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WESTERN USA MINING 2024

Top Jurisdictions - Production and Development - Exploration
Green Transition - Critical Minerals - Labor Shortage - Digitalization

Dear Readers,

The last year has been transformational for the mining industry in the Western US. The motto "Mined in America" now prevails across the entire mining value chain, and was mentioned during most of the interviews Global Business Reports (GBR) conducted for this *Western USA Mining 2024* report.

There is currently a prime for operating in the USA, with reshoring finding favor among investors, operators, and government alike. The geopolitical nature of the energy transition, where some minerals can be weaponized with dire economic effects for the US economy, has led Washington to play its cards. The Biden-Harris Administration has passed several bills and regulations, including the IRA and the CHIPS, to foster a domestic supply chain of critical minerals, and the entire mining industry is adapting to try and leverage these.

However, challenges persist, some self-imposed and others due to the cyclical nature of mining. The US mining industry confronts a growing labor shortage, hindering efforts to meet Washington's goals and the increases of production required by the energy transition. Additionally, cumbersome permitting processes and opposition from environmental groups present obstacles to bringing new mines online.

While navigating these challenges, miners, engineering and consultancy firms, as well as service providers must strike a balance between sustainability and profitability, while conveying the message that mining is necessary to maintain the current foundations of American society and the economy, and is fundamental in realizing a greener future. Off-take agreements between mining companies and automakers are breaking the silos that characterized industries until a few years ago, contributing to a more vertically-integrated supply chain. The goal is the same: To extract the minerals necessary to ensure a more sustainable future and reduce dependence on other countries.

This *Western USA Mining 2024* report offers a comprehensive analysis encompassing more than 100 interviews with mining leaders across the largest mineral-producing region in the US. In the upcoming pages, we give a voice to the key players as they share their insights and thoughts on the challenges and opportunities that the industry is undergoing, as well as outlining their ambitions.

We would like to thank all those who contributed to this report, and express particular gratitude to our partner associations at both state and national levels.

Alfonso Tejerina
Director and General Manager
Global Business Reports

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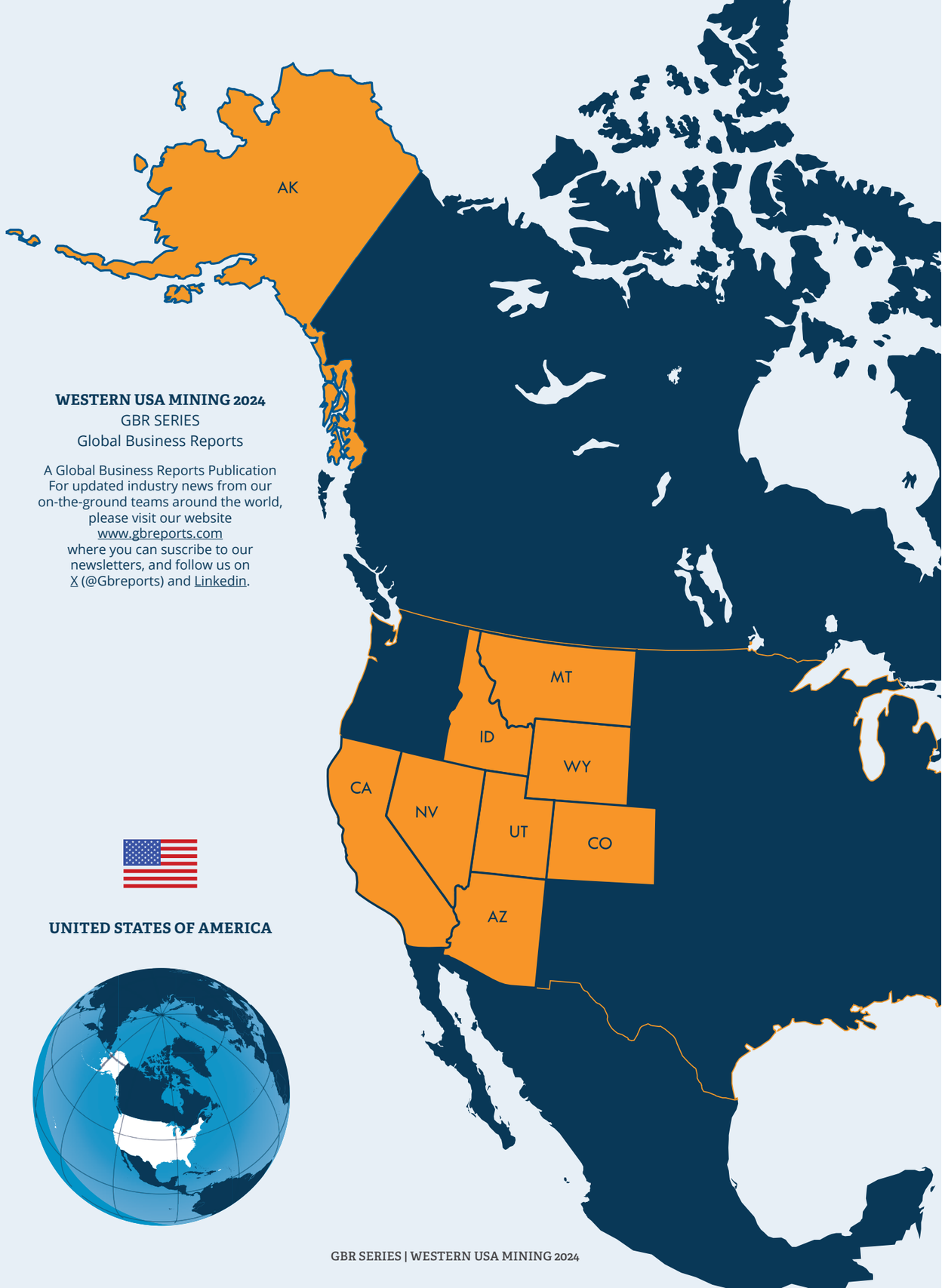

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UNITED STATES OF AMERICA

Introduction

> The US and, more broadly, Western countries are realizing the risk of relying on foreign countries like China for critical supply chains due to potential trade disputes. This realization leads to changes, but as with all change, it takes time.

Graham Richardson
CFO
FARADAY COPPER

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Introduction to the Western USA

Tier-one jurisdictions

Mark Compton
Executive Director
AMERICAN EXPLORATION & MINING ASSOCIATION (AEMA)

> Relying solely on allies for our needs is no longer a viable strategy. While complete mineral independence may be challenging, responsibly utilizing our domestic resources whenever feasible is imperative.

Few countries contain vast land extensions rich in minerals comparable to the US. From the discovery of gold in California's Sierra Nevada mountains during the gold rush, to the emergence of copper mines in the deserts of Arizona, and the wild and untapped Alaskan wilderness, the Western US hosted some of the most prolific mining operations in history. Mining for silver and gold is embedded in the early history of many Western states. However, in today's world order, mining has gone way beyond precious metals and is playing a pivotal role in geopolitics by extracting critical minerals and rare earth elements (REE).

Moreover, the Western United States stands out as the primary hub for extracting metals and metallic minerals, including Nevada, Arizona, Wyoming, Idaho, Utah, Alaska, Colorado, California, Montana, New Mexico, Washington, and Oregon. According to the data from United States Geological Survey (USGS), the Western US, encompassing the states of Washington, Oregon, California, Nevada, Idaho, Montana, Utah, Arizona, Wyoming, Colorado, New Mexico and Alaska, emerged as the leading region in metal and metallic mineral production, accounting for over US$27 billion of production, or 77.8% of the total US production. Nonfuel mineral production in the US reached US$98.2 billion in 2022, an increase of 4% from US$94.6 billion in 2021.

The top 10 producing states and their respective production values were: Arizona (US$10.1 billion), Nevada (US$8.9 billion), Texas (US$8.0 billion), California (US$5.6 billion), Minnesota (US$4.8 billion), Alaska, (US$4.5 billion), Utah (US$3.6 billion), Michigan (US$3.4 billion), Missouri (US$3.2 billion), and Florida (US$2.8 billion). Conversely, the estimated value of American metal mine production in 2022 amounted to US$34.7 billion, reflecting a 6% decrease compared to 2021.

While some Western states like Washington, Oregon, Idaho, Montana, Wyoming, and New Mexico did not secure positions in the top-10 list of producing states, others such as Arizona, Nevada, and California compensated for this, effectively balancing the overall production compared to the other regions. Finally, in terms of commodity, the principal contributors to the total value of metal mine production were copper, gold, iron ore, zinc and molybdenum, accounting for 33%, 28%, 15%, 9% and 5%, respectively.

Despite its importance, the mining industry in the Western US is confronting significant pressure. On a broad scale, miners are compelled to function within rigorous environmental standards, requiring a continuous demonstration of their commitment to investing in and adopting new technologies to enhance sustainability. At the same time, at the exploration stage, miners are grappling with a cumbersome permitting process that acts as a barrier, impeding the development of the next generation of mines crucial for the ongoing energy transition.

The Paris Agreement of 2015, which set ambitious goals to reduce emissions by 45% by 2030 and reach net zero by 2050, is an opportunity for many critical minerals-producing states like Arizona, the copper state, or Nevada, where lithium is abundant, to help achieve these targets, but the energy transition has taken on a geopolitical dimension, especially amid escalating political tensions involving the West, China and Russia. Certain minerals, vital for achieving decarbonization goals, have become a national priority for Washington, driven by economic considerations and strategic defense imperatives. Recent events have underscored the vulnerability of the US supply chain, revealing potential disruptions that could have far-reaching consequences. Like a domino effect, the scarcity of a particular mineral can trigger negative impacts in unexpected sectors of the economy.

In this context, the US has forged alliances with its allies and developed new policies. Where jurisdictions like Ontario or Québec have been working in the last years on a critical minerals strategy, the Western US applauded and welcomed the decision of the US Department of Energy (DOE) to include copper for the first time in its Critical Materials Assessment, published in July 2023.

Asserting that the US can establish a complete domestic supply chain of certain minerals is bold, especially under current conditions. While political interest might be there, the reality is that there is a lot of work to do in terms of permitting and educating society. As long as these factors do not align, a fully integrated US domestic supply chain may remain only an American dream.

Nevada

In 2022, gold production from mines in Nevada totaled slightly over 4.04 million ounces (oz), a decrease from the 4.47 million oz recorded in 2021. Silver production amounted to 5.47 million oz, down from 6.22 million oz in 2021, as the Nevada Division of Minerals reported. Copper production in 2022 amounted to 141.77 million pounds (lb), a decrease from the 163.73 million lb reported in 2021. On the other hand, molybdenum production experienced an increase, reaching 275,620 lb compared to 240,000 lb the previous year. Being the primary hub for gold and silver production in the Western US, and home to companies like Nevada Gold Mines, Coeur Mining, Jerrit Canyon-First Majestic Silver, and i-80 Gold, Nevada's economy has experienced a decline. Despite this downturn, the state still boasts a noteworthy economic output and GDP contribution, amounting to an impressive US$12.6 billion and US$4.9 billion, respectively.

Maintaining an unbiased perspective when evaluating Nevada as a mining jurisdiction can be challenging. It is difficult not only because the Fraser Institute consistently ranks Nevada as the top global mining jurisdiction for investment (including for 2022), but also due to the surge in activity across various minerals and the entire value chain, establishing Nevada as a vertically integrated state.

All that glitters in Nevada is indeed not gold. The state is home to the only lithium-producing mine in the US; the Silver Peak operation from Albemarle. The surge in activity within the lithium exploration sector has positioned the Tonopah-Clayton Valley area, with its clay-rich deposits, as a potential global lithium hub. ABTC, having received funds from the DOE, is establishing a cutting-edge facility in Tonopah to manufacture battery-grade lithium hydroxide from claystone deposits together with a recycling plant. Similarly, Ioneer has secured DOE funds for its chemical processing facility, advancing its Rhyolite Ridge lithium-boron project. Furthermore, in Northern Nevada the construction of Lithium America's Thacker Pass is a notable example of the state's commitment to the "white gold" revolution.

"There is abundant investment flowing in from the Inflation Reduction Act and the Bipartisan Infrastructure Act. Mining, auto, battery, and technology companies are coming together in the state to develop the homeland lithium supply chain. In the not-so-distant future, we will likely be referring to Nevada as the "Lithium State," stated Pan American Energy's CEO and president, Jason Latkowcer.

Indeed, Nevada is also home to Tesla's Gigafactory, and more recently, Biden named the "Nevada Lithium Batteries and Other EV Material Loop", led by the University of Nevada, Reno, one of 31 federally recognized regional tech hubs across the nation. This Tech Hub aims to position Nevada as a robust node in a critical supply chain, enhancing the resilience and competitiveness of the battery economy and accelerating the energy transition. In addition to DOE funding, several off-take agreements are unfolding in the state. For example, Lithium Americas has signed an off-take agreement with

Image courtesy of Freeport-McMoRan

EDITORIAL

General Motors. Ioneer has partnered with Ford Motors, Prime Planet Energy Solutions (a JV between Toyota Motor Corporation and Panasonic Corporation), EcoPro, and, more recently, DragonFly. These partnerships have broken the silos that characterized the industry until a few years ago and will foster synergies across different players in the supply chain, reshaping it into a more vertically integrated structure in Nevada, paving the way for earlier-stage projects.

Arizona

If in Nevada what glitters is either gold, silver or lithium, in Arizona, the warm, red desert landscape resembles the richness of copper. Arizona, the copper state, —where major copper mines belong to big players such as Freeport-McMoRan, Asarco, Carlota Copper (a subsidiary of KGHM International), Taseko Mines' Florence Copper asset, and Excelsior Mining—, maintained its position as the leading copper-producing state, accounting for approximately 70% of domestic output.

In the past year, Arizona has maintained its position in the top 10 most attractive jurisdictions for investment, according to the Fraser Institute. However, there has been a slight decrease of 2 points in the Investment Attractiveness Index, moving from the 5th spot out of 84 to the 7th out of 62. Despite the decline, all producing mines in the copper state make a significant contribution to the state's economy: "Arizona mining production was over US$10 billion and ranked 1st in the nation in 2021 and 2022. The hard rock mining sector is a US$14.2 billion industry, and combined with the aggregate industry, it is US$20 billion impact on the state's economy," said Steve Trussell, president of the Arizona Mining Association.

Many of these producing mines and several other exploration-development projects are located at the state's heart, in what is known as the 'Copper Triangle´: "To put this in perspective, there are only three copper smelters in the US, and two are in the Copper Triangle. To date, the triangle has produced approximately 37 billion lb of copper, and there are still believed to be over 95 billion lb of known reserves and resources," stated Dan Weir, co-founder and CEO of Copper Bullet Mines.

