, Paraguay)**

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"We have been based in Australia for 50 years, but South America has amazing potential. We work all over the world, but here the mining market is strong and we believe South America offers the greatest opportunities for growth. Within Chile specifically, we see a lot of room for growth from traditional minerals such as copper."

**- John Hofmann,**
**Executive Director,**
**Hofmann Engineering**

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"The Chilean mining industry is facing many challenges. Production capacity is stagnating, and cost of production is too high, due to different factors such as electricity cost, salaries, work force capabilities, innovations and improvements. Industry must work improve quality of life and environment through the use of technology in energy management."

**- Raúl Toro,**
**Sales and Marketing Manager,**
**Eaton**

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"We are in the process of defining three scenarios for demand in the future – realistic, pessimistic and optimistic. If the political situation in Chile is solved and stabilized, we will lean more towards our optimistic view, as we believe that investment into the mining industry will then grow. From a realistic viewpoint, there are many mining companies that would have to renew their contracts, which will lead to new contracts and new sales. My realistic expectation for the future is that we will sell equipment in the mining market , but these sales will be for renewals of brownfield projects, rather than new fleet sales for greenfield projects."

**- Alejandro Miranda,**
**General Manager,**
**Doosan Bobcat Chile**

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"In times when the commodity price is low, our customers look to us to provide chemical solutions to improve the efficiency of their process and lower cost of production. In contrast, when commodity prices are high, that behavior changes, and businesses want us to find solutions that increase throughput and production. We still try to be as efficient as possible, but the main priority is increasing production."

**- Ricardo Capanema,**
**Global Marketing Director,**
**Solvay**

| COMPANY/ INSTITUTION | WEBSITE |
|---|---|
| Abraplata | abraplata.com |
| Albemarle | albemarle.com |
| ALS | alsglobal.com |
| American Air | americanair.cl |
| AMPHOS 21 | amphos21.com |
| AngloAmerican | angloamerican.com |
| Antofagasta Minerals | aminerals.cl |
| Aprimin | aprimin.cl |
| Arcadis | arcadis.com |
| Barrick | barrick.com |
| Becker Mining | becker-mining.com |
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| Bertling | bertling.com |
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| Black & Veatch | bv.com |
| BOSCH | bosch.cl |
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| Codelco | codelco.com |
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| DISAL | disal.cl |
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| DSI UNDERGROUND | dsiunderground.com |
| Dyno nobel | dynonobel.com |
| EATON | eaton.com |
| eBooting | ebooting.com |
| Echeverría Izquierdo | ei.cl |
| EMERSON | emerson.com |
| Enaex Robotics | enaex.com |
| Enngie | engie.cl |
| Epiroc | epiroc.com |
| ERAL | eralchile.com |
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| Fordia | fordia.com |
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| Gold Fields | goldfields.com |
| Griffith Drilling | griffith-drilling.com |
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| Haug | haug.com |
| Haver & Boecker | haverboecker.com |
| Herrenknecht | herrenknecht.com |
| Hexagon Mining | hexagonmining.com |
| HighService Corp | highservice.com |
| Hofmann Engineering | hofmannengineering.com |
| Hot Chili | hotchili.net.au |
| ICP Ingenieria | icpingenieria.cl |
| IIMCh | iimch.cl |
| Ingenalse | ingenalse.cl |
| Ingetrol | ingetrolcorp.com |
| InvestChile | investchile.gob.cl |
| JRI | jri.cl |
| KGHM | kghm.com |
| Kinross | kinros.com |
| Komatsu | komatsulatinoamerica.com |
| Kura Minerals | kuraminerals.com |
| Liebherr | liebherr.com |
| Los Andes Copper | losandescopper.com |
| Lundin Mining | lundinmining.com |
| Mantos Copper | mantoscopper.org |
| Mas Errázuriz | maserrazuriz.cl |
| Master Drilling | mastedrilling.com |
| Maxam | maxamcorp.com |
| McLanahan Corporation | mclanahan.com |
| Metso | metso.com |
| Michelin | michelin.com |
| Mineria Activa | mineriactiva.com |
| Motion Metrics | motionmetrics.com |
| Normet | normet.com |
| OHL | ohl.es |
| Orica Mining | orica.com |
| Outotec | outotec.com |
| Páres y Álvarez | pya.cl |
| Perfochile | perfochile.cl |
| Plasma 4th | plasma4th.com |
| POLPAICO | polpaico.cl |
| Revelo Resources | reveloresources.com |
| RIO 2 | rio2.com |
| Rio Tinto | riotinto.com |
| Salfa Maquinarias | salfa.cl |
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| STANTEC | stantec.com |
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| Wealth Minerals | wealthminerals.com |
| Wood | woodplc.com |
| Worley | worleyparsons.com |
| Xylem | xylem.com |
| Yamana Gold | yamana.com |

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