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GBR GLOBAL BUSINESS REPORTS

Mining in Peru

Adding new capacity in copper

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This report was researched and prepared by Global Business Reports (www.gbreports.com) for Engineering & Mining Journal.

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Cover photo: Quellaveco camp, courtesy of Anglo American.

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A Healthy Industry Survives the Political Shake-ups

While the Odebrecht scandal keeps adding new chapters to the saga, Peru's mining sector sees a fresh wave of investment

Quellaveco will yield 330,000 mt/y of copper during the first five years of production. Photo courtesy of Anglo American.

On April 17, 2019, Peruvian citizens were shocked by a disturbing piece of news as they were having breakfast or heading to work. Former president Alan García, who ran the country during two mandates (1985-1990 and 2006-2010), had shot himself as agents arrived at his home to put him in preliminary detention, in the context of a corruption investigation linking García with Brazilian construction firm Odebrecht. García was rushed to the hospital, but his death was confirmed later that morning.

García's death served as the dramatic climax to a series of events that saw Peru's last four presidents all involved in the *Lava Jato* corruption scandal and accused of a variety of charges, from Alejandro Toledo (2001-2006) to Pedro Pablo Kuczynski ('PPK', 2016-2018). Indeed, current president Martín Vizcarra only became head of state because he was the vice-president when PPK decided to resign in March 2018.

Such levels of political and judicial turmoil are bound to have an impact on any country's economic well-being; indeed, these developments have seriously affected the construction segment and put to a halt a wide range of badly needed infrastructure projects in Peru. Yet, there was a silver lining: as political leaders across the spectrum fell into disgrace, the mining industry pushed ahead with significant projects, empowered by better commodity prices and a breaking point in the mining cycle.

2018 brought three significant pieces of good news to the industry in Peru: the US$1.3 billion expansion project at the Toromocho copper mine, operated by Chinalco; the start of construction of Mina Justa, a US$1.6 billion copper project; and the final green light by Anglo American to build the US$5.3 billion Quellaveco copper operation. On top of these ongoing investments, Southern Copper completed its US$1.3 billion expansion at its Toquepala copper unit, and Chinese miner Shougang completed the expansion of its Marcona iron ore operation mid-2018.

To put these figures into perspective, total mining investment amounted to US$4.95 billion in 2018, according to the Ministry of Energy and Mines (MEM). This represents close to a 26% increase from the US$3.93 billion invested in 2017. While official estimates for 2019 are around US$6 billion, these amounts still lag behind the record investment figures of the super-cycle period between 2011 and 2015, when the annual average was US$8.4 billion.

Realizing the Country's Potential

While no one expects another super-cycle, an old theme persists: Peru could fare much better in terms of project development. Luis Rivera, president of the Peruvian Institute of Mining Engineers (IIMP), pointed to Peru's enormous geological potential: "Peru is a relatively large country with 1.3 million square km, but it is small if compared to continent countries like Canada, the United States or Australia; yet, Peru has all the metals that are important to the industry. What we do not have is political stability. If Peru could develop projects like Tía María, for instance, we would have double the investors; we would be even more attractive than Canada," he suggested.

In any case, the global mining market is moving. Peru doubled its copper production in just a decade between 2007 and 2016, positioning itself as the world's second largest producer after Chile, and the country continues to host a very promising pipeline of copper projects. Furthermore, major gold companies have entered a new wave of mergers and acquisitions, led by the Barrick-Randgold and the Newmont-Goldcorp consolidations. Peru is the sixth largest gold producer according to the United States Geological Survey (USGS, 2018 data). While the country's main international gold producers are beginning to wind down (Yanacocha has entered a new phase with the Quecher Main project, and Barrick is exhausting its in-pit oxide reserves this year at Lagunas Norte), Peru has actually moved up to fifth place in terms of reserves according to the USGS, reiterating the fact that the country's geology is not under question – Peru only needs to promote an environment that is business-friendly to recognize its full potential.

Creating Clusters

Looking at the future of copper production, Peru intends more multi-billion dollar investments to catch up with the red metal leader, Chile. Pablo de la Flor, executive director of the National Society of Mining, Petroleum and Energy (SNMPE), noted that Peru has a portfolio comprising of 48 projects worth US$60 billion in future investment, and half of these projects are in copper: "If you look at the main 20 copper producing mines in the world today, only four of them started in the 21st century. So, Peru has the potential to bring new capacity at very competitive costs, in a context where older mines are becoming more expensive," he said.

While Peru is probably a couple of decades behind in its mining development when compared to Chile, this can be seen as an opportunity: the country has the chance to start new mines with the latest technology to assure the lowest cost per pound of copper produced. Additionally, labor and power costs in Peru are more competitive than in Chile.

A main objective ahead is the creation of mining clusters and a move in this direction has already been taking place in the Arequipa region as a result of the large copper production coming out of southern Peru. Luis Rivera, president of IIMP, elaborated on the factors underpinning this region's success: "There is already a natural mining cluster in Arequipa: Matarani is the largest port in the world for mineral concentrates, handling 6 million tonnes annually (mt/y), while the port of Mollendo is critical to receiving inputs for mining operations. Meanwhile, the pampas of Uchumayo, Majes and La Joya are transforming into industrial service hubs for the mining sector."

While there has been great progress in the south, there is room for more industry integration in the area with the development of the large Las Bambas copper district in Apurimac. Additionally, at the other end of the country in the north, some industry leaders see an opportunity to go one step further and have several large copper projects in the area share actual operations infrastructure: for instance, a tailings dam, processing plant or concentrate pipeline.

"In the north we have Michiquillay, Galeno, Conga, Yanacocha's sulphides, La Granja, Tantahuatay and Cerro Corona," explained Carlos Gálvez, former president of SNMPE and current president of the organizing committee of PERUMIN, the country's main mining conference and exhibition. "To develop all these projects, we cannot look at them as isolated endeavors; we need to consider the wider picture with an optimized plan, making the most of new technologies," he affirmed.

For this to happen, the State needs to play a key role in coordinating the different projects, developing the underlying infrastructure and collaborating with the industry on a sustainable development plan, bearing in mind that most mineral deposits in Peru are located in remote and economically underdeveloped districts.

Suresh Vadnagra, president of Minera Las Bambas, the country's third largest copper producer, gave his view on the matter, reflecting on his experience in the remote district of Apurimac where Las Bambas operates: "What needs to come first: The

infrastructure that incentivizes the mining projects, or the mining projects that support the development of the infrastructure? It is a catch-22 situation. Whatever way we look at it, significant coordination between the various parties is required."

Working the Political and Social Aspects

In Peru, the level of conflict between the mining industry and anti-mining activists has eased with respect to past confrontations, such as those that paralyzed the Conga project in Cajamarca and the Tía María project in Arequipa. Yet, while Quellaveco and Mina Justa have successfully moved into the construction stage, the aforementioned projects remain on stand-by. Southern Copper spokesmen regularly state their eagerness to put the US$1.4 billion Tía María project into production as soon as possible, but Newmont seems to have abandoned Conga until further notice.

Across Peru, the industry should be careful to build good relations with the new regional governors elected in October 2018, particularly in the Puno region, where Walter Aduviri was elected as governor. Back in 2011, Aduviri led violent protests that ended with six deaths and he is now on trial for this case. Following this violence, Bear Creek Mining lost its concession for the Santa Ana project. Today, Bear Creek is still in Puno with another silver project, Corani, which is expected to move to the construction phase soon.


Luis Rivera, president, IIMP.

Since the Santa Ana issue, Bear Creek has undertaken an intensive community program around Corani with a strong focus on local innovation and entrepreneurship. For Andrés Franco, VP of corporate development at Bear Creek, the idea is to elevate academic levels so that the community can participate in a new dynamic economy, rather than become providers of the future mine. "We want the communities to become ideal neighbors for a mining operation, and the solution is not for them to work in the mine, but to be able to develop solutions to the region's main challenges to achieve sustainable development."

As part of this process, Bear Creek has developed more than 100 inventions using local products, including new construction materials, zinc-rich sun block cream, anti-bacterial alpaca fiber with silver and a new immunoglobuline that has dramatically reduced the previously high rate of alpaca death at birth. Franco assures that the communities of Chacaconiza and Quelcaya unanimously supported the project, so political questions at the regional level should not be an obstacle for development. Rather, financing the US$585 million capex in a context of low silver prices appears to be the greater challenge.

Puno is not the only region where tough questions about mining development are being raised. While the new governor of Cajamarca, Mesías Guevara, is not an outspoken opponent of mining like his predecessor Gregorio Santos, he is not likely to push ahead any mining projects that could raise controversy. In the south, the new governor of Arequipa, Elmer Cáceres, has shown opposition to the Tía María copper project.

"Regional and local elections bring a new scenario, and companies *(continues on page 6)*

"The conflict at Las Bambas' corridor was not caused by opposition to mining activity or investment"

Francisco Ísmodes, minister of Energy and Mines, Government of Peru

Could you describe your government's vision for mining development in Peru until 2030?

In January 2019 we unveiled our "Vision of Mining in Peru to 2030," which prioritizes seven lines of action, the first being the need to build up capacities in the regional and local governments. The second is the promotion of a modern legal framework that will favor exploration efforts. Another important issue is the development of clusters: for instance, last year CAF, a regional development bank, signed an agreement with the Chamber of Commerce and Industry of Arequipa to promote sustainability and boost competitiveness in southern Peru.

The other prioritized lines of action are: the promotion of best water management practices; a push for research, development and innovation throughout the whole value chain; the implementation of a wide-reaching plan for the eradication of illegal mining; and the execution of a pilot plan to ensure spaces for permanent multi-actor articulation.

Do you expect total mining investment in Peru to increase this year?

Preliminary data as of April 2019 show that private investment in mining totaled US$1.62 billion, which represents 31.2% more than in the same period of 2018. Quellaveco, Mina Justa and the expansion of Toromocho together represent approximately 35% of that amount. The increase in investment is a reflection of the greater dynamism we are seeing in the sector.

After Quellaveco and Mina Justa, do you think Tía María can move to the construction stage?

Tía María is a project prioritized by the Government that is waiting for the final authorization to begin construction. [Note of the editor: Tía María was granted its final construction permit on July 8, 2019.] We are aware of the need to obtain greater social acceptance towards mining investment in the Tambo valley. To this end, we will implement a comprehensive development strategy based on public-private investment, including water and sanitation projects, improvements in healthcare provision, the modernization of irrigation systems and water consolidation works in the Tambo basin. The idea is to solve the water shortage in the area, which is the main concern of the people.

What lessons has the country learned from the conflict at Las Bambas' concentrate corridor earlier this year?

The conflict was not caused by opposition to mining activity or to private investment. It was the result of a lack of resolution to previous claims and the intervention of third parties stirred up the conflict. Currently, the Government is present in the area and is strongly committed to dialogue as a tool to reach definitive agreements. In spite of the tension experienced at Fundo Yavi Yavi and in other portions of the corridor, we have managed to strengthen dialogue. This will allow us to reach a consensus on how regional development can meet the needs and expectations of the communities.

Exploration activity decreased by 15% in Peru in 2018. What can be done to improve this?

Peru continues to be one of the main destinations for exploration investment. Currently we have 26 projects underway for a total investment of US$239.2 million; there are another 10 that are about to begin, having received the respective authorization (approximate investment: US$94 million); and a group of 23 initiatives are completing their procedures (approximate investment: US$231.2 million). By 2021, it is expected that these 59 exploration projects, which are located in 17 regions of the country, will be underway. Overall, we maintain our objective of capturing 8% of global investments in exploration for 2021. We currently receive 6.4%, and we are working on initiatives to facilitate the development of new exploration campaigns and the arrival of more junior mining companies.

What regulatory changes is the government working on?

The normative improvements that we are promoting, which should be finalized in 2019, include modifications to exploration contracts and tax stability contracts; a new regulation of mining procedures; improvements to the mine closure plans; and the adaptation of the regulatory framework to allow for the exploitation of lithium. With all these efforts and others we are undertaking (for instance, we will propose extending the value-added tax refund for exploration projects for three years), we are confident that investment in exploration, which experienced a slight setback at the beginning of this year, will be stimulated.

(continued from page 4) need to rebuild their relationships," explained Oscar Díaz, CEO of Viceversa Consulting, a specialist firm in environmental and social services. Díaz advised mining companies to be more proactive in their communication efforts with political leaders: "Companies always wait for the results of the polls, but what they should do instead is work with the main candidates before the elections."

Building Trust

Getting a project to the stage where it has all necessary permits and a social license is a great amount of work, but it is just the start. Once the mine is in production, a whole new set of questions is generated in terms of how to design the social strategy in the area of influence. Indeed, defining the area of influence itself is one of the first headaches for companies operating in remote areas, where state institutions are weak or non-existent. "There is a great deal of discussion about whom the mining company should work with: just with the direct area of influence, or if it should include the indirect area as well? There is no guideline for this and every project is different. The State should be the one mediating to help companies define their area of influence," explained Díaz of Viceversa.

A recent conflict around Las Bambas, one of Peru's main operations that represents 2% of the world's copper output, showcases how the interaction between the communities, the mining company and the State can go wrong. Allegedly following counsel from the Chávez Sotelo brothers, a duo of controversial lawyers investigated for extortion, local communities blocked the road used to truck the copper concentrates out of the mine for more than two months. The standstill put MMG, the mine's operator, on the verge of having to halt all mining activities on site. Finally, in April 2019, and only after negotiations with high-level participation from the government, the communities ended the blockade.

Manuel Fumagalli, president, SNMPE.

One reason given for the communities' protest was the State's non-fulfillment of several commitments related to the conversion of the local road used to transport the concentrates into a national highway. Yet, the communities directed their ire at the mining company.

Manuel Fumagalli, president of SNMPE, asked the national and regional governments to play a more proactive role in cases like these: "Adding the mining canon and the royalties, the regions have received 67 billion soles [PEN, US$20 billion at today's exchange rate] from the mining and energy industries over the last 10 years. However, on average, regions have only spent 66% of that. Without better investment execution capacity, the roles of the State and the private segment will continue to be misunderstood."

It is difficult to accept that, nearly three decades after modern mining development took off in Peru, the country's population continues to face severe development issues in the poorer areas. This must prompt both industry and government to continue working together so that the industry, representing around two thirds of Peru's total exports by value, continues to be a key driver of Peru's economic and social development at both the macro and micro levels.

Interview with Derek Cooke, president, Sociedad Minera Cerro Verde

How has Cerro Verde performed in 2018 and 2019?
Cerro Verde had an excellent year in 2018. We celebrated the safest year in history with respect to our Total Reportable Incident Rate. We successfully ramped up mining operations to meet improved concentrator performance, particularly at our newly expanded CV2 concentrator where throughput averaged approximately 15% more than the original plant design of 240,000 mt/d. In 2019, we are continuing to improve our already strong safety performance and to debottleneck and enhance throughput at both our concentrators. We expect to continue improving throughput at CV2 by about 20% more than designed capacity, or about 288,000 mt/d.

What are the main advantages and challenges for Cerro Verde?
Our primary advantages are our dedicated and skilled workforce and the strong collaboration we have with our parent company, Freeport-McMoRan. This collaboration allows us to share ideas and best practices across all our global operations. Meanwhile, our biggest challenge is low grade ore. We must continually look for more efficient and innovative ways of mining because we cannot rely on higher grades.

How is the strategy of rebuilding equipment helping to increase sustainability of the operation?
As far as "rebuilding" mine equipment, Freeport-McMoRan and Cerro Verde have been doing this for years. For example, the company has not purchased a new haul truck for its operations since 2008. Instead, we rebuild them to well-defined specifications at a significantly reduced cost compared to acquiring new machines, and we maintain overall availability at around 90%. We have similar programs for shovel rebuilds and also other support equipment.

What are Cerro Verde's main initiatives in the Arequipa region?
Today the main initiatives of Cerro Verde focus on the health sector (implementation of hospitals and health centers, purchase of equipment, donation of ambulances, health campaigns); education (improvement of school infrastructure, implementation of innovation classrooms, donation of textbooks, Maestro 3.0 scholarships); and on improving the population's access to water. Through the financing and co-financing of several projects (dams, drinking water system, collection and wastewater treatment) we have completed the so-called Virtuous Circle of Water in Arequipa, turning the city into a leader in water management at the continent level.

Interview with Tom McCulley, CEO, Anglo American Quellaveco

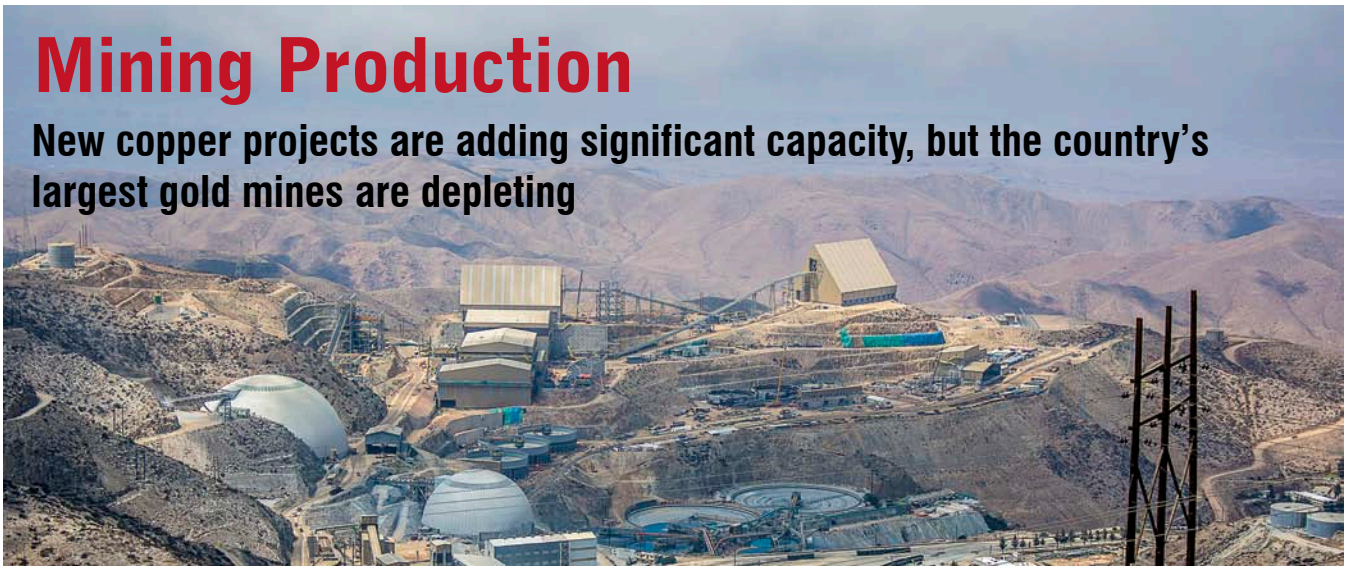
How does Quellaveco fit into Anglo American's copper portfolio?
Quellaveco puts us in a very good position. Right now, we are the eighth largest copper producer worldwide, with around 600,000 metric tons per year (mt/y) in Chile, and once Quellaveco and some of our other smaller projects are commissioned, we should become the fifth largest. Quellaveco will contribute 300,000 mt/y for the first 10 years, including 330,000 mt/y for the first five years. We expect Quellaveco to be in the first quartile of costs worldwide. It enjoys several advantages, such as low-cost power and a very low strip ratio of 0.8. Additionally, we believe there is potential to extend Quellaveco's 30-year mine-life. If you look at the mines around us, Toquepala and Cuajone, they have been producing for several decades. I think Quellaveco has the potential to become a generational asset.

Could we have some basic details about the operation?
It is a straightforward copper concentrator with the standard SAG/ball mill configuration, although we have just started the feasibility study for one of our technologies, Coarse Particle Flotation (CPF), an additional flotation circuit to gain more recovery and use less water. Then, the concentrate will be trucked to the Engie port in Ilo for over 160 km. At the port, we are investing US$100 million to build a new shed to store the concentrate, as well as a conveyor and offloading system.

What do you think are Quellaveco's most positive impacts on the project area and Moquegua's wider region?
One of the challenges for us is that we have been there for a long time; on the official day one of the project we already had approximately 5,000 people on site, whereas most projects start from a small number and then ramp up. So, one of the key challenges we have is managing expectations. Overall, the things I am proudest of include water and employment. Out of the 11,000 people we have hired, 44% are locals. That is a great achievement in a project of this scale. Also, with the Moquegua Development Fund we have impacted up to 25,000 people directly, which is a huge benefit for a region with around 120,000 people. Once the mine is up and running, our canon and royalty payments will amount to between US$150 million and US$200 million annually, which should help improve roads, schools, water treatment and health infrastructure.

Mining Production

New copper projects are adding significant capacity, but the country's largest gold mines are depleting



Following a US$1.3 billion investment, Toquepala has doubled its processing capacity from 60,000 mt/d to 120,000 mt/d. Photo courtesy of Southern Copper.

2018 saw no significant changes in Peru's copper production. The annual total of 2.44 million metric tons (mt) actually represented a slight decrease of 0.4% year-on-year. The country should, however, see an important increase in volumes in the coming years. For starters, the expansion of Toromocho is taking the plant from 120,000 mt/d to 170,000 mt/d, which should yield a 45% increase in copper production after commissioning; Mina Justa (60% Minsur - 40% Copec), will add 100,000 mt/y of copper; and the largest project in the pipeline, Quellaveco (60% Anglo American - 40% Mitsubishi), will produce 300,000 mt/y of copper starting in 2022 (330,000 mt/y for the first five years).

Tom McCulley, CEO of Anglo American Quellaveco, outlined the advantages of the US$5.3 billion project, which is currently under construction: "Quellaveco has access to low-cost power and a very low strip ratio of 0.8. We are diverting the Asana river upfront, so we will not have major investments once the mine is commissioned. Additionally, we believe there is potential to extend Quellaveco's 30-year mine-life. If you look at the mines around us, Toquepala and Cuajone, they have been producing for several decades. I think Quellaveco has the potential to become a generational asset."

McCulley also mentioned two key advantages at Quellaveco: the high percentage of local employment, with 44% of the 11,000 people currently on site coming from the Moquegua region, and the project's water management. Quellaveco will require 22 million cubic meters (m^3) annually, and 18 million of those will come from the Titire river, a stream that is not fit for human consumption or agricultural use due to the presence of natural contaminants. The remaining 4 million m^3 will come from the Vizcachas dam built by the company, which will also provide 24 million m^3 annually to the communities.

Interestingly, Quellaveco's mining trucks and drills are going to be automation-ready, although it is not clear when an autonomous operation will be implemented. Additionally, Quellaveco will be the first mine to run the company's FutureSmart operating model from day one. McCulley explained: "The idea is to build a stable base on which we can layer new technologies, Coarse Particle Flotation (CPF) being one of them. We will also apply Anglo American's P101 approach, a model that pushes for higher performance in our equipment than the industry standard; additionally, we will be a fully digital mine, which brings us future benefits in terms of understanding and applying changes in real time."

Construction is also underway in the coastal region of Ica at Minsur's Mina Justa project. While not as large as Quellaveco, the US$1.6 billion project still represents a very important investment for the country's mining industry and elevates Minsur, historically a tin producer, into the big leagues of copper production. Juan Luis Kruger, CEO of Minsur, gave more details about the operation: "Production will come from two plants: for oxides processing, Mina Justa

will have the largest vat leaching operation in the world, with 15 vats each measuring 30 x 30 x 8 m. This culminates in a solvent extraction and electrowinning (SX-EW) plant to produce high purity cathodes. Additionally, we will produce copper concentrates in a conventional flotation plant."

Mina Justa should be commissioned in Q4 2020 and reach commercial production in the second half of 2021. As a brand new mine, the operation is trying to be as environmentally-friendly as possible, explained Kruger: "We will use sea water for the mineral process; we will not touch any aquifer in the area. Furthermore, the district has excellent conditions for wind and solar power generation. The shovels and the drills in the project are electric, and the rigid trucks will run on natural gas to reduce emissions."

With Quellaveco and Mina Justa under construction, all eyes are turning towards Southern Copper's Tía María project in Arequipa, which is expected to be the next copper deposit to move into production. While the project finally received its construction permit in July 2019, its social components continue to present a serious question mark, with groups opposing the development of Tía María in Arequipa. Ongoing social dissent has kept the project in limbo since conflict first erupted in 2011, but if it does finally receive the green light, the US$1.4 billion project is expected to produce 120,000 mt/y of copper anodes annually via a leaching process.

Major Copper Mines

The Peruvian market is dominated by the large open pit segment, since eight mining operations run by seven companies represent more than 90% of the country's total output.

According to data from the Ministry of Energy and Mines, the main producer continues to be Cerro Verde, the mine operated by Freeport McMoRan in Arequipa,

Juan Luis Kruger, CEO, Minsur.

with 494,300 mt/y in 2018, followed by Antamina (a BHP-Glencore-Teck-Mitsubishi joint venture) with 459,500 mt/y, and Las Bambas, operated by MMG, with 385,300 mt/y. After that comes Southern Copper with 330,800 mt/y between Toquepala and Cuajone; Chinalco, with 208,300 mt/y at Toromocho; Glencore's Antapaccay with 205,400 mt/y; and Hudbay Minerals with 122,200 mt/y at Constancia.

Comparing results with 2017, Antamina, Southern Copper and Chinalco recorded positive growth in 2018 (4.6%, 8.1% and 7%, respectively), while production decreased slightly at Cerro Verde (-1.5%).

The latter operation continues to increase throughput volumes to offset the effect of low grade in the Cerro Verde deposit. After a US$4.6 billion expansion that added a second concentrator (known as CV2) basically doubled output volumes in 2016, the company wants to push performance at CV2 to go beyond nameplate capacity.

Derek Cooke, president of Cerro Verde, gave more details: "We successfully ramped up mining operations to meet improved concentrator performance, especially at our newly expanded CV2 concentrator where throughput averaged approximately 15% more than the original plant design of 240,000 mt/d. So, the CV2 expansion is far exceeding expectations. Through the creative power of our employees, we expect to continue improving throughput by about 20% more than designed capacity, to reach about 288,000 mt/d."

Cooke insisted that the company must continually look for more efficient and innovative ways of mining, much more so than other mining operators that exploit higher-grade deposits. In a move that applies this line of thinking to the mining fleet, the operation has been working on doing complete equipment overhauls: "Cerro Verde has not purchased a new haul truck for its operations since 2008. Instead, we rebuild them to well-defined specifications at a significantly reduced cost compared to new machines, and we maintain overall availability at around 90 percent. We also have similar programs for shovel rebuilds and other support equipment," said Cooke.

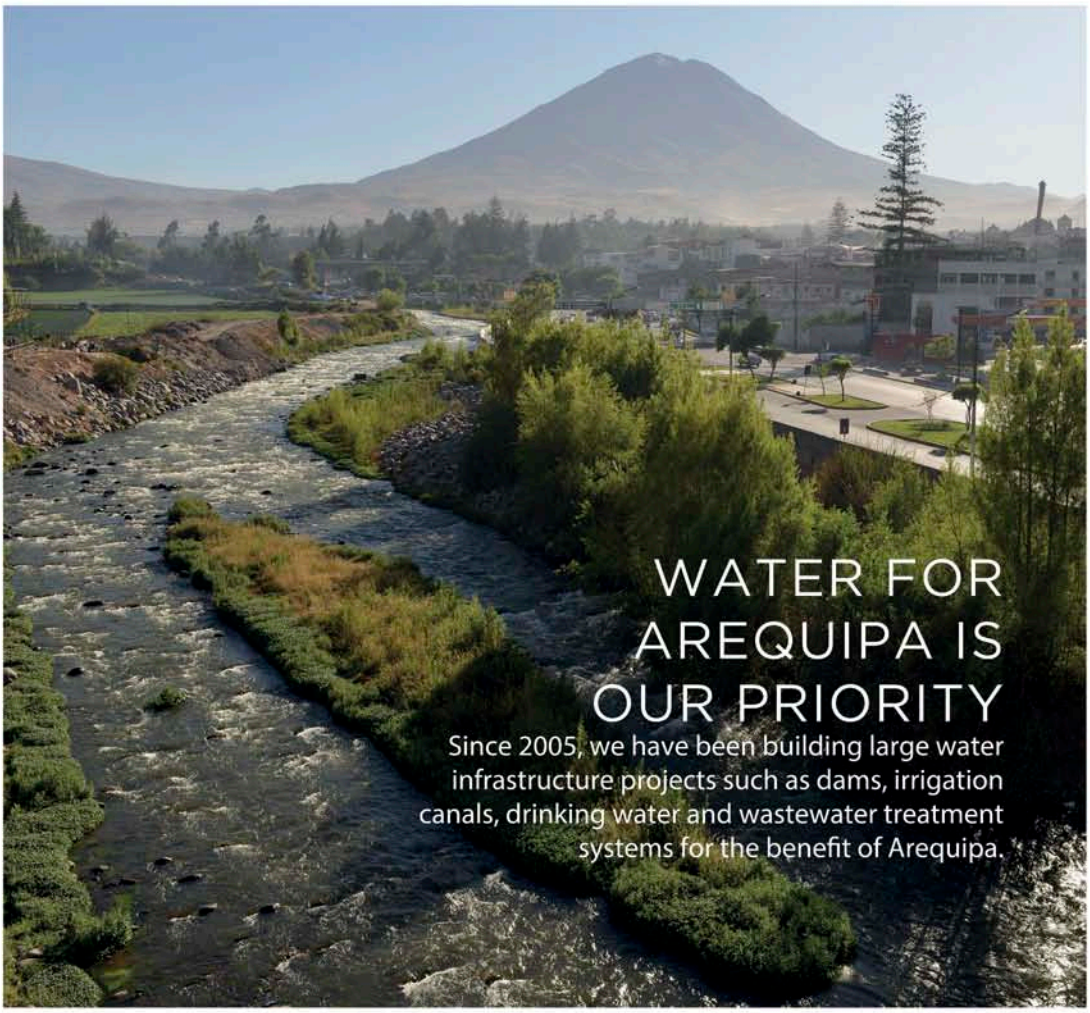
With regard to Las Bambas, another very large mine, the operation experienced a challenging first few months in 2019 when a road blockade led by local communities that lasted 68 days almost provoked a total stoppage of activities. Yet, MMG reported production of 101,452 mt of copper concentrate during Q1, which fits in the company's annual production guidance of between 385,000 and 405,000 mt/y.


Suresh Vadnagra, president, Las Bambas

The initial plan for Las Bambas, located in the Apurimac region, was to complete the first five years of operation with a total of 2 million mt of copper produced. Suresh Vadnagra, executive general manager of operations for the Americas at MMG and president of Minera Las Bambas, gave more details about some of the efficiency initiatives undertaken to eliminate bottlenecks: "In H2 2018, we were able to operate the plant at an annualized throughput rate of approximately 52 million mt/y, which exceeds the nameplate capacity of 51 million mt/y. We also delivered a 1% improvement in recovery. We have an aggressive work program to continue debottlenecking the operation."

Las Bambas is currently exploiting the Ferrobamba open pit, but the mine plan includes the Chalcobamba and Sulfobamba satellite pits as well. The potential of Las Bambas does not end there, affirmed Vadnagra: "The three pits currently part of the project represent less than 10% of the overall Las Bambas tenement, which is 35,500 hectares. The current mine life is more than 20 years, but we see the potential to continue for 60 or 70 years, so we plan for the long term."

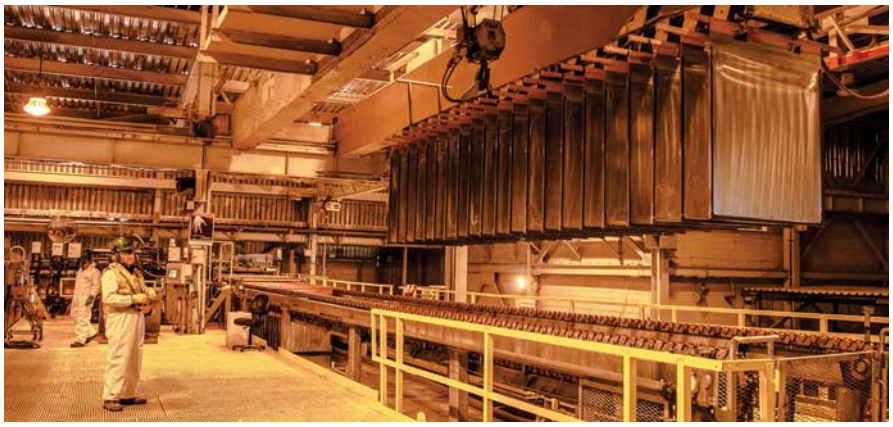
Hudbay Minerals, which operates the Constancia mine in Cusco, is actively looking to implement several new technologies including drones and radars to monitor geotechnical aspects, an integrated mine and plant control room in Hudbay's Lima office and an expert system that manages the process from the conveyor belt all the way to the flotation cells. Javier Del Río, VP South American business unit at Hudbay, provided more information about this: "There are algorithms that warn us of the hardness of the mineral: if the ore is very hard, you need more energy in comminution so that the belts will reduce their speed. If the ore is very soft, you can process more tonnage per hour. We also have an online technology to measure particle



WATER FOR AREQUIPA IS OUR PRIORITY

Since 2005, we have been building large water infrastructure projects such as dams, irrigation canals, drinking water and wastewater treatment systems for the benefit of Arequipa.

Cerro Verde



Copper production in Peru remained stable in 2018 at 2.4 million mt/y. Photo courtesy of Southern Copper.

Javier Del Río, VP South American business unit, Hudbay Minerals.

size, because there is a direct relationship between particle size and recovery."

Moving forward, Hudbay continues negotiations with the local community regarding the exploitation of the Pampacancha deposit, although the company is also evaluating other prospects in the area: "We are taking a very cautious approach, because the results of the Pampacancha negotiation may affect the future of other exploration areas. Pampacancha, located east of Constancia, holds 39.9 million mt of reserves, yet west of Contancia we may have a much higher potential, with 8,000 brownfield exploration hectares close to the mine at the Caballito, María Reyna and Kusiorcco areas," explained Del Río.

In addition to the large open pit copper operations, Peru offers copper production from medium-sized underground mines. These include Buenaventura-controlled El Brocal, that yielded 47,300 mt/y; Cerro Lindo, the largest operation by Brazilian company Nexa Resources (formerly Milpo-Votorantim), that produced 39,800 mt/y; and Condestable, operated by private company Southern Peaks Mining, which had 18,000 mt/y copper production in 2018.

As part of a plan to launch an IPO in Toronto last year, which was ultimately postponed, Southern Peaks undertook an extensive exploration campaign to expand reserves. Adolfo Vera, president and CEO of Southern Peaks Mining, related: "Historically, Condestable always had between three and four years of reserves, with 10 million mt that were regularly replenished, but now we have 24 million mt of reserves. The idea is to keep that figure moving forward," he said.

Based on exploration results, the company is expanding volumes at the operation: "We already have the permits to go from 7,000 mt/d to 8,400 mt/d and, following a new EIA approval process, by 2021 we should be processing 10,000 mt/d. That is nearly a 50% expansion of today's production rate, and it will be achieved with a very reasonable capex," Vera added.

Southern Peaks is also adding a new operation to its portfolio; the Ariana mine located in Junín, already under construction. Ariana has 16 million mt of resources and will initially process 2,000 mt/d. "Between Ariana and the Condestable expansion, we are moving from 23,000 mt/y copper equivalent to 42,000 mt/y copper equivalent, and our combined all-in cash cost will go down from US$1.54 per pound (US$/lb) to US$1.12/lb. That puts us in the first quartile of costs, typically populated by the large open-pit mines," Vera concluded.

Precious Metals

Buenaventura leads the ranking of Peru's mining producers in both gold and silver. In gold, between its own operations and its stake in Newmont-operated Yanacocha, the company had a total attributable production of 590,100 oz/y in 2018, accounting for nearly 13% of the country's total gold production of 4.59 million oz.

Silver production in Peru was 133.8 million oz last year, 5.8% down year-on-year. A big chunk of that total is produced as a by-product of the large copper mines, like Antamina and Toromocho. The country's main primary silver mine is Buenaventura's Uchucchacua, which yielded 15.4 million oz/y. Buenaventura's total attributable silver production was 24.7 million oz last year.

Over the last months, Buenaventura has focused its efforts on a debottlenecking program across the company's four main operations: Orcopampa and Tambomayo (gold), Uchucchacua (silver) and Marcapunta (copper), for a total capital expenditure of between US$35 million and US$45 million. Víctor Gobitz, CEO of Buenaventura, gave more details: "We are improving the lifting,

Adolfo Vera, president and CEO, Southern Peaks Mining.

Victor Gobitz, CEO, Buenaventura.

dewatering and ventilation infrastructure, while changing the mine preparation and extraction method as well. We are also obtaining more precise geological information ('in-filling'), which allows us to be more effective with our mine planning."

Gobitz highlighted that the debottlenecking program offers quicker returns than greenfield projects, yet the company is also advancing new ventures. In gold, the company has San Gabriel, located in Moquegua. "We have very solid knowledge about San Gabriel's geology and metallurgy, but there is an issue with the rock quality, which is very soft, so we need more geo-mechanical studies. If we overcome this issue, the project will move quickly," said Gobitz, adding that San Gabriel would process 3,000 mt/d and produce between 140,000 and 160,000 oz/y of gold.

After Buenaventura, the country's main gold producers are Barrick (332,100 oz/y from Lagunas Norte and Pierina), Minera Poderosa (278,700 oz/y), Newmont (264,200 oz/y attributable from Yanacocha), Tahoe Resources (243,000 oz/y between La Arena and Shahuindo), Aurífera Retamas (201,300 oz/y), Consorcio Minero Horizonte (182,900 oz/y), Hochschild Mining (181,200 oz/y) and Gold Fields (157,800 oz/y from Cerro Corona).

Yanacocha's total gold production last year was 514,600 oz/y. While the mine remains the country's largest single gold operation, output is expected to continue declining. Through the Quecher Main project, Yanacocha should yield 200,000 oz/y through 2027. Meanwhile, Barrick's Lagunas Norte, Peru's largest gold mine after Yanacocha in years prior, is currently facing the depletion of its oxide reserves, and pit operations are expected to end this year.

Peru's gold segment therefore seems to be maturing, at least in terms of the larger operators, and companies are focusing on stretching mine-life as much as they can. Like elsewhere in the world, the industry is suffering from the lack of new discoveries.

In the case of Gold Fields, last year the company announced that it is extending the life of Cerro Corona from 2023 to 2030, despite the limitations the operation has in terms of footprint. Cerro Corona is actually a gold-copper operation, and total output including copper was 314,000 oz/y gold equivalent in 2018. The mine, located in Cajamarca, continues to be one of the best-performing operations for Gold Fields globally, with all-in costs below US$700/oz.

Luis Rivera, executive VP of the Americas for Gold Fields, explained that the plan is to further extend operations at Cerro Corona: "This year we are going to do a preliminary study to extend mine life to 2033 or 2034. For that, we are evaluating the use of new technologies. By 2030, the pit is going to become a tailings storage facility, so any plan beyond 2030 requires the introduction of mixed disposal technologies to filter the tailings and stack them together with the waste rock. This way we can optimize the use of space."

While the production costs at Cerro Corona are tremendously competitive, this is not the case elsewhere on the gold spectrum, said Rivera: "Today, the average cost of a gold operation worldwide, including exploration, is US$1,200/oz. If the gold price was below that figure, many mines would have to shut down. This is why gold is not going under $1,200/oz, and we are even seeing a small rally with prices above US$1,400/oz."

A traditional Peruvian gold producer that is increasingly gaining traction is Poderosa: through the expansion of its two processing plants, Marañón and Santa María, to an aggregated total of 1,600 mt/d, the company expects to reach 300,000 oz of gold production in 2019. The company uses filtered tailings in the operation and is increasingly outlining modernization initiatives such as a


The Yauricocha mine had a 134% increase in resources in 2018. Photo courtesy of Sierra Metals.


Ignacio Bustamante, CEO, Hochschild.

plan to introduce autonomous locomotives for mineral extraction. Marcelo Santillana, general manager of Poderosa, explained that the company's production growth would never have been possible without sizable exploration undertakings: "For every 20 meters of exploration, we have defined approximately one ton of ore. Therefore, to replace the annual production of 300,000 oz, we need to drill 60,000 m. That is a significant investment."

Finally Hochschild, in the past a primary silver producer, is also an important gold producer today thanks to its flagship Inmaculada operation. Last year this mine, located in Ayacucho, produced over 251,000 oz/y gold equivalent. The company's other two assets in Peru achieved mixed results: while Pallancata's production was up by 22% for a total of 9.4 mililon oz/y silver equivalent, thanks to the new Pablo vein, Arcata's operation was put on care and maintenance. Ignacio Bustamante, CEO of Hochschild, explained the rationale behind this move: "Arcata had been operating for 55 years with a three-year life. Because of changes in permitting, we were unable to drill for two years, so we ran out of ore. We recently found a new area that is called Quadrant IV but, by the time we prove the resources, obtain the permits and develop the mine, we are talking a further three years before we can put Arcata back into production."

The prospects are certainly better for Inmaculada, as the company recently found 17 new structures in this mine, adding 1.3 million oz gold equivalent and extending mine life from four to 10 years. Looking at the wider district, the future is very promising, according to Bustamante: "In an area of about 60 km we have Inmaculada, Pallancata and Selene, a former producing mine. After years of immobility in the district due to the lack of permits, we were able to sign agreements with the communities last year, so we will be able to do significant exploration around Pallancata. The three key areas of focus are Pablo Sur, Palca and Cochaloma, which all offer great geological potential."

Base Metals

Peru's zinc production remained stable in 2018, with negligible growth of 0.1% for a total of 1.47 million mt/y. The main producer of this metal is Antamina, which continued growing its zinc volumes (475,700 mt/y, +7.5%) after a spectacular 69% increase recorded in 2017. The other main zinc producers in Peru are Volcan, now controlled by Glencore, and Nexa Resources.

In parallel to this, lead production was 289,200 mt/y in 2018 (a 5.7% contraction); molybdenum production was stable at 28,000 mt/y; iron ore production grew by 8.3% to reach 9.5 million mt/y thanks mainly to Shougang's expansion; and tin output by Minsur saw 4.6% growth for a total of 18,600 mt/y. Moving forward, Minsur's B2 project at San Rafael will actually add an extra 4,500 to 5,000 mt/y tin, with first production in late 2019.

Juan Luis Kruger, CEO of Minsur, elaborated on how the B2 project will strengthen the company's position in the tin market: "Some new projects are entering production, such as Bisie in DRC and B2 in Peru, and there is some additional production in Nigeria while Myanmar is falling. In this context, Minsur is the only integrated supplier of tin in the world, both through San Rafael and the Pisco smelter, as well as through the Pitinga mine and the Pirapora smelter in Brazil. This is important, because end users are increasingly insistent on tin traceability."

Back to zinc and copper, Nexa Resources is currently focused on maintaining production levels at both Cerro Lindo and the Pasco complex (Atacocha and El Porvenir), in spite of grade variations. The Brazilian company, listed on the TSX and NYSE, is currently building the Aripuanã mine in Brazil, and has three projects at

Igor Gonzales, president and CEO, Sierra Metals.

the pre-feasbility stage in Peru: Shalipayco (zinc), Magistral (copper) and Pukaqaqa (copper). Ricardo Porto, CEO of Nexa Resources Peru, summarized the latest developments at Cerro Lindo: "In 2018, we drilled 57,000 m, starting at the Orcocobre area north of Topará river. We plan to drill a further 20,000 m in 2019. Mine development increased by 33% last year, which allows us to continue expanding production."

Nexa also operates the large Cajamarquilla zinc refinery near Lima, where the company is investing US$40 million to move the technological route from goethite to jarosite, which will allow for an increase in recovery from 93% to 97%.

One of the country's traditional polymetallic mines is Yauricocha, 82%-owned by Sierra Metals, a listed company that also has two mines in Mexico. Yauricocha is located in the Lima region and currently operates at a 3,150 mt/d rate producing zinc, lead and copper, with some gold and silver content as well. Last year, Sierra Metals increased resources by 134% and is evaluating a potential plant expansion to 3,600 mt/d for 2020, according to the company's president and CEO, Igor Gonzales.

Gonzales expanded on the company's efforts to increase mechanization levels at Yauricocha: "We have introduced many improvements in rock support and we still have space to make our sub-level caving method more efficient. We have just concluded a tunnel to connect the mine with the plant, which generates significant savings in transportation. In addition, we are investing to have 100% of the mine covered by our ventilation systems, and we are expanding our pumping systems as well."

Sierra is also investing US$8 million in a fourth shaft in the operation that should be operational in 2021.

Asked about the current valuations of zinc producers, Gonzales commented: "Last year we did three PEAs showing that


Underground mines are increasingly mechanized. Photo courtesy of AESA.


Isabel Arias, president of the board, SIMSA.

Sierra Metals' stock should be valued at US$4. The trade wars have affected the valuations of mining companies across the board. Once we overcome this problem and realize the real demand for metals consumption, we will see a renewed appetite for investment in mining," he concluded, adding that his expectation is that zinc will stay around US$1.25/lb levels due to low inventories and limited smelting capacity, especially in China.

Meanwhile, Compañía Minera San Ignacio de Morococha (SIMSA), a local zinc producer that has been exploiting the San Vicente mine in central Peru for nearly 50 years, is using a US$1.11/lb price to base its forecasts for the next five years, although the company expects to leverage the high grade of its Mississippi Valley-Type deposit.

Isabel Arias, president of SIMSA, explained that the company has been making strong exploration efforts over the last year. As a result, the average grade of reserves is currently above 10% Zn, allowing the company a strong opportunity to improve economic parameters: "If we are successful in increasing the average grade feeding the plant from 6% to 8%-10% Zn, a zinc price of US$0.82/lb will be enough for us."

Being price competitive in zinc is key for SIMSA, considering that San Vicente is virtually a 'mono-commodity' mine (lead amounts to just 3% of the company's sales). In order to improve efficiencies, the company is investing US$25 million this year in items such as a system of short tunnels to drain water, the expansion of the tailings storage facility and exploration both to the north and south of the current operation.

Finally, another player in Peru's medium-sized polymetallic spectrum is Minera Lincuna, a local company that restarted mining operations in 2014 in the historic belt of Aija Ticapampa in the Ancash region. The com-

After taking over Vale's interest, Mosaic is the new operator of Miski Mayo's Bayóvar phosphate mine. Photo courtesy of Mosaic.

Alan Lulf, president, Miski Mayo (Mosaic).

pany's 3,000 mt/d plant is currently working at a 2,500 mt/d rate and is producing silver, zinc and lead concentrates.

Miguel Sánchez, general manager of Minera Lincuna, elaborated on the operation's cost position and ongoing investments: "We have managed to reduce the operating cost to US$45 per metric ton of ore processed (US$/mt). The all-in cost is US$60/mt, if we include the US$12 million we are investing this year: US$4 million in exploration on breccia pipes, mantos and a skarn system; US$2 million in the plant to expand volumes to 3,000 mt/d; US$ 2 million to expand the tailings dam; US$3 million in mine infrastructure, ventilation and services; and US$1 million in the rest of the support areas."

Sánchez added that 50% of production already comes from massive long-hole mining methods, which has further helped reduce costs. In terms of future developments, the company has identified 20 breccia pipes where copper mineralization increases at depth. "The new design we are preparing for the breccia pipes is a polymetallic plant that can also yield copper, a metal we currently do not produce. We are going to start a modification of our EIA to include the breccia pipes, two new tailings storage facilities and a new plant configuration of 10,000 mt/d," he said.

Phosphate

In addition to a wide variety of metals, Peru also hosts significant non-metallic resources in the Sechura basin – specifically phosphate. Located in Piura, a region in the north of the country, Mosaic has recently taken over a majority stake there in Minera Miski Mayo, previously operated by Vale, a joint-venture company exploiting the Bayóvar phosphate mine. Mosaic today holds a 75% stake, the remaining 25% being with Mitsui.

Alan Lulf, president of Miski Mayo, offered some details about the Bayóvar operation, which currently yields 4 million mt/y phosphate: "The mine is an open pit with five individual layers of phosphate. Being a sedimentary deposit, the process does not require any drilling, blasting or crushing. Indeed, it is a relatively simple operation, but the difficulty lies in the significant amount of rock that needs to be moved in order for us to ensure profitability – between roughly 75 million and 80 million mt of rock per year."

Lulf explained that Mosaic's focus when taking over Miski Mayo was on making the most of the operation. "We strived to obtain efficiency gains, which is an inevitable part of our business if you consider that the margins in this segment are currently quite tight. We were successful and last year we achieved record production and record low costs per mt."

The Bayóvar mine still has a mine-life of between 22 and 25 years ahead, and the company is also undertaking exploration activities to expand the current reserve base. Lulf was optimistic about the phosphate market fundamentals: "We are at a peculiar juncture where population is growing fast as farming land is shrinking, which means that it will be increasingly necessary to incorporate efficiency in agricultural production through the use of fertilizers. We are convinced that the market will see an uptick again," he concluded.

Peru's Junior Segment

Juniors have good projects to work on, but continue to suffer costly delays to obtain government permits

Peru offers exceptional geology, as long as juniors can raise funds and overcome the permitting bureaucracy. Photo courtesy of PPX Mining.

The mining industry has entered a positive cycle with more stable commodity prices, and this has promoted an increase in global exploration expenditure, which is expected to break the US$10-billion barrier during 2019. This consolidates the upward trend since 2017, yet this year's figure represents barely half the US$21.5 billion invested globally in exploration at the peak of the 2012 supercycle (S&P Global data). Peru, however, is moving against the current: according to official data, investment in exploration fell by 15% in 2018 at US$412 million, as opposed to US$484 million in 2017. Unlike statistics from S&P Global, these figures do not include most of the early exploration work prior to drilling, yet the trend is worrying: the country recorded a further 20% decrease year-on-year between January and May 2019.

In Peru, most industry leaders agree that the main problem is permitting: "Today, companies have to wait between six months and two years to obtain the drilling permits," lamented Jorge Granda, general manager of AK Drilling International, a contractor.

While the authorities need to make sure companies operate in a responsible way, such delays affect not only the juniors' cash position, but also their market perception. If the Peruvian administration is to be successful in reaching its goal of attracting 8% of the world's exploration budget, it needs to make life easier for explorers; both institutional and retail investors in mining are being lured by other options like marijuana and cryptocurrencies, which presents an additional challenge for the industry.

Nevertheless, some good news is coming from a variety of fronts in Peru's junior segment. Beyond the progress made across different exploration and development projects, Peru has strengthened its ties to Canadian financial markets, thanks to the TMX's opening of a Lima office this year. This is certainly a positive development at a time where financing for juniors continues to be difficult. Dean McPherson, head of Global Mining at TMX Group, affirmed: "We see Peru as a leading country in Latin America for mining. Peru has great governance and transparency, which continues to improve and is bringing more confidence for investors."

Gold

Between December 2018 and February 2019, PPX Mining completed its pre-feasibility study for the Igor gold-silver project

and obtained the final permits to build the processing facilities. "The initial underground mining development is already completed, therefore the capex outstanding to put the project into full production is less than US$4 million," explained Brian Maher, president and CEO of PPX Mining. "At Callanquitas [part of the Igor project] the underground mine is already working at 120 to 130 tonnes per day (mt/d) and has produced around 8,000 ounces (oz) of gold since we started our test mining and bulk sampling program in 2017. Now, for a modest capital contribution, we are buying a crushing plant, an agglomerator and a Merril Crowe plant, all of which can take production to 1,200 mt/d in the future," he said.

The initial production rate at the Igor project will be 350 mt/d, which will allow for an eight-year mine life and total production of 120,000 oz gold equivalent. The company envisions expanding both tonnage and mine life through exploration, based on the potential at both the Callanquitas and Portachuelos areas within the Igor project.

Maher explained that the focus of the subsequent exploration campaign (17,000 m drilling planned during 2019 and 2020) will be threefold: drill in and around Callanquitas to drive plant expansions; further drilling in Portachuelos; and target the Tesoros area, on the southern side. "Portachuelos has the potential to be a game-changer for us. The sheer size of that system requires us to start defining the limits of the deposit," he said.

Meanwhile, Palamina, an exploration company, is focusing on the Puno orogenic gold belt, and more specifically on the Coasa gold project, which includes the Veta discovery zone where the company plans to drill 2,500 m this year.

Andrew Thomson, president and CEO of Palamina, affirmed that the project also hosts the Phusca shear zone – potentially an extension of the Ucanuma shear zone that hosts Goldmining Inc.'s 1 million oz Crucero gold deposit. "In Coasa's Veta zone, surface gold assay results are much higher than those of Crucero and we cover a much larger area, so we are very excited to carry out our initial drill program. We see potential for open pit mining, but drilling is definitely required to determine a third dimension," he said.

Another gold-focused company is Pucara Resources, a private entity that is looking at a public listing sometime this year. The company has a portfolio of 14 projects following the project generator model but is also funded to carry out its own exploration programs. In this respect, the company is focusing on its Lourdes and Pacaska gold projects in Ayacucho. Pucara's CEO, Steve Zuker, said: "Lourdes is located in a belt of Miocene volcanic rocks, host to other gold deposits. The texture and clasts of rocks are indicative of multiple hydrothermal events occurring, increasing the chances of one or more of them carrying significant amounts of gold. The first phase of drilling will be 3,000 m in 10 to 15 drill holes."

Meanwhile in Pacaska, Pucara is planning to carry out an IP geophysical survey. So far, the project shows significant gold values at surface (7 g/mt Au) in hydrothermal breccias and vuggy silica, according to Zuker.

Regulus released an updated resource at AntaKori earlier this year. Photo courtesy of Regulus Resources.

Copper

The last 12 months have been eventful for some of the juniors active in copper, such as Chakana Copper (in which Gold Fields recently acquired a 16% stake), and also Regulus Resources. Last year, the latter company spun out its Argentinean assets into a new vehicle called Aldebaran Resources, and just before PDAC Regulus published an updated resource estimate at its flagship AntaKori project located in Cajamarca.

AntaKori's new resource contains 250 million mt with 0.48% Cu, 0.29 g/mt Au and 7.5 g/mt Ag (indicated) plus 267 million mt with 0.41% Cu, 0.26 g/mt Au and 7.8 g/mt Ag (inferred). John Black, CEO of Regulus Resources, gave more details about these results: "We have seen an increase of approximately 75% in the size of the deposit while maintaining similar grades. There has thus been a substantial increase in the total amount of contained copper and gold, and we have very good combined grades, with an average of 0.7% copper equivalent."

With respect to metal content, AntaKori contains approximately 8 billion pounds of copper equivalent (Cu equivalent), versus 5 billion pounds Cu equivalent in the previous resource estimate. "From a gold perspective, this equates to 17 million oz gold equivalent," said Black, who added that there is potential for the resource to continue growing: "We are still a long way from the edge of the system, and the Phase 2 drilling program is underway with more than 25,000 m planned for 2019. We hope to encounter porphyry-style mineralization as drilling progresses to the north."

AntaKori is located right next to the Tantahuatay gold mine, owned by Coimolache (a joint venture of Buenaventura and Southern Copper). Currently a gold oxide mine, Tantahuatay will transition into a sulphide copper-gold operation at some point. Regulus has collaborative agreements with Coimolache and Buenaventura for exploration, yet Black indicated that it is still early to define how the district will evolve.

With regards to Chakana Copper and its Soledad project in Ancash, the company has already completed over 25,000 m of drilling and is processing permits for a further 20,000 m. Soledad is a breccia-type system, where Chakana is focusing on having multiple deposits in a single cluster. To date, 23 outcropping pipes have been identified; while the company has outlined 12 additional areas that are strongly altered, Chakana wants to start proving economic mineralization in four or five pipes with an initial inferred resource, and then increase that with the remainder of the known pipes.

David Kelley, president and CEO of Chakana, highlighted the importance of gold and silver for the project, with 65% of the value in breccia pipe 1 coming from precious metals. He also emphasized the importance of Gold Fields' C$8 million strategic investment in Chakana: "This is a great endorsement and validation of the exploration work we have completed thus far. It also brings Gold Fields' technical and operational capabilities in Peru together with our team."

Highlighting the advantages of Soledad, Kelley added: "Mineralization goes at depth within a very small footprint. There is also 500 m of relief from the bottom to the top of the project, so you can access mineralization at various elevations early on in the mine life. After that, the infrastructure can be developed to access multiple pipes simultaneously, using standard underground methods."

Auryn Resources has also entered the country to tap into Peru's copper and gold potential. The company, 11.8%-owned by Newmont, expects to replicate its team's previous success stories with Keegan Resources (now Asanko Gold) and Cayden Resources (sold to Agnico-Eagle). With the assistance of Miguel Cardozo, a well-known local geologist, Auryn has obtained access to a number gold projects in southern Peru including Sombrero, Baños del Indio, Huilacollo and Curibaya.

Ivan Bebek, executive chairman of Auryn, affirmed that finding good projects is increasingly challenging: "Replacing ounces of gold and pounds of copper has become much more difficult. The easy,

Logging area at Field Camp, Soledad. Photo courtesy of Chakana Copper.

John Black, CEO, Regulus Resources.

David Kelley, president and CEO, Chakana Copper.

high-quality projects in Canada and South America have already been found, so it is going to take a considerable amount of perseverance, luck and thinking outside the box to find something new."

In Peru, the initial focus is on the Sombrero property, where Auryn has expanded its initial land position to the current 120,000 hectares. "Sombrero has the same types of rocks and mineralized intrusions that we see in the Las Bambas-Tintaya belt," said Bebek. "Other companies likely missed this opportunity because of the volcanic cover in this part of the belt. Also, we have found significant sulphide mineralization outcropping that carries as high-grade – or even higher grade – as the oxide zones," he added. Auryn expects to undertake a maiden drill program at Sombrero in Q3 or Q4 2019, for a total of 15,000 m.

Copper exploration is also being targeted by privately held companies, such as Latin America Resource Group (LARG) and Element 29 Resources. LARG is focused on the Jasperoide copper project in Cusco, located between the Las Bambas and Constancia copper mines. The project's land package includes 1,200 hectares that LARG acquired from Hochschild (with an internal resource of 50 million mt at 0.8% copper equivalent) and 7,100 additional hectares in the same district. The company re-logged all core previously drilled, which helped define five different styles of mineralization, ranging from lower grade skarn to high-grade copper-gold mantos.

Kimberly Ann, president and CEO of LARG, elaborated on the company's subsequent steps at Jasperoide: "We moved on to metallurgical testing and we had very good recoveries of 93% in gold and 73% in copper. Utilizing this data, we updated the economic model for the project, that could support a robust open-pit mine."

LARG is awaiting its water permits to start drilling at Jasperoide for an initial 3,000 m to 5,000 m campaign. The intention is to verify the historic resource and follow up on previous drilling to the north. Kimberly Ann added: "If we compare ourselves with the mines around us we have good grades. Our system is unique, with stacked high-grade mantos underneath disseminated, lower-grade copper that extends to the surface. The mantos grade is between 2% and 3.5% copper with high gold grades as well, in addition to being very thick. So we want to drill out a number of samples and have those results support the transaction to go public."

Finally, Element 29 Resources is a new junior company recently created as the vehicle to advance exploration efforts at Elida and Flor de Cobre, two projects coming out of Globetrotters Resource Group's portfolio. Brian Booth, until recently at Pembrook Copper, another private copper-focused junior, is Element 29's president and CEO. While Elida is located in central Peru, Flor de Cobre sits on the trend between Cerro Verde and Nexa Rexources' Chapi asset in the south of the country.

Like many other juniors, Element 29 is currently undergoing the permitting process. Booth commented: "Permitting processes are often too slow, and we are supportive of the steps that the government is taking in order to improve the system. At the same time, we have significant experience working in Peru, and we have always obtained the permits that we needed, so we do not foresee any obstacles."

Zinc

Following the strong performance of the zinc price over the last couple of years, the market is seeing a renewed interest in the metal. In Peru, the largest junior-held undeveloped zinc deposit is Tinka Resources' Ayawilca, located in central Peru. Following a recent resource expansion, Ayawilca now has 11.7 million mt at 6.9% zinc (in-

Graham Carman, president and CEO, Tinka Resources.

Alex Holmes, CEO, Plateau Energy Metals.

dicated) and 45 million mt at 5.6% zinc (inferred). Including the indium, silver and lead content, the zinc equivalent grades are 8.1% and 6.7%, respectively. Additionally, Ayawilca has a separate tin resource of 14.5 milion mt at 0.70% tin equivalent (inferred).

In July 2019, Tinka published its preliminary economic assessment (PEA) for Ayawilca, that contemplates a mid-sized underground mining case of 5,000 mt/d, with expected production of 101,000 mt/y Zn and 906,000 oz/y Ag over a 21-year mine-life. Initial capital would be US$262 million, and the after-tax NPV is estimated at US$363 million, using an 8% discount rate.

In parallel to this, the company has resumed drilling activities at the project with a new 10,000 m campaign. The objective is to test new zones, find more ore and complete some in-fill drilling in support of the future pre-feasibility study at Ayawilca, according to Graham Carman, president and CEO of Tinka: "There are still open areas at depth and on the edges of the deposit. Last year we found that zinc grade increased significantly with depth. We had one hole that intersected 10 m at 44% zinc underneath the previous resource, which is basically direct shipping ore in terms of grade," he said.

To move the project forward with this new focus on economic studies and exploration, the company has hired Ken Engquist, who was formerly involved in Arizona Mining (one of the latest success cases of M&A in this segment, having been acquired by South32 last year for US$1.3 billion). Also, in June 2019, Tinka published its latest metallurgical tests, showing 92% zinc recoveries. Speaking of the next steps for Ayawilca, Carman added: "We believe that Ayawilca still has the potential to contain 80 to 100 million mt of mineable zinc mineralization […] With the PEA completed, we may consider bringing in a strategic partner, if it makes sense to do so."

Lithium and Uranium

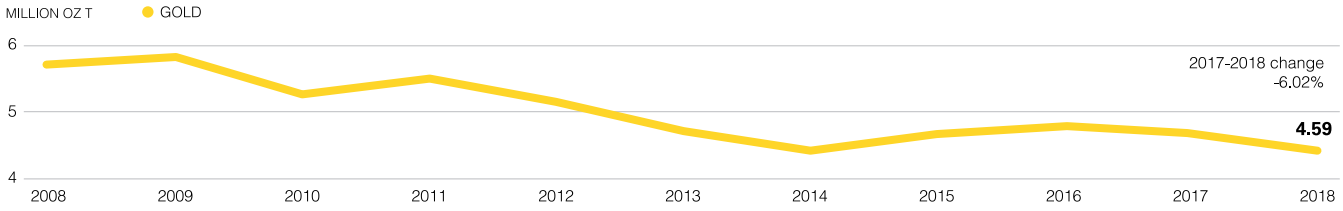
For years, Plateau Energy Metals (previously Plateau Uranium) worked on the consolidation of extensive uranium resources in the Macusani district in Puno, south-eastern Peru, until the Falchani lithium discovery changed the company's focus. The lithium resource built up very quickly so that the recent resource update announced in March 2019 reported a 90% increase in tonnage for a total of 4.7 million mt of lithium carbonate equivalent (LCE). According to Alex Holmes, CEO of Plateau Energy Metals, this is the world's sixth largest hard rock lithium project. However, Holmes understands that the company still needs to educate investors on the particularities of Falchani, considering South America is mostly known for brine-type lithium deposits: "The host rocks at our lithium project are volcanic mostly as a lithium-rich tuff (hardened volcanic ash), which is believed to be similar to the lithium source rocks (volcanic rocks) for brine projects […] Thus, we refer to our lithium project as a 'solid brine.'"

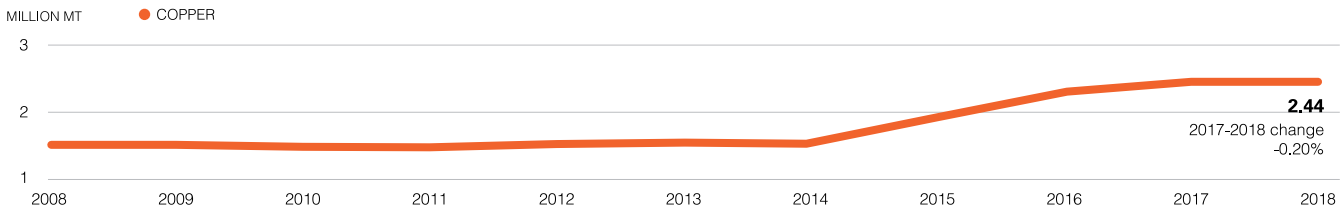
Plateau has been testing different methods of recovery, including tank/vat leaching, roasting, baking and heap leaching, and the company will now start to focus on the engineering aspect of the project while also looking at potentially expanding the resource toward the west and the north.

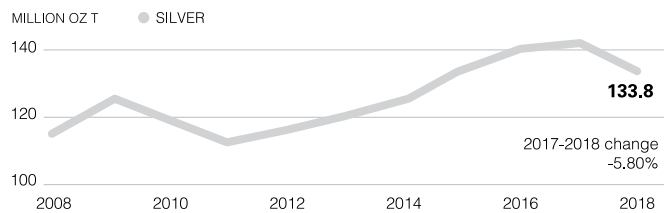
With regard to Plateau's uranium project, the company is waiting for the legal framework for uranium exploitation to develop in Peru, as well as for better uranium prices. In either case, the uranium project could be placed into a different investment vehicle, said Holmes: "Even though both uranium and lithium fit well into the green energy market, the equity investors on our two projects are very different. We are thus considering strategic options including a potential spin-off, joint venture with the right strategic partner as well as other alternatives."

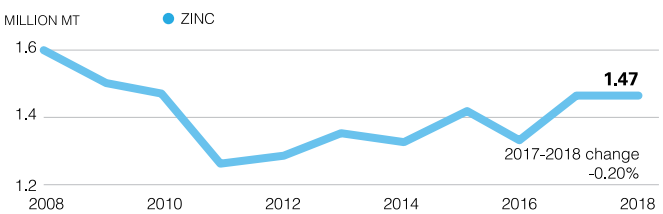
PERU, A DIVERSIFIED METALS PRODUCER

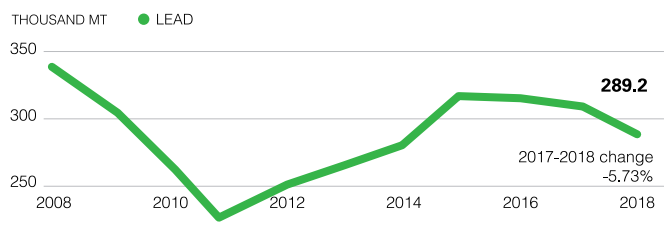
(Source: Ministry of Energy and Mines / Global Business Reports)

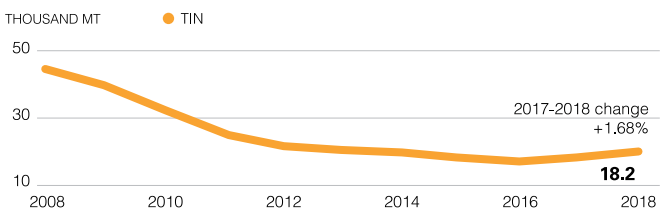






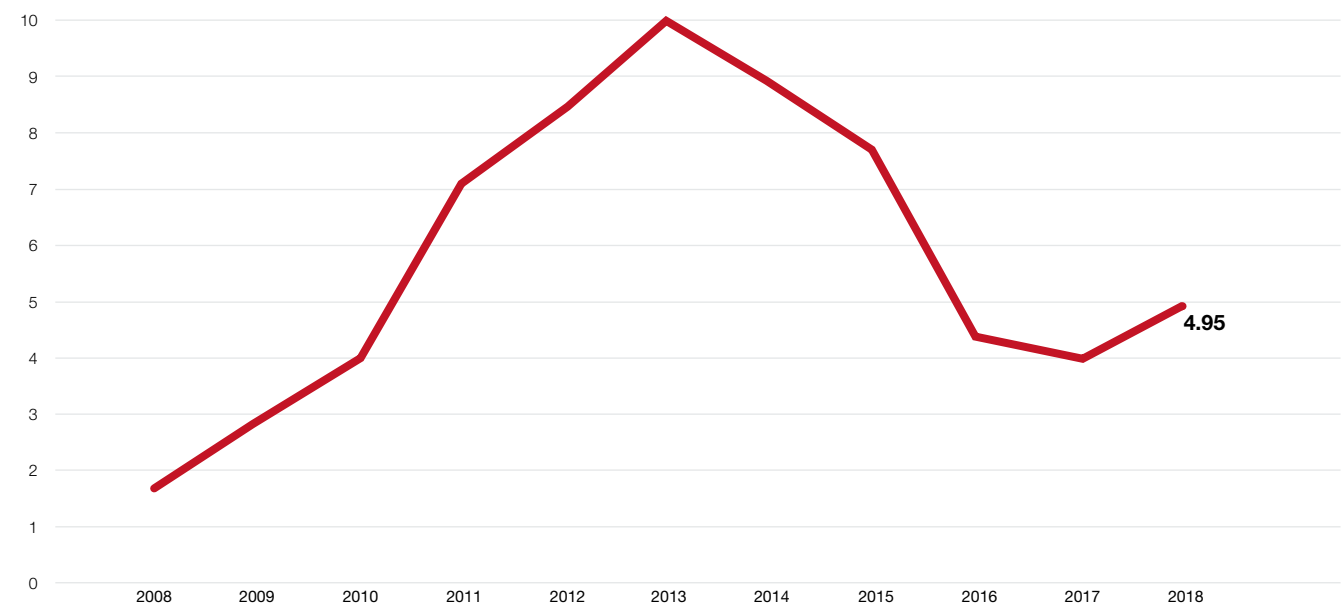






TOTAL MINING INVESTMENT IN PERU (US$ BILLION)

(Source: Ministry of Energy and Mines)



Engineering and Construction

The uptick in activity translates into more work across the board for consultants and contractors

New copper projects require large construction teams: Quellaveco has 11,000 people on site, and Mina justa will require 5,200 people during the peak. Photo courtesy of Marcobre.

During the boom years, a number of projects suffered hefty cost overruns and significant delays, spurring an ongoing debate between those defending the need to engage large EPCM contractors in large projects, and those advocating the division of projects into smaller pieces.

The latter model whereby smaller EPC players managed the different bits independently offered lower upfront costs, but presented mining companies with the challenge of piecing the puzzle together, risking significant inefficiencies later.

Bechtel, one of the largest organizations in engineering and project management, believes that one single player controlling the whole process, including construction, is most effective. The company is therefore promoting its EPC 'Direct Hire' model in Peru and Chile, even for multibillion dollar ventures.

Carlos Alarco, president for Latin America at Bechtel, explained that the company has set up an innovation center for construction that includes transformational tools related to the digital world, as well as improvements in previous procedures: "From the engineering stage, we integrate all the construction schedules with the 3D model and all the key information about procurement and costs for equipment and materials […] In our projects we have drones flying over the site permanently recording progress in real time, identifying in which warehouses the materials are stored and alerting if any material is missing."

Chilean firm Ingeniería y Construcción Sigdo Koppers (ICSK) is undertaking a similar approach in terms of innovative construction procedures using drones, geo-referencing and exoskeletons. The company, which previously participated in construction and industrial installation projects in Peru through a different legal entity called SSK, is now targeting growth in the regional market as ICSK. The company's goal is to establish itself within Latin America's main markets, namely Chile and Peru, but also Brazil and Colombia where it set up operations two years ago.

Sandro Tavonatti, CEO of Ingeniería y Construcción Sigdo Koppers, affirmed that the company is looking at specific mining project sections that lend themselves to the EPC model: "There are niches within projects, such as truck shops, power substations and desalination plants, where we can handle the EPC. In Chile and Brazil we have already carried out these sorts of projects successfully, including substations and transmission lines, of which we have executed over 7,000 km."

Marco Guerrero, general manager of ICSK's Peru office, explained that the business in Peru is much more exposed to the mining cycles than in Chile, where the company has more projects in power, pulp and paper and general industry. In Peru, the company's main assignments are at the Toromocho expansion and the installation of Mina Justa's concentrator. "The mining cycle is on an upward trend, although project development is not happening as quickly as we expected," he said.

Sector Consolidation

Through M&A activity, several engineering and consultancy players have strengthened their presence in the country. The former MWH, for instance, has now become Stantec through the combination of both firms. Meanwhile, WSP has made a series of acquisitions in the last three years, namely Schlumberger Water Services, POCH, ConCol and, most recently, Louis Berger. Furthermore, in 2017, Amec Foster Wheeler was acquired by Wood Group in a US$2.7 billion transaction.

The new Wood combines Wood Group's experience in oil and gas with Amec's track record in mining and metals, environment and mine infrastructure. According to Franco Pedraz, Peru operations manager for mining and minerals at Wood, the company covers a comprehensive range of services from front-end geology to mine closure, including project automation: "Our automation and control business provides artificial intelligence services for the integration of complex facilities through remote controls, virtual systems and robotics," he said.

The decline of commodity prices in previous years led mining operators to increase production through the implementation of new technologies and in this context, the latest projects for Wood's Lima office have been with Minsur's San Rafael tin mine:

Franco Pedraz, Peru operations manager mining and minerals, Wood.

first, the ore sorting project, which exploits an innovative technology; secondly, the B2 project, concerning which Pedraz elaborated: "The B2 project, which includes tailings reclamation, re-processing and tin recovery, has been developed in our Lima office from concept to execution."

Wood now has 60,000 employees worldwide, including 4,000 in the Mining & Minerals division, and WSP also has ambitious plans to grow from its current level of 48,000 employees to 65,000 people by 2021. Gonzalo Covarrubias, recently appointed Peru general manager at WSP, summarized the main areas of expertise absorbed by the company through M&A: "Schlumberger Water Services was a highly-reputable firm in water management, POCH had engineering experience in Chile and Peru, and Concol was a Latin American leader in power transmission projects. To all this we have now added Louis Berger's great capacity in infrastructure projects."

Covarrubias reckons that the strategy will position WSP as a long-term strategic consultant to work with the clients throughout the whole project cycle. "We are not active or inactive depending on the projects; we want to help clients meet the challenges of the future and that requires a multi-disciplinary approach," he said.

As an example, the company is already using its power transmission experience to design the transmission line for Quellaveco. "Mining clients are large consumers of energy and we can do all the technical, environmental and economic analysis to help them select the best option, which could be to connect to the grid or to develop self-generation or hybrid solutions," he explained.

Finally Alberto Coya, Peru country manager of Stantec, also outlined the synergies created by the Stantec-MWH merger: "MWH had a wider geographical footprint, whereas Stantec had a deeper service portfolio. Under the new structure, in Peru we


Hitachi equipment doing early works at Mina Justa. Photo courtesy of Zamine.


Paul Murphy, manager South America, Mining Plus.

have incorporated new services such as underground mining, and we have consolidated the water treatment offering that MWH had in other countries but not in Peru."

Optimizing Processes

While the construction of new mines like Quellaveco and Mina Justa is controlled by the EPCM players (Fluor and Ausenco, respectively), ongoing operations continue to be a great source of work for engineering companies.

Denys Parra, general manager of Anddes, a local engineering firm with 300 people in Peru, explained: "Once the mine starts production, the opportunities are endless. For instance, we have 30 people in Cerro Verde giving support in electro-mechanical projects, and we are participating in many projects in areas such as piping, power and instrumentation, sometimes through master engineering contracts."

Indeed, confronted by the various challenges of building greenfield projects, many operators have remained focused on extracting the maximum value from their existing sites. Buenaventura's debottlenecking program is an example of this, but not the only one. Hatch, for instance, is advising Nexa on a debottlenecking program at the Cajamarquilla zinc refinery. Following this trend, a number of companies in the segment are finding their own niches and acting as external advisors; for example, Hatch actually has a transversal Advisory practice covering mining, energy and infrastructure.

The opportunity to add value to the vast range of installed mining facilities in Peru has also attracted new players to this segment. Keypro of Chile, for instance, is opening an office in Lima. Jorge González Cohn, the firm's general manager in Peru, gave more details: "We are known for our debottlenecking solutions for concentrators. We have a specialized unit in metallurgical optimization, and we already see a space in the market because many plants will require modernizations, expansions and low-cost optimizations."

This, said González Cohn, would be a good entry door for the firm to then explore other areas where Keypro already has experience in Chile, such as fluid transportation, tailings management and disposal, and energy infrastructure. The firm would also like to capitalize on its Chilean experience in master engineering contracts: "We currently have five such contracts in Chile and, in the last five years, we have invoiced more than US$35 million following this model. This is a tool that is increasingly being used in Peru, so companies can avoid burdensome bidding processes," he added.

Underground Planning

Peru has a wide portfolio of underground mines but so far all of them are medium or small-scale. Peru's largest underground operation is Cerro Lindo, with a throughput rate of 20,000 mt/d (Codelco's El Teniente in Chile, by contrast, has a concentrating capacity of 135,000 mt/d). Yet, the situation is changing. Glencore is advancing the next phase of Antapaccay with the Coroccohuayco project, which has an underground component, while Yanacocha, is also entering an underground phase.

Paul Murphy of Mining Plus affirmed that large underground operations will become commonplace in Peru in the future: "We are seeing a lot more activity in the mass mining space for underground mining. Pits that are approaching the end of their life have very hungry processing plants that need to be fed. In this context, underground mining methods such as long-hole open stoping with large stopes and multiple mining areas, sublevel caving or block caving will be attractive for operators."

Mining Plus is the consultancy arm of Byrnecut, a large Australian underground contractor that is positioning itself in the Peruvian

market. Murphy emphasized that large open pit operators need to plan the transition to underground before it is too late to optimize efficiency: "The pit that delivers the most value to the operation in an open cut/underground scenario may in fact be smaller than the 'optimal' open pit considering just the open cut scenario. As such, this study has to be done well in advance."

Another consultancy firm looking at growth in Peru's underground segment by leveraging its experience in North America is Stantec. Alberto Coya gave more details: "In Peru, underground mines are dominated by local companies and initially it was difficult for us to transfer our expertise from Canada and the United States. Today, we already have bilingual experts. Moreover, we are working with Yanacocha on feasibility studies for underground mining."

Environmental Permitting

Beyond engineering, consultancy firms also support clients throughout environmental permitting and management. A recent increase in environmental impact assessments (EIAs) has ended a drought in activity, however the lengthy approval process for these studies has remained an impediment.

SNC-Lavalin, for instance, was awarded three different EIAs virtually at the same time.

Alexandra Almenara, general manager, SNC-Lavalin.

Alexandra Almenara, the firm's general manager in Peru, said: "This is unusual but it is very positive, because we will be able to share the best practices in these studies to obtain approvals in the shortest time possible."

Denys Parra, of Anddes, lamented that approving a mere modification of an existing EIA can take as long as processing a new one (this timeframe is currently two and a half years). "Today, SENACE [a government body under the Ministry of Environment] is in charge of all the tools for environmental management. We would like to see an optimization of timeframes to be more competitive as a country," he said.

Almenara of SNC-Lavalin pointed at another problem: since it started handling EIAs three years ago, SENACE has given its seal of approval to hundreds of consultancy firms, while the market only offers a handful of EIAs each year. "Many firms are not serious and that does not help the client. An EIA should be the tool that allows the client to plan and manage the whole operation from an environmental perspective," lamented Almenara.

Tailings Management

The terrible accident at the Brumadinho tailings dam in Brazil is another wake-up call for an industry that, so far, has only taken very modest steps to change the way tailings dams are designed and operated. Solutions for dry stacking are available nowadays, but the cost is still seen as too high for large volumes. "Brumadinho was built using an upstream construction methodology, meaning that after the starter dam is built and the impoundment fills with tailings, subsequent raises are built upstream of the starter dam on top of tailings," explained Dan Etheredge, regional manager South America at Klohn Crippen Berger, a firm widely recognized for its tailings dams expertise. "Downstream construction presents less risk, but it is more costly as it requires significantly more rockfill," he added.

The industry needs to pay extra attention to tailings management after the recent disasters. Photo courtesy of Nexa Rexources.

Eduardo Ruiz, general manager, Amphos 21.

Dams are often looked at as an operational aspect, but during the earlier-stage studies, selecting the location of the facility is the first headache that needs to be addressed. According to Heiner Bueno, chief of operations at Arcadis, a Dutch multinational firm: "The main issue is the dam location, and it requires a holistic analysis that considers the economic, technical and social aspects to realize a solution that is sustainable over time."

Etheredge of Klohn Crippen Berger elaborated on this: "A typical tailing site selection study will investigate several alternative locations, rank them, conduct a fatal flaw analysis to eliminate some alternatives and then determine not only the best location option, but also the preferred tailings technology to be employed."

Denys Parra of Anddes agreed that the industry has made only tentative moves toward dry stacking and that in Peru, handling filtered tailings becomes difficult during the rainy season. Anddes is focusing on consolidating its tailing practice considering the whole life cycle of the facility – from the design of the TSF and the engineering of the different elements, such as the thickeners, to construction supervision, monitoring and closure. The company has organized a number of tailings safety workshops with the idea of sharing best practices: "Today, more projects have an engineer of record (EOR), as well as an independent geotechnical review board (IGTRB). This means giving the responsibility of assuring the dam's behavior to a particular company or individual," noted Parra.

The problem is that these high-level experts are scarce worldwide and proper tailings safety reviews are a lengthy process. Antonio Samaniego, director of SRK Consulting, affirmed: "Tailings management is a complex issue because the industry does not have a critical mass of professionals to monitor the existing facilities."

Beyond initiatives coming from within the industry, the mining sector should also expect changes in regulation in the coming years. Etheredge of Klohn Crippen Berger highlighted the risks of upstream dams such as the one that collapsed in Brumadinho: "In Chile, which is a highly seismic country, upstream construction is not permitted. In Peru, seismicity is also a concern, although upstream facilities are not illegal. A few of them have been constructed, yet they are not as common as in Brazil. I personally believe that upstream dams should be decommissioned in the next few years."

And one should not forget the cost of mine closure: if Peru has seen hardly any proper mine closure (meaning the mining company returns the concession to the state), this is because the authorities do not give the final closure certification due to problems related to acid water, related Samaniego of SRK. Samaniego added that, after you stop mining, the next 30 years can be spent carrying out maintenance activities related to tailings.

The Water Cycle

Tailings are a key aspect of water management, but by no means the only one. Amphos 21, for instance, a specialized firm that originated in Spain and focuses on overseeing the whole water cycle, sees 90% of its business in Peru coming from mining. The company saw 30% growth in Peru in 2018, and its current local team of 80 people covers areas such as hydrology, hydro-geology and geochemistry, among others.

Eduardo Ruiz, general manager of Amphos 21, affirmed that demand in this area of business will continue to grow: "These services are necessary and they also add value to mining clients. The market will continue to evolve in terms of water and effluent quality, especially in water management and the optimization of water treatment, which is very costly and ends up impacting the mining companies' cash-flow."

Returning to the Brumadinho issue, Ruiz said that filtered tailings rely on weather conditions. "In areas where filtered tailings are not possible, you can control the destabilizing elements, one of the main ones being the associated water. In this respect, we have worked to better control the phreatic level within tailings dams."

The company has been incorporating instrumentation and control tools to its projects to be able to take better decisions.

Builders and Operators

The past few years have been tough for the Peruvian construction segment, which was simultaneously hit by both a slowdown in mining investment and, in some cases, corruption scandals involving public officials and construction firms.

Focusing strictly on mining, the influx of new projects is undeniable, as shown by the case of STRACON, a large mining contractor: in Q1 2019, 75% of the company's business came from construction activities, the remainder being in contract mining operations. STRACON initiated a new era last year when it disengaged from Graña y Montero with the support of Ashmore Group. Then, in October 2018, the company embarked on the acquisition of 60% of Dumas Mining in Canada, a specialized

Steve Dixon, CEO, STRACON.

underground contractor. Steve Dixon, CEO of STRACON, commented on the synergies created: "The Dumas acquisition had the objective of growing the underground business in the Americas, as well as to provide STRACON with a platform to offer surface mining and construction services in North America."

Local contractor Pevoex has also pushed for diversification in recent years. Traditionally a blasting specialist, Pevoex's largest project was at Las Bambas, where it executed the blasting and earth removal for the crusher and concentrator areas. The company has developed its expertise in tailings dams over the years, including contracts with Nexa at El Porvenir, Pan American Silver at Huarón and Colquisiri.

Rómulo Mucho, general manager of Pevoex and former president of the Peruvian Institute of Mining Engineers (IIMP), commented on the risks associated with tailings dams post-Brumadinho: "In Brazil dams are made with compacted clays, but in Peru, we have a lot of rock. Particularly in Brumadinho, although they had placed vegetation on top, the tailings were still shaky, like jelly. I believe dams in Peru are very safe; they are built to the highest safety standards, on different types of soil and with the use of accelerometers so that they are not affected by earthquakes."

Beyond tailings, Pevoex is already doing earthworks at Quellaveco and has a contract to carry out open pit operations for Nexa's Atacocha. By mid-2019, the company had 700 workers in Peru and had recently obtained the triple certification.

Underground Contractors

Thanks to technology and economies of scale, large open pit mines have achieved high levels of efficiency, but the same does not apply to underground mining in Peru. Víctor Gobitz, CEO of Buenaventura, commented that open pit mines enjoy 18 pro-


Underground contractors are increasingly expanding their scope of services. Photo courtesy of INCIMMET.


Gianflavio Carozzi, general manager, AESA.

ductive hours per day, whereas that ratio goes down to 12 or 13 hours per day underground.

Gianflavio Carozzi, general manager of AESA, one of Peru's largest underground contractors, reflected on the latest market trends: "You have an increasing number of operations, but they tend to be smaller in size because miners are optimizing the infrastructure. They require less meters and that is a challenge for our business model because it reduces our options to optimize the work by both our people and our machines."

In line with this quest for productivity, some mining companies are looking for a sole integrated contractor that can handle the whole operation. The problem is identifying a company with enough capacity to take on such responsibility. Eduardo Cossio Chirinos, CEO of INCIMMET, another underground contractor, elaborated on this: "Having just one contractor is still difficult in Peru. This will require higher levels of automation and technology. Until then, a big leap in terms of volumes translates into higher safety risks for the contractor. In our case, we cannot sacrifice our safety standard just to grow in volumes," he said.

The demand for larger contractors is also attracting international players. Deep Concept Mining (DC Mining), a local company created by the former Dumas management team in Lima and that is highly specialized in shaft sinking, has recently signed a joint venture with Thyssen of Canada (TMMC) for the creation of a full-fledged underground contractor called DC Thyssen Mining. Since earlier this year, the company has been bidding all new contracts under the new entity. Wayne Levert, general manager of DC-Thyssen Mining, emphasized that the company's range of action dramatically increases with the financial and operational support of Thyssen, with an initial investment plan of US$15 million: "We are capable of handling all phases of contract mining, including engineering and design, shaft sinking, construction, underground development and production, Alimak raising, raise boring, shotcrete application, ground freezing and anything needed in an underground project."

As DC Mining, the company currently has 250 people working for Sierra Metals on four separate contracts, including underground development, the rehabilitation of the old Central and Mascota shafts and the blind sinking of the new Yauricocha shaft. Levert developed on the latter: "This is a fairly large timber shaft of 5x5 m with four compartments and 350 m of depth. Normally timber shafts are rectangular, but this one is a square design."

Incorporating New Technology

A big limitation for the introduction of technology in Peru's underground segment is the significant amount of narrow-vein operations, as well as the fact that mechanization is still a work in progress. However, this has actually boosted local innovation. Tumi Raise Boring, for instance, has designed a raise boring machine that can be used not just for traditional ventilation or ore passes, but also for production processes. Local equipment manufacturer Resemin has become globally recognized in the narrow-vein segment for designing and producing a 1 m wide jumbo. Additionally, Robocon, a shotcrete specialized contractor, recently produced its first robots for shotcrete application, also for narrow-vein operations, through its sister company Tecnomecánica.

Enrique Sattler, CEO of Robocon, highlighted that the development of this new machine, which has a width of 1.6 m and can be used in 3x3 m tunnels, is an enormous milestone in a context where some mining companies want to reduce tunnel sections to decrease dilution, all while maintaining mechanization. The first models are going to be used by Pan American Silver in Peru.

Furthermore, the company has the capacity to integrate shotcrete operations through the implementation of cement plants on-site and the installation of slick lines. Sattler gave more details: "The slick line is a vertical pipe to transport shotcrete via gravity. We already designed and installed a 470 m slick line at Volcan, which helped reduce the number of machines from 23 to 19 in that operation. This also meant 15 less people. Despite the savings this technology brings, Peruvian companies are not familiar with it."

Eduardo Cossio Chirinos, CEO, INCIMMET.

While some miners go for smaller tunnels, larger operations also require bigger infrastructure items. Tumi Raise Boring, a specialist raise boring contractor that only uses its own machines, has developed its 700 SR machine for 3 m diameter and 150 to 250 m long ventilation holes, the first of which is going to Minsur's San Rafael. "The biggest improvement of the 700 SR is the implementation of new safety features, always looking at removing the human from physical contact with the operation of the machine. It also has new vibration absorbers," said Marc Blattner, general manager of Tumi.

The company has 14 machines in operation, in both infrastructure (ventilation chimneys, ore passes) and production processes, and it expects to add two to three more machines by the end of 2019, all of which will be Tumi's SR models. Standing for 'slot raise' and designed and manufactured in-house by Tumi in Peru, the SRs have substantially changed this particular niche of underground mining, assured Blattner: "By now, the standard raise boring machine is becoming a thing of the past: our SR machine is safer, more economic, offers better returns and it is easier to transport. For the six years we have had the SRs in operation, we have had zero incidents and zero accidents," he affirmed.

While the company remains focused on its activity as a contractor in the Peruvian market, it has also sold machines to other countries, including Mexico.

Pushing Performance

Advancements in technology allow both mining operators and service providers to achieve unprecedented gains in efficiency

Drilling contractors have been incorporating new technologies for productivity and safety. Photo courtesy of Geotec.

Anglo American's Quellaveco is not only a milestone for Peru in terms of the size of the investment, estimated at US$5.3 billion, it is also the first mega-project in Peru that can be built from the ground up as a fully digital model, reflecting how technologies have developed over the last few years.

So far, the mining industry has not adapted to the digitalization era as fast as some industry insiders tend to think. While Komatsu introduced its first autonomous truck fleet in Chile at Codelco's Gabriela Mistral division in 2008, more than a decade later autonomous truck operations are far from being the norm – although the trend is changing.

Quellaveco's working fleet of autonomous-ready trucks (the operation will initially be manned by drivers) includes 27 Caterpillar 794 model trucks with a payload capacity of 320 short tons. Caterpillar distributor in Peru is local company Ferreyros, which is also providing the truck fleet to Mina Justa, the other main project under construction, for a total of 26 250-ton trucks. Gonzalo Díaz Pró, general manager of Ferreyros, commented on the accelerated trend towards the adoption of autonomous equipment: "Autonomous trucks allow for circuits with less interference, increasing speed and enhancing process standardization. Towards the end of this year, Caterpillar will already have 250 autonomous trucks in operation worldwide. We are at the dawn of a new, more productive mining industry."

Paradigm Shifts, beyond Automation

Ángel Tobar, general manager for the Andean region at Epiroc, a global OEM, explained that connectivity offers great opportunity for remote operations as well as for data acquisition and mine digitalization while the industry continues to rethink its current methods for extracting ore. Continuous mining is shaping up as the way forward in the years to come, provided the technology continues to improve its performance: "The advantages of continuous mining versus discontinuous operations [drilling and blasting] are obvious, both in extraction and transportation," affirmed Tobar. "So far, the technology available has been used for soft rock, like coal or potash, but we are already transferring that to semi-hard or hard-rock applications."

Epiroc's Mobile Miner equipment is already working in mines in South Africa, Australia and the United States.

The same goes for Wirtgen's surface miners, which are now offered locally by IPESA, a Peruvian distributor. Giorgio Mosoni, chief strategy officer at IPESA, outlined the advantages of this piece of equipment: "The surface miners can extract the different ore layers very accurately, foregoing the need for blasting and preventing the mix of ore with waste rock that happens in the shovels. The hardness of the rock is not an obstacle for these machines. The challenge is to design mines in a way that we can fully extract value from this equipment."

Underground Equipment

The underground segment is well-served in Peru, with OEMs covering the full range: larger-scale equipment with brands such as Epiroc, Sandvik, Normet, Putzmeister, Komatsu and Caterpillar, as well as machines adapted to work in small tunnel sections to avoid dilution in narrow-vein systems, with local manufacturers such as Resemin and Tecnomecanica.

Overall, with the exception of narrow-vein operations, there seems to be a trend towards larger equipment across the board, said Díaz Pró of Ferreyros: "Many clients have been migrating from Caterpillar's R1300 loader to the R1600 model because they are aiming at bigger galleries and larger production volumes."

Ferreyros has recently introduced to the Peruvian market its R1700 loader as well, in addition to a new version of the underground articulated truck, the AD22. Díaz Pró added that Caterpillar already has a prototype for battery-powered equipment. Indeed, one key element in the underground equipment segment is the transition from internal combustion engines to electric and battery-powered machines with a view of reducing ventilation needs and increasing efficiency. While not long ago there was a certain degree of skepticism about battery performance, today it is widely accepted that battery-powered equipment will prevail.

Gonzalo Díaz Pró, general manager, Ferreyros.

In Peru, Epiroc has already been testing its battery-powered scooptram ST7 with several clients, while Resemin, a local manufacturer specialized in narrow-vein equipment, plans to launch its first battery-powered jumbo this year: "This technology still presents some challenges, such as the price," said James Valenzuela, CEO of Resemin. "Battery prices are going down from US$1,000 per kilowatt hour (kWh) to US$600/kWh, but they need to decrease further."

Mineral Processing and Handling

For Fernando Samanez, VP sales mining equipment at Metso, a mineral processing specialist, the market finally recovered in 2018. One of the latest milestones for the company has been the contract to provide Quellaveco with two SAG mills (40x25 feet) and two large ball mills (48x44.5 feet).

While there is an effort by plant OEMs to standardize equipment sizes and types, this is still difficult to achieve in big mining. Samanez said: "For large-scale the equipment is still tailor-made. Engines vary a lot depending on altitude, for instance. The equipment adapts to the tonnage of each mine with ad-hoc structural designs. Standardization is more suitable for brownfield projects, since it helps the client reduce lead times to just four or five months."

Rafael Ravettino, general manager, Aceros Chilca.

Miguel Ángel Arenas, general manager, Geotec.

At a Latin American level, a focus on tailor-made engineering has helped TecProMin grow in the market. TecProMin combines its in-house capability to design systems such as reagent preparation plants (including lime slurry preparation plants) and ore sampling systems with the representation of different brands for items such as ball mills, vertical mills, thickeners, agitators, filters and water treatment solutions, among others. "Our focus has been on meeting the clients' needs and not on the mere sale of equipment," said Francisco Kaiser, general manager of TecProMin.

The increased throughput volumes across the copper segment are also pushing demand for grinding media. Aceros Chilca, a manufacturing operation commissioned in 2017 just south of Lima, has completed the migration from the former cast ball production of Metalúrgica Peruana (MEPSA) into a plant dedicated to forged grinding balls. Following a US$45 million investment, Aceros Chilca's new plant has a capacity to produce 90,000 mt/y of grinding media, expandable to 130,000 mt/y. The new facility also intends to increase its capacity to host the group's mill liners and wear parts business in the near future. The company is

expecting to capitalize on the increased demand for grinding media across Peru and Chile, said Rafael Ravettino, general manager of Aceros Chilca: "This year we have started to sell grinding balls overseas. Peru consumes around 250,000 mt/y of grinding balls between 1 and 3.5 inches in diameter, while Chile's consumption is over 400,000 mt/y."

In a market where miners have pushed down the price of supplies, efficiency is key. Ravettino emphasized the fact that the new Chilca plant barely uses 10% of the energy a manual plant would require. Meanwhile, international company Magotteaux, part of Chile's Sigdo Koppers group, believes there is also space in the market for a more tailor-made approach. Edwin Vildósola, general manager for Peru and Chile at Magotteaux, affirmed: "Mining constantly presents new challenges. Some ore is very hard, and some ore is softer but with high levels of abrasion. Our high-chrome cast ball, for instance, does not contaminate the ore; it is a more expensive ball, but it increases recovery at flotation."

By contrast, Aceros Chilca's vision is that the vast majority of demand from mining companies will be increasingly coming from forged balls. Ravettino said: "The forging technology is a cleaner process from an environmental point of view and the product achieves better performance in the milling process. We aim to have Latin America's most modern plant and to be fully automated," he concluded.

Drilling Services

Investment in technology is driving efficiency across service contracts and this is helping to offset the enormous pressure on providers to reduce costs that took place during the recent downturn. Particularly in drilling, the downturn caused a collapse of the price per meter. When the market touched bottom, miners started to offer long-term agreements to contractors, probably anticipating that prices would go up as soon as the mining cycle picked up. The advantage of long-term deals was that providers could leverage those contracts to invest in the latest technology for productivity and safety.

Drilling contractor Geotec, for instance, spent US$12 million in 2018 on new equipment, with the support of three-year drilling contracts with both Las Bambas and Yanacocha amounting to 12 rigs each. With 240 people, the Las Bambas contract is probably one of the largest drilling contracts worldwide, said Miguel Ángel Arenas, general manager of Geotec: "Long term contracts allow us to renew our fleets and to invest in hands-free technology following the industry trends. Today, the market is moving toward smaller rigs as well as automation," he explained.

These investments in technology have not caused the rate per meter drilled to go up, however. Arenas said: "The market is not ready to pay a big difference to incorporate this technology, however, automation brings higher levels of safety and productivity, which pays off the initial investment."

Jorge Granda, general manager AK Drilling International, a contractor with operations in five countries, lamented that during the downturn the market was heavily driven by price. "A number of companies have looked for market positioning based on a low-price strategy. We had to adjust our rates in some instances, but overall we focused on service quality."

As part of this, Granda added, AK Drilling expanded its diamond and RC drilling fleet, while it renewed its triple certification for the water well drilling service.

Concerning the introduction of new technologies, Granda believes that the ball is largely in the client's court: "These technologies demand large expenditures, so if you have a market that is just looking for cheap drilling, it is risky to invest in them. The client must understand the value of quality service and the investment the contractor

needs to make for this, rather than just considering the lowest price possible. In the long run, you get what you pay for."

To add value, many contractors are undertaking their own technology development. Geotec not only uses standardized third-party rod handlers, like Epiroc's Christensen models, but is also developing its own rigs, together with Safedrill of Chile. As an example, for Las Bambas, they have developed a modular rig with a smaller footprint of just 15x10 m. The rig is 100% hands-free, has its own mud treatment plant that eliminates the need for excavating mud ponds and can drill holes of 2,000 m in depth.

Blasting Solutions

As in the drilling segment, pressure on rates and shorter contracts were also seen in the explosives market during the downturn. For Mario Matuk, general manager of Exsa, a blasting solutions company, this had negative consequences: "The problem with short contracts lies in the learning curve. We are talking about remote deposits and complex facilities and if the timeframes are too short, the process will not be optimized."

Today, the trend in blasting is to have at least three-year contracts, but the market continues to be very competitive, including large players such as Orica, Famesa, Enaex and Maxam, while EPC Groupe of France is also setting up shop in Peru. For Matuk, the key component for blasting solutions players is to demonstrate value: "The clients need to perceive value in aspects such as the mine-to-mill performance and the overall impact of the explosive on their bottom line."

For Exsa, open pit mining represents 60% of its revenue. In this segment, its Quantex technology has played a key role in helping the company grab a 40% market share and recently, Exsa was awarded its first contract in Chile using Quantex. Meanwhile, underground mining accounts for 30% of the company's revenue; the latest development in this sector is the introduction of Quantex SUB, a pumpable gasifiable emulsion that offers better progress per blast, less overbreak and lower dilution, while also requiring less ventilation, according to Matuk. Finally, initiation systems represent the remaining 10%.

Matuk gave an indication of how the blasting market may grow in Peru: "New projects require explosives for early works – we estimate that Quellaveco and Mina Justa are already generating 3% to 4% growth in 2019. Once they enter production, we should reach double-digit growth."

In light of this expansion, Peru's mining industry is attracting new blasting players. EPC Groupe recently decided to enter Peru, and it is setting up a local facility to produce explosive products. However, the company's initial strategy is to penetrate the market through a services company – a 50-50 joint venture with underground contractor IESA, called EPC Servicios Perú. EPC Servicios Perú wants to capitalize on the opportunity generated by the mechanization of processes in underground mining. Its business development manager, Armando Picoy, said: "90% of processes in underground mining are already mechanized yet blasting is still done using manual methods. Our vision is to adapt our technologies in explosives and blasting engineering to mechanize 100% of underground processes."

For this, EPC Groupe has developed smart modules for the charging of pumpable gasifiable emulsions with the idea of improving productivity, safety and environmental performance. "One decade ago, dynamite accounted for 70% of the underground market; today, the market has migrated toward packaged emulsions, yet these still require manual work. We are going to offer our technology to fully mechanize charging and blasting processes," Picoy affirmed.