If Arizona is rich in copper, it is poor in water. As one of the driest states in the US, society closely scrutinizes water usage by mining operations. This has encouraged companies to invest in research and development, emphasizing environmental stewardship to showcase that copper extraction can be more sustainable. Thus, Arizona has emerged as a focal point for companies delving into in situ recovery (ISR), a method for extracting copper with minimal disruption to the surface environment. By learning from the uranium segment, companies like Excelsior Mining and Taseko's Florence Copper are adopting this eco-friendly approach, opening the door for earlier-stage companies like Copper Fox to follow.

Arizona's abundant copper resources continue to attract major players. For instance, Arizona Sonoran is advancing its brownfield Cactus project, incorporating the Parks/Salyer deposit under a new PFS. The state's copper richness has motivated the technology division of Rio Tinto's Nuton to explore innovative leaching methods to unlock the copper potential.

On the other hand, despite navigating the intricacies of the global mining permitting process, the Resolution Copper project, a joint venture between Rio Tinto and BHP, stands as a clear example of copper's significance for Arizona's future if the US would work on streamlining the permitting process. With a projected LOM spanning 60 years, the project is anticipated to generate around 3,700 direct and indirect jobs, potentially fulfilling up to 25% of the current US copper demand.

Alaska

Alaska, renowned as the second-largest gold producer in the United States and the top silver producer in 2022, surpassing Nevada, is also considered one of the best mining jurisdictions. Despite a slight drop of 5 points, ranking 11th in the Fraser Institute's survey, mining activity in this geologically rich state remains robust. Key mines in Alaska include Teck's Red Dog mine in the Northwest Arctic region, extracting zinc, lead and silver; Hecla's Greens Creek and Coeur Mining's Kensington mine in the Southeast region, yielding silver, zinc, gold and lead. Northern Star's Pogo and Kinross' Fort Knox mine primarily focus on gold in the Interior region. Finally, Alaska is home to the Usibelli coal mine, the only active coal mine in the state. More recently, the Manh Choh mine, a JV between Contango Ore and Kinross, was brought online to produce gold leveraging Fort Knox's mill.

According to the figures from the Alaska Miners Association, mining plays a pivotal role in Alaska's economy, generating 11,400 jobs and contributing US$1 billion in wages statewide. In terms of exploration, the state has seen US$645 million spent in 2022, and noteworthy projects include the Whistler gold-copper project and the Donlin project for precious metals, and for critical minerals and REE the Bokan REE project, Graphite Creek, Niblack, Palmer, Upper Kobuk and the Pebble project.

Explorers are drawn to Alaska for its vast, wild expanses that present an untapped jurisdiction; juniors navigate the potential for discovering world-class deposits while grappling with infrastructure limitations. "Exploration and infrastructure are related, and exploration companies are looking for terrains that can deliver geologically but also balance your understanding of the geologic potential with the relative opportunity that under-exploration and remote areas offer," explained Tim Smith, president and CEO of U.S GoldMining, which owns the Whistler gold-copper project.

Alaska includes part of the `Golden Triangle´, a renowned region encompassing significant gold, silver and copper deposits that stretches to Stikinia, British Columbia, Canada. Yet, the US side is often neglected, missing out on potential synergies that could be leveraged with its neighbor, Canada. "Despite witnessing numerous billion-dollar buyouts and ongoing mine developments in the Golden Triangle, the US side seems overlooked, especially on the Alaska side. Geologically, such boundaries do not abruptly cease, prompting curiosity and further exploration," said Morgan Lekstrom, CEO of Blackwolf Copper and Gold.

Wyoming, Utah and Colorado, the state agreements and a hub for critical minerals

While there is no historical evidence, it is believed that Abraham Lincoln once stated "Utah will yet become the Treasure House of the nation." These words ring true, not only for Utah but also for Wyoming and Colorado. These three geologically diverse states share common themes in their mineral wealth.

Regarding the Fraser Institute figures, Wyoming was not listed on the index. Utah dropped 11th to 17th in the investment attractiveness index but rose to 4th in policy rankings. The most notable change was for Colorado, which significantly improved its policy standing, moving from 37th to 9th place with a 17-point increase in its policy score. This improvement translated into a higher overall ranking, elevating Colorado from 20th in 2021 to 5th in the 2022 Investment Attractiveness Index.

Because they are `agreement states´, they have entered into agreements with the US Nuclear Regulatory Commission (NRC) to regulate certain radioactive materials within their borders, including uranium mining and milling. "New facilities only need to go through state-level permitting for radiological concerns, eliminating the need for NRC involvement. This change has significantly reduced the time required for permitting," explained John Cash, president and CEO of Ur-energy.

Utah's Henry Mountains and La Sal Complex, Wyoming's Laramie Mountains, and Colorado's Uravan Mineral Belt—all in the Colorado Plateau—showcase the potential that these states will play in the green transition.

Colorado is also renowned for the Colorado Mineral Belt, known for its rich deposits of gold, silver and copper. Meanwhile, Wyoming is emerging as a critical player in the Rare Earth Elements (REE) segment and features rich REE locations such as Bear Mountain in the north and the Laramie Mountains in the south, housing the flagship projects from American Rare Earths and Rare Element Resources. These companies are advancing their respective projects and forging partnerships with various entities ranging from governmental agencies to universities. In their pursuit of extracting REEs, Wyoming is giving birth to an innovative approach that diverges from conventional practices seen in other countries, like China, to extract these minerals. Environmental considerations remain at the forefront for the state and mining companies.

Idaho and Montana

Idaho and Montana, while not as famous as Nevada and Arizona, have a rich history rooted in mining. Both states share a profound mining legacy, but their future role in critical minerals may be more promising. Despite falling out of the top 10 investment-friendly jurisdictions, dropping from 7th to 28th in this year's Fraser Institute survey, exploration, and development companies in these states remain optimistic about the state's approach toward mining. Laurel Sayer, president and CEO of Perpetua Resources, said: "Idaho's commitment to balancing natural resource development with sustainability for future generations is truly commendable. We derived our name, Perpetua Resources, from the state's motto, 'Esto Perpetua,' underscoring our dedication to responsible resource stewardship. The accessibility of state government agencies and their solution-focused approach to discussions regarding permitting aspects further bolsters this commitment."

Idaho hosts two vital mineral belts: The Idaho Cobalt Belt and the Idaho REE-Thorium Belt. The Idaho REE-Thorium Belt runs in close alignment, situated 15 miles east of the more widely recognized Idaho Cobalt Belt. Much like Alaska, Idaho is not as mature and developed as other mining jurisdictions, making it open to new discoveries. Jonathan Buick, president and CEO of Champion Electric, commented: "Idaho is an attractive destination for mining due to its well-established mining code, a strong foundation of the rule of law, and a supportive environment for the mining industry. Moreover, the state has not witnessed the same level of historical investment as neighboring states like Nevada. Consequently, there remains a regional opportunity for mining ventures, with vast geologic potential waiting to be tapped within the state."

For its part, Montana, similar to Colorado and Nevada, has experienced an improvement in its ranking on the Fraser Institute's Attractiveness Index. As of the latest data, Montana now holds the 23rd position, showcasing an ascent from its previous 31st position. In southern Montana, the Stillwater complex has been a prolific source of platinum group elements (PGEs), nickel, copper, chromium and other minerals. According to Michael Rowley, president and CEO of Stillwater Critical Minerals: "Montana is undeniably a pro-mining state. With its century-long history of mineral production, the Stillwater District stands as a testament to the region's mining-friendly environment."

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Dana Bennett

Former Interim President
NEVADA MINING ASSOCIATION (NVMA)

How important is the mining industry to Nevada?
Nevada has long stood as the nation's leading mining jurisdiction. We are at the forefront of mineral extraction and production, crucial for 21st-century needs, positioning us as a forward-focused industry. Our role is pivotal in laying the foundation for green technology trends and transition, contributing to a sustainable future.

In 2022, our sector contributed a total economic output of US$12.7 billion and a US$4.9 billion contribution to the state's GDP. We achieved this with just 1% of Nevada's workforce, demonstrating remarkable efficiency. The approximately 36,000 mining-related employees earn wages double the state average, totaling around US$3 billion, creating a substantial economic impact throughout Nevada.

How is the labor shortage affecting the industry?
Despite offering attractive salaries, finding qualified individuals to fill positions has proven challenging, exacerbated by the remote locations of mining sites. Over the past two decades, the closure of mining schools in the US has contributed to a shortage of professionals, including geologists, environmental scientists, mining engineers, and metallurgists. The impact of these closures is now evident as the industry experiences a resurgence, emphasizing the pressing need for skilled personnel.

Is the labor shortage due to misconceptions about mining, and how does the NVMA bridge this gap?
A recent study focusing on individuals aged 15 to 30 revealed a notable reluctance to work in the mining industry, a sentiment attributed to misconceptions. The industry is often perceived through a historical lens. In reality, the sector has evolved significantly, with enhanced safety measures and increased female representation.

One of the most effective tools for dispelling misconceptions about the mining industry is organizing mine tours. By taking teachers and students on field trips to active mine sites, we provide firsthand exposure to 21st-century mining practices. The NVMA, in collaboration with the Nevada Division of Minerals, has been hosting annual teacher workshops for nearly four decades, updating them yearly to align with state curriculum standards.

How is Nevada poised to lead the energy transition in the US?
Nevada boasts the only operational lithium mine in the US, and the McDermott Caldera presents a promising future for lithium discovery.
Vanadium, recognized for its potential in energy storage, now has an operational mine in central Nevada. Copper is a vital resource in which Nevada is the leading producer. Ongoing exploration reveals other metals and minerals crucial for emerging technologies.

Can the US government do something else to help secure its critical minerals supply chain?
A crucial consideration lies in carefully managing land use on public lands. The federal government faces the challenge of balancing various interests when withdrawing land for purposes such as solar production, military operation, or wilderness status. While such withdrawals serve specific objectives, they limit access to potential mineral resources, impacting future production. ■

Steve Trussell

Executive Director
ARIZONA MINING ASSOCIATION (AMA)

What is the role and evolution of AMA in supporting Arizona's mining industry?
We are interested in maintaining the viability of the industry in three ways: Community relations, regulatory work, and public policy. We strive to keep Arizona the number one producer of nonfuel minerals in the nation and in the top ten jurisdictions in the world for attracting investment in mining.

What makes Arizona an advantageous jurisdiction to explore and develop a mine?
Arizona has a favorable economic, political and regulatory climate. People know we are the 'copper state' and generally understand mining's importance and the need for mined materials. Arizona ranks first in mineral potential in the US and has a policy perception ranking that is also favorable to mining. Our state agencies are good to work with and do pre-permitting work to efficiently issue key authorizations.

What is mining's economic impact and contribution to the state?
Arizona mining production was over US$10 billion and ranked 1st in the nation in 2021 and 2022. The hard rock mining sector is a US$14.2 billion industry and, combined with the aggregate industry, is a combined US$20 billion impact on the state's economy. According to the US Bureau of Labor Statistics the mining industry output per worker is US$545,100, which ranks third behind the aerospace and semiconductor industry. Mining employs approximately 27,000 people directly and supports another almost 75,000 jobs indirectly. The contributions to state tax revenues are also quite substantial.

What are the biggest challenges that miners in Arizona face today?
University mining program enrollment has been down. College and high school students do not see mining as an agreeable career option. Industry and academia need to quickly adapt to attract the next generation of talent.

The good news for Arizona is the University of Arizona has a new mining school. We are affirmed that we will see significant changes at the university level. They are also engaged with the K-12 system through demonstrations, workshops, and engagement to recruit and attract future talent. The challenge is rebranding the industry for young people.

What are your main goals for your presidency?
Even though we are a high-ranking jurisdiction in terms of friendliness to investment and mining, it still takes 10 or 12 years to permit new mining operations. We are looking at opportunities to get mines online expeditiously to meet increasing demand. This will include permitting reform, bringing older mining sites back into production and looking at mining waste, which can hold significant opportunity.

Arizona Mining Association's goal is to keep the Arizona competitive. Arizona should continue to lead the nations as the number one producer of nonfuel minerals, but do it in a very responsible way in terms of environmental health and safety. ■

Travis Deti

Executive Director
WYOMING MINING ASSOCIATION (WMA)

Can you provide an overview of the Wyoming Mining Association?
The Wyoming Mining Association (WMA) has been active for 65 years. We represent about 30 member companies engaged in mining, covering a diverse range of minerals. While uranium was the primary focus in the 1950s, our current flagship commodity is coal, with Wyoming being the nation's largest coal producer, accounting for 40% of the country's coal production. We advocate for the coal industry at both state and federal levels, facing challenges due to climate change initiatives and the Biden administration's shift away from fossil fuels.

In addition to coal, we mine trona, a unique mineral processed into natural soda ash, which finds applications in various industries, including glass, chemicals, and lithium batteries. Natural soda ash from trona is becoming increasingly significant in addressing global climate change through applications like flue gas desulfurization and carbon capture techniques. Because of this, our industry is looking at significant expansion in the near future. Bentonite clay is another key industrial mineral used in oil and gas products, cosmetics, clarifying agents, fertilizer, and cat litter. And although currently scaled back, our uranium production aims to revitalize in response to renewed interest in nuclear energy. Furthermore, we are exploring rare earth deposits, considered among the richest in North America.

What measures is Wyoming taking to secure domestic supply chain for critical minerals?
Wyoming is strategically positioned to address the geopolitical challenges affecting critical minerals, particularly in the uranium sector. The dependency on Russia for nuclear fuel raises national security concerns, prompting efforts to enhance domestic uranium production. With its in-situ mining operations, Wyoming is poised to contribute to this revival. Legislative support at both state and federal levels is aiding these endeavors. Challenges such as supply chain issues persist, hindering a swift ramp-up.

In addition to uranium, Wyoming is actively involved in addressing the demand for rare earth minerals. Projects led by private companies, along with support from institutions like the University of Wyoming, aim to explore and exploit rare earth deposits. Legislative reforms are streamlining regulatory processes, fostering a comprehensive, all-encompassing effort to develop critical minerals.

What are the primary challenges facing the mining industry in Wyoming?
Permitting, particularly on federal land constituting 50% of Wyoming, poses a significant hurdle. While uranium operations find some relief with state-level primacy, federal regulations, including those by the NEPA process, involve a complex web of oversight agencies, making it time-consuming and costly. Workforce scarcity, especially in the nuclear and uranium sectors, presents another critical challenge, requiring efforts to raise awareness among young individuals and address the reluctance to work in remote areas. ■

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California

According to the Fraser Institute, California remains the least favorable jurisdiction in the United States. Primarily due to policy-related factors, California's score saw a significant decline of over 19 points, resulting in its current ranking of 46th out of 62. The survey, a benchmark for the industry, claims that respondents in California voiced apprehensions about the enforcement of existing regulations, as well as heightened concerns about regulatory duplication and inconsistencies.

Securing permits poses a formidable challenge universally. However, what sets California apart? Warren Coalson, president of the environmental consulting firm EnviroMINE, shed some light on this disparity: unlike most states, California entrusts mining regulation to local agencies, introducing a distinctive regional variability. This decentralization results in a proliferation of agencies, complicating the regulatory framework and contributing to a multifaceted process. Furthermore, the public's misconception of mining, largely based on outdated stereotypes, further complicates the matter. "California's B-52 bill mandates Native American consultation for projects requiring discretionary approval. This adds another dimension, with Native American tribes potentially introducing challenges, such as requesting cultural significance reports, often with financial motivations," added Coalson.

Despite the unfavorable perception from the Fraser Institute, mining activities continue in California, a region boasting several ongoing or development projects poised to enhance the United State's self-sufficiency. A prime example is the Mountain Pass mine situated on the south flank of the Clark Mountain range, close to Las Vegas in Nevada. Operated by MP Materials, it stands as the sole operational REE mine and processing facility in the entire country. On the other hand, in the southern part of California, in the Mojave Desert in San Bernardino County, the Fort Cady project is emerging as the next significant boron-lithium project in the US: "We are fortunate to operate in San Bernardino County, a mining-friendly jurisdiction within a state historically challenging for new projects. Our project has a significant positive impact on an area marked by high unemployment rates and limited opportunities for younger citizens and graduates to secure well-paying jobs," commented J.T. Starzecki, chief marketing officer of 5E Advanced Materials.

In the upcoming commercial Phase 1 production, 5E Advanced Materials expects to generate 90,000 short tons of boric acid and approximately 1,100 short tons of lithium carbonate by the latter half of 2026. A pivotal aspect of their strategy lies in the method intended to extract boron and lithium. By embracing In-situ Recovery, 5E Advanced Materials can reshape public understanding of contemporary mining practices and foster a more positive viewpoint of the industry. California must enhance its perception against neighboring states in the Western United States to unlock its full potential. ■

Green Transition and the Role of the US

Pushing for new policies, but permitting remains slow

Warwick Smith
CEO
AMERICAN PACIFIC MINING

> "The world is gradually shifting away from globalization. The US government has taken significant steps to secure the supply chain of critical minerals, such as copper, which the Department of Energy recently designated as a critical material."

As the transition to clean energy swiftly advances, critical minerals have become a focal point in global discussions. For the US, as the leading economy in the world, ensuring a supply of these minerals is crucial not only to achieve its decarbonization goals but to reduce reliance on competitors such as China.

The 'green metals' are beginning to resemble oil in terms of their geopolitical significance. Several countries, including the US, are taking protectionism initiatives and policies to either nationalize, lower, or ban exports of these minerals. Chile, for instance, has attempted to acquire equity stakes in its lithium mines, and Namibia and Zimbabwe have imposed bans on raw lithium exports. The DRC has proposed export quotas for cobalt, and Indonesia has prohibited raw nickel exports to encourage investment in nickel processing within the country.

In terms of leadership, an asymmetric advantage exists for countries possessing resources and those controlling the supply chain, exemplified by China. Goldman Sachs Research indicates that China accounts for approximately 85 to 90% of the global rare earth elements (REEs) mine-to-metal refining. China also refines 68% of the world's cobalt, 65% of nickel, and 60% of lithium for EVs.

Washington has acknowledged the US' exposure to supply chain disruptions and vulnerabilities stemming from critical minerals, and thus the Biden Administration passed the Inflation Reduction Act (IRA) in August 2022 to strengthen the supply chain for metals and incentivize production of EVs. Lawmakers also passed the Bipartisan Infrastructure Investment and Jobs Act, which will fund a federal study of the use of abandoned mine lands and mine waste for critical mineral extraction. The CHIPS & Science Act to fund microelectronic research and manufacturing became the third legislative piece of a new industrial strategy. "Both political parties acknowledge the critical need for more secure mineral supply chains. The pandemic and events like the Russian invasion of Ukraine, ongoing issues in the Middle East, and China's global dominance in mineral supply chains have certainly heightened concerns and highlighted our vulnerability to unstable or hostile countries," commented Mark Compton, executive director of the American Exploration & Mining Association (AEMA).

However, are national policies enough? In the current era of globalization, to establish a fully integrated supply chain to fulfill its mineral-related goals Washington needs friends. The US government has strategically collaborated with its closest allies through various means, including bilateral cooperative agreements with countries such as Japan and Australia, a Memorandum of Understanding with Mongolia, and broader partnerships like the G7-backed Partnership for Global Infrastructure and Investment (PGII) to develop clean energy supply chains. Additionally, initiatives like the Minerals Security Partnership focus on producing, processing, and recycling critical minerals. Compton continued: "Relying solely on allies for our needs is no longer a viable strategy. While complete mineral independence may be challenging, responsibly utilizing our domestic resources whenever feasible is imperative".

Image by Mike Mareen at Adobe Stock

If mineral nationalism is the solution, the US faces substantial challenges, with one of the most critical being the permitting process. To stimulate domestic mineral production, the US needs to eliminate self-imposed obstacles and expedite numerous projects in the permitting stage, instead of resorting to a political discourse filled with empty words advocating for green economies while simultaneously imposing control and regulations. "Despite discussions about permit reform, tangible actions have yet to materialize. This extended timeline increases the risk associated with projects in the US, diverting foreign investments to countries like Canada and Australia or regions with questionable environmental practices such as Congo or Indonesia," commented Chris Summers, CEO of Burgex.

While the entire mining value chain in the Western US has been advocating for a more streamlined permitting process, there is unanimous agreement that this should not entail lowering environmental standards. Mark Compton questioned why, for instance, the FAST-41 designation granted for South 32's Hermosa project should not be applied to all mining projects, and he raised the point in the Senate: "If we can expedite permitting for these projects without compromising our high environmental standards, it logically follows that we should apply such efficiency to all projects. We should be expanding this permitting system of increased transparency and agency coordination, not limiting it."

Copper, closer to being listed as critical

According to the USGS, for a mineral or commodity to be categorized as `critical,´ it must meet specific criteria: It should be essential to the economy and national security, produced from a supply chain vulnerable to disruption, and serve a crucial role in the manufacturing of products whose absence would have substantial consequences on domestic economy and security. Copper fulfills all three: It is the cornerstone of the green energy transition, copper is the second most widely used material by the US Department of Defense, and US production is struggling to meet with demand. However, it is still not listed as a critical mineral.

The decision of the US Department of Energy (DOE) to include copper for the first time in its critical material list, published in July the 2023 Critical Materials Assessment, was therefore well received, but we must consider the difference between critical minerals and critical materials. While the DOE defines the critical material list, it is the USGS that designates the critical minerals list, and many claim that the USGS copper evaluation is out of date. The Copper Development Association (CDA) slammed the USGS for “misleading” and denying a bipartisan request to add copper to its critical mineral list. Including copper could result in enhanced scrutiny from the USGS regarding marketing trends and reserves and could potentially lead to streamlined permitting processes, facilitating domestic production. “For us, the key would be the USGS adding copper to their critical minerals list. This would recognize the need for processing copper and finding and producing more to meet clean energy targets,” commented Graham Richardson, CFO of Faraday Copper.

Not being currently listed as a critical mineral, copper does not qualify for the Inflation Reduction Act (IRA) tax credits.

Same deposits, new tricks

According to the Society for Mining, Metallurgy & Exploration (SME), the US needs 359 additional mines across all commodities to meet the needs of the clean energy transition. However, there is a lack of everything: new mines, good deposits at the surface, and labor, the perfect combination for failure. In this context, technology can help. VerAI Discoveries is an AI-based mineral asset generator dedicated to sourcing critical minerals essential for the energy transition. The company owns 73 exploration projects for critical minerals in eight portfolios of different commodities: Three portfolios, each focusing on cobalt, nickel, and lithium in Ontario; a copper portfolio in Arizona, which is undergoing advanced review and commercial discussion with several majors; and a gold-silver portfolio in Nevada, where VerAI is seeking a partner; and two portfolios in South America (in Peru and Chile). The lack of success in project exploration and moving to production is disconcerting, according to Yair Frastai, co-founder and CEO of VerAI: "Roughly one in every 1,000 projects successfully transitions into a functioning mine, and existing exploration methodologies fall short in effectiveness, economic viability and scalability," he explained.

According to Michael Rowley, president and CEO of Stillwater Critical Minerals, all apparent deposits have already been identified in today's context—a problem exacerbated by drilling costs at unprecedented levels. The elixir? "Integrating geophysics, AI, and machine learning becomes invaluable in uncovering previously concealed resources," he said.

ASTERRA, an Israeli-American company, is also actively involved in exploring critical minerals through its proprietary technology. The company focuses on employing Earth observation techniques, specifically through Synthetic Aperture Radar (SAR) wavelengths. While its initial focus was on providing Earthworks, a solution geared towards supporting risk and disaster prevention by analyzing underground soil moisture to monitor tailings behavior, ASTERRA has recently developed a model for pinpointing mineral deposits with enhanced precision and speed. "Instead of collecting multiple samples over several years, we have streamlined the process into a much shorter timeframe. This approach allows us to validate satellite findings, swiftly resulting in significant advantages," commented Elly Perets, the company's CEO. ASTERRA’s initial case study involved collaboration with ACME Lithium, focusing on its Fish Lake project in Nevada.

Ivanhoe Electric, an exploration company that owns the Santa Cruz copper project in Casa Grande, Arizona, the Tintic copper-gold project in Utah, and the Hog Heaven copper-gold-silver project in Montana, has developed the Typhoon data acquisition system. Typhoon excels in induced polarization and electromagnetic surveying, offering the ability to cover large areas at considerable depths and accelerating exploration by penetrating to depths over a km: "For example, at our Tintic project in Utah, we conducted a 70-square-kilometer survey at depths of up to 1.5 km in under 45 days, showcasing Typhoon's speed and efficiency," commented Taylor Melvin, president and CEO of the company. ■

> We have a generational opportunity to strengthen our domestic mining industry and ensure that *Made in America* means *Mined in America*.

Mark Compton

Executive Director
AMERICAN EXPLORATION & MINING ASSOCIATION (AEMA)

What has been AEMA’s focus over the last few months?

Over the past 15 months, the Biden administration initiated the Department of the Interior-led Interagency Working Group on Mining Regulations, Laws and Permitting (IWG) to study ways to enhance domestic mineral supply chains. In September 2023, this group finally released a report containing dozens of recommendations. We engaged closely and in good faith with the Biden administration throughout this process. We viewed the IWG process and development of their report as an opportunity to identify ways to eliminate current barriers to discovering and developing minerals on public lands. While the goal of the working group was ostensibly to promote domestic mining production, unfortunately several recommendations will only hinder mining. That is disappointing, but we are committed to working constructively with the administration and Congress to ensure that our members and the broader industry can successfully develop the minerals essential to our society.

What are some key developments or reforms introduced by the Fiscal Responsibility Act?

The Fiscal Responsibility Act included some essential permitting reforms, such as enabling project proponents to prepare environmental review documents, acknowledging their interest in a timely and accurate product. The Act also introduced time limits for NEPA documents, although the practical enforcement of those limits remains to be seen. Much work remains, and tackling the litigation phase of the permitting process is imperative if we are going to accomplish meaningful permitting reform.

Should the industry work on delivering a clearer message about the value of mining to society?

One of our primary roles as an association is educating the public and policymakers about the modern mining sector. There is a prevailing "not in my backyard" sentiment in this country, partly stemming from misconceptions about what modern mining truly entails. The reality today is quite different from years ago. Current mining is highly regulated and technologically advanced, adhering to the world's strictest environmental and safety standards. Mining companies are deeply committed to their surrounding communities and collaborate with stakeholders to design, develop, and responsibly close mining projects.

We must work to educate the public about today’s industry and help them understand the beneficial impact mining has on their daily lives. Americans and the environment lose when we offshore our mineral requirements.

Why can't the US expedite the permitting process for all projects as it did with South32's Hermosa project?

I made that very point at a recent Senate committee hearing focused on countering China's dominance in mineral supply chains. The FAST-41 process that the Hermosa project is now undergoing was initially designed for large infrastructure projects, such as roads and transmission lines, and now includes mining projects. If we can expedite permitting for these projects without compromising our high environmental standards, it logically follows that we should apply such efficiency to all projects. Unfortunately, the Federal Permitting Improvement Steering Council recently proposed limiting participation to mining projects that involve only critical minerals, unnecessarily hindering our goal of bolstering domestic mining.

How have recent geopolitical events heightened concerns about secure mineral supply chains in the US?

Both political parties acknowledge the critical need for more secure mineral supply chains. The pandemic and events like the Russian invasion of Ukraine, ongoing issues in the Middle East, and China's global dominance in mineral supply chains have certainly heightened concerns.

China's investment in the mineral supply chain worldwide, including processing, has created a situation where nations will increasingly compete for limited resources due to the surging demand for minerals. Relying solely on allies for our needs is no longer a viable strategy.

What should we expect from the AEMA in the next 12 months?

The genuine bipartisan interest in permitting reform is encouraging, so we are working hard to enact further permitting reforms as soon as possible. We also anticipate the Biden administration will put forth numerous rulemaking, policy and guidance proposals to implement the Interagency Working Group’s recommendations, and we will be heavily engaged in those processes.

With skyrocketing global mineral demand, there is more attention on mining issues than ever before. I believe we have a generational opportunity to strengthen our domestic mining industry and ensure that *Made in America* means *Mined in America*. ■

> We have developed a model to enhance the efficiency of the exploration process by locating mineral deposits with greater precision and speed.

Elly Perets

CEO
ASTERRA

Can you introduce us to ASTERRA and the technology that you use?
ASTERRA has been operating since 2016 with a core mission of assisting society in gaining a deeper understanding of the earth, particularly from a ground engineering perspective, utilizing Earth Observation techniques, specifically through Synthetic Aperture Radar (SAR) wavelengths.

In ASTERRA, we employ the L band wavelength, which spans from 20 to 30 cm, making it relatively long compared to other wavelengths. The L band wavelength actively interacts with the ground and penetrates it, providing information about surface and subsurface conditions by being sensitive to electromagnetic objects. 85% of failures start with issues related to drainage, water, moisture, and other water-related problems. Thus, this technology can identify potential leaks in water distribution networks, which typically stem from aging infrastructure. This led to the development of a model that could provide water utilities with data regarding the location of leaks, helping them tackle operational challenges like in the mining industry, where attention is directed toward monitoring tailings storage facilities.

What is EarthWorks, and what does it prevent?
When it comes to tailings facilities, it is not uncommon to observe that some tailings extend beyond the boundaries of the dam owner's property. This situation presents a significant risk, especially from a liability perspective. EarthWorks is a solution designed to support risk and disaster prevention by analyzing underground soil moisture. We can assess these risks by remotely measuring soil moisture data on dams from space. This information is crucial for understanding how pressure and moisture contribute to the movement of tailings through the dam and soil from one side to the other, providing an early indication of potential risks.

What other solutions do you have for the mining industry?
We have developed a model to enhance the efficiency of the exploration process by locating mineral deposits with greater precision and speed. We initially tested this technology in the lithium sector in the US market. Instead of collecting multiple samples over several years, we have streamlined the process into a much shorter timeframe, eliminating the need for many samples. This approach allows us to validate satellite findings, swiftly resulting in significant advantages. For instance, it helps reduce carbon emissions, expedites the claim process for vast areas, and prevents the unintended use of land for alternative purposes. This approach is especially beneficial in regions such as Nevada and Utah, where we want to minimize the use of heavy machinery, reduce travel, and optimize mining equipment use during exploration.

We aim to expand this technology to commodities like precious metals and copper.

What are the benefits of Earth Observation techniques compared to ground monitoring techniques?
Ground monitoring techniques are often highly localized, offering limited scope. Visual inspections or sensor data can provide information only about the specific area where they are applied, potentially missing significant events occurring just a few centimeters away. In contrast, Earth Observation provides a much broader perspective, enabling the monitoring of larger regions.

One example is InSAR (Interferometric Synthetic Aperture Radar), which employs X-band wavelengths to capture multiple images over time for ground deformation monitoring. While this method yields valuable insights, it can become costlier and riskier when multiple images are required, as the earth is constantly in motion. ASTERRA's technology, on the other hand, is built on pulsar polarization and stands out because, unlike other methods that require 10 to 15 flyovers, taking several months, our approach relies on just a single flyover. This method reduces costs and detects phenomena before they escalate into significant issues, aligning with a proactive and efficient strategy for prevention.

What would you like to have achieved over the next 12 months?
With EarthWorks, we are exploring diverse markets and applications on a global scale, such as engaging with the world's major mining companies in Chile, Argentina, the USA, Canada, and Australia. However, penetrating these markets is not straightforward due to their highly fragmented nature, with each operation often functioning as an independent entity and employing its methods for measuring and managing risks. Moreover, mining tends to be somewhat traditional, characterized by the lengthy process of adopting new technologies. These factors have prompted us to consider the insurance market as a potential driver for solutions, as our technology can play a pivotal role in enhancing risk management. ■

> VerAI Discoveries is an AI-based mineral asset generator dedicated to sourcing critical minerals by cracking the code of concealed mineral deposits in the geophysical data space.

Yair Frastai

CEO and Co-Founder
VERAI DISCOVERIES

Could you introduce us to VerAI Discoveries and its business model?
VerAI Discoveries is an AI-based mineral asset generator dedicated to sourcing critical minerals for the green energy transition by cracking the code of concealed mineral deposits in the geophysical data space. Our primary focus lies in targeting covered areas in mature mining jurisdictions, which remain largely unexplored. We firmly believe these untapped terrains are the key to the next major mineral discoveries, and our thesis suggests that the potential findings will extend beyond individual deposits, leading to new clusters of mineral resources. Our core business model revolves around the potential upside of mineral discoveries rather than providing services or selling technology. Our approach involves staking claims on the land, owning the assets to 100%, and subsequently seeking a suitable partner to collaborate with.

What is VeriAI's current portfolio and mineral diversity?
We currently own 73 exploration projects for critical minerals, with a total of 217,000 acres in five mining jurisdictions. Our projects are divided into eight portfolios of different commodities. In Ontario, we have three portfolios, each focusing on cobalt, nickel and lithium. Additionally, we have a copper portfolio in Arizona, specifically in the southern region of Tucson, which is currently undergoing advanced review and commercial discussions with several majors. Moreover, we possess a substantial gold-silver portfolio in Nevada and are actively seeking potential partners to collaborate with us on this opportunity. On the other hand, we are operating in South America, with ongoing projects in Peru, while in Chile we have two portfolios comprising secured assets that are ready for partnership.

How certain is the use of AI for exploration?
Using AI and machine learning brings a distinct advantage by offering an objective and measurable approach to mining exploration. Unlike subjective hypotheses put forth by human experts, the data-driven nature of this technology allows for continuous improvement through an iterative process of feeding more data into the model as part of a feedback loop testing process. This technology is achieving a success rate of two orders of magnitude better than the industry, which is facing an alarmingly low success rate: Roughly 1 in every 1,000 projects successfully transitions into a functioning mine, and existing exploration methodologies fall short in effectiveness, economic viability, and scalability.

When we applied our techniques to trace porphyry copper-molybdenum deposits (PCDs) in Arizona, we achieved a success rate of approximately 1 in 7, a solid foundation for building a successful business model around this approach.

Should the government provide enhanced support and resources to mining start-ups to foster the success of new mines?
Securing the domestic supply chain for critical minerals has become a national interest for the US, where the government is working closely with Canada, Australia and Chile to achieve its long-term goals. These can only be achieved through making new discoveries and developing mining operations. Investors have acknowledged this shift, and there has been a notable change in how people perceive the challenge and the desired solutions. However, the support in the US has primarily focused on downstream activities by establishing battery plants, with limited emphasis on sourcing the production materials. To fully realize the potential of the energy transition, the government must provide substantial support for the upstream sector, including the licensing process for new mines and supporting exploration efforts.

How does VerAI contribute to a better ESG performance?
Our remote-based technology enables us to engage with the communities and other stakeholders in a completely different manner, emphasizing the importance of ethical and responsible conduct during the exploration phase.

A key aspect of our approach is targeting without the need of land acquisition, which grants us greater control over potential considerations and risks in specific areas. By adopting this strategy, we minimize our footprint and proactively engage with stakeholders, creating favorable conditions for their involvement from the earliest stage of the process.

This is a great opportunity to invite the First Nations communities, investors, and exploration teams to engage with us to generate value from high-performing and responsible AI targeting processes of critical minerals in mining jurisdictions with challenging vast cover terrain. ■

Labor Shortage

Attracting new talent

Based on the information provided by Walter Copan, VP of research and technology transfer at Colorado School of Mines, more than half the current domestic mining workforce will be retired and replaced by 2029 (221,000 workers). A study published by Deloitte earlier in 2023 supports these statements, according to which nearly 50% of skilled engineers are reaching retirement age in the next decade. Figures from the US Bureau of Labor Statistics show that US mining employment has experienced a long-term decline from 2008 until early 2020. However, since then, it has been gradually increasing.

One can only wonder why working in the industry is not popular when the median annual wage for mining and geological engineers was US$97,590 in May 2022, nearly double the national average. Among the Western US states, California is the only one that comes close to matching the mining industry's average salary, with an annual average wage of US$73,222.

If not the salary, then working conditions may be a contributing factor. Mining occurs in remote areas with limited amenities, which may not appeal to younger generations. Additionally, the pandemic has shifted people's attitudes toward work-life balance, with a preference for work from home in many cases. A survey published by McKinsey & Company targeting individuals aged between 15 and 30 revealed that 42% of respondents do not find the mining industry attractive and would "definitely not work" in mining. This places mining at the bottom of the rankings, with other sectors like oil and gas, high tech, and healthcare being more appealing to this age group. Another issue the mining industry must tackle is the gender imbalance. According to the latest data from the IEA, updated in November 2022, women represent only 15% of the labor force in the US mining industry.

The industry requires a makeover. Technology is set to lead this transformation. Mining companies can leverage technological disruptions, such as automation and AI, to make the sector more attractive and have access to a broader talent pool: "In industries such as construction and mining, a significant labor shortage has made it difficult to find skilled workers to operate machines. By blending machine learning with the skills of human operators, we can take advantage of where autonomous technology is today while increasing productivity and addressing labor shortages," commented Vinay Shet, CEO and co-founder of Teleo, which specializes in automizing mining and construction equipment.

Universities: A hotbed of new miners

Besides decreasing mining employment, enrollment in mining-related fields at universities has also been falling recently. According to Steve Trussell, executive director of the Arizona Mining Association, college and high school students do not consider mining a career option because they do not know enough about it. "One crucial aspect is transforming young people's narrow perspective of mining, who often perceive it as a dirty profession. Instead, we want to showcase the industry's advanced technological aspects," stated Misael Cabrera, director of the University of Arizona's School of Mining and Mineral Resources.

According to Data USA, a comprehensive website and data visualization platform for public US Government data powered by Deloitte and Datawheel, the institutions that awarded the most degrees in mining & mineral engineering are the Missouri University of Science and Technology, the University of Arizona, and the Colorado School of Mines. The latest figures indicate that the total number of degrees awarded in 2021 was 314, representing a decline of 41.09% compared to the peak of 533 degrees awarded in 2016. "The shortage of mining engineers in the US demands immediate attention. While the US needs 500 to 1,000 mining engineers annually, we only graduate around 200," stated Cabrera.

This decline is accompanied by decreased availability of mining and mineral engineering programs at US colleges and universities. According to a report from the Society for Mining, Metallurgy & Exploration (SMNE), in 1982 there were 25 mining and mineral engineering programs at US colleges and universities; this number had declined to 14 by 2014 and has remained unchanged since.

The University of Arizona School of Mining and Mineral Resources has a long-standing history supporting the industry, dating back to 1885. Today, the School of Mining and Mineral Resources combines existing mining and geological engineering departments, economic geology, public health, and social and environmental science disciplines to facilitate education and research.

The US Government has already taken actions to boost geological and mining education. According to Cabrera, the Mining School Act proposes to allocate US$10 million to support and strengthen mining schools, a breath of oxygen to enhance mining education. ■

Image courtesy of University of Arizona, School of Mining and Mineral Resources

Misael Cabrera

Director
SCHOOL OF MINING AND MINERAL RESOURCES, UNIVERSITY OF ARIZONA

What are some of the R&D projects the School is currently developing?

We have researched mine workers' internal body temperatures using a swallowable sensor for monitoring heat stress in underground work environments. Another project uses AI to detect whether workers are wearing personal protective equipment. Automation is also a key focus, with projects using specialized cameras to predict slope stability and detect minerals using hyperspectral technology. Additionally, we are actively investigating existing copper porphyry deposits for valuable rare earth elements and assessing the potential for reprocessing and recycling tailings piles.

With the Center for Environmentally Sustainable Mining, we are pioneering eco-friendly chemical compounds for dust suppression at tailings piles, with potential application in mineral extraction from acid mine drainage. Furthermore, researchers are converting mine tailings into concrete that sequesters CO_2.

What is the history and mission of the School of Mining and Mineral Resources?

The University of Arizona has a long-standing history of supporting the mining industry, dating back to 1885, when it introduced its first mining program. However, in 2021, the university leadership recognized that a more transdisciplinary approach to mining and minerals education was necessary; thus, the School of Mining and Mineral Resources was conceived.

Today, the mining industry faces various challenges related to environmental protection, social acceptance, and the exploration of deeper and less concentrated deposits, demanding a comprehensive multidisciplinary approach. To address these challenges, the School of Mining and Minerals brings together existing mining and geological engineering departments, economic geology, public health, and social and environmental science disciplines to facilitate education and research to tackle the industry's current and future obstacles.

What type of programs does the School offer?

We support the existing faculty and traditional majors related to mining. Additionally, we offer a minor in Sustainable Mineral Resources, allowing students to understand the mining industry comprehensively. We also provide professional development courses through the Lowell Institute and the Geotechnical Center of Excellence. These courses are designed to keep industry professionals abreast of the latest technologies and emerging issues. Furthermore, the Global Mining Law Program serves individuals with science or engineering degrees seeking specialized mining legal training. During the fall of 2023, the University will offer a course focused on automation and artificial intelligence in mining.

To enhance the student experience, we partner with the University's San Xavier Experimental Mining Laboratory, where students can train with mining equipment and develop hands-on experience in a real-world environment.

How is the School attracting the next generation?

Transforming young people's narrow view of mining, often seen as a dirty profession, is crucial. Instead, we want to showcase the industry's advanced technological aspects.

Part of our initiative involves clarifying the lucrative prospects of mining, with salaries starting around US$80,000 in Arizona. Additionally, we strive to highlight that mining is not an enemy of the environment but rather a catalyst for environmental preservation. ■

Production, Development and Exploration

“Mining holds a crucial place in shaping America's future. With abundant reserves of minerals and metals, America has the power to create countless jobs, drive economic growth, and ensure a sustainable future.”

Keaton Turner
Founder and CEO
TURNER MINING

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Precious Metals Production and Development

Nevada and Alaska are the precious metals bastions

Mark Bristow
President and CEO
BARRICK GOLD

> We are closely watching early projects and are intrigued by Hercules, hitting 0.84% copper over 185.29 meters in Idaho. As a major US miner, we are keen on investing early in promising opportunities for substantial value creation, leveraging our extensive exploration budget in mining-friendly states.

Precious metals production results in the US present opposite trends, with gold production declining while silver production rose. In 2022, domestic gold production was estimated to be 170 t, 9% less than in 2021, a trend that goes back to 2018, when US gold production peaked at 245 t/y. The opposite happened with silver. In 2022, the US produced 1,100 t, slightly above the 2017 production of 1,020 t. Nevertheless, thanks to robust gold prices, producers in the Western US have experienced a positive year. Not only does it seem that the gold price is in their favor, but global geopolitical turmoil has prompted investors to seek safe havens. Like gold, mining jurisdictions like the Western US are considered as safe havens when it comes to investments.

Nevada, the leading gold-producing state in the US, is home to Nevada Gold Mines (NGM), the world's largest gold-producing complex. NGM, a Joint Venture between Barrick (65.1%) and Newmont (38.5%), yields an annual gold production of approximately 3 million oz, encompassing 10 underground and 12 open-pit mines. Additionally, NGM's infrastructure includes two roasting facilities, two autoclave facilities, four oxide mills, and five heap leach facilities.

According to Peter Richardson, executive managing director of NGM, the first half of 2023 experienced a temporary dip in production due to planned processing restrictions, with expectations for a stronger second half. The decline in NGM's production was anticipated as they implemented planned outages at the Carlin processing facilities, including the roasters and autoclave. At the same time, maintenance activities took place at the Goldstrike and Gold Quarry roaster and, in the first operation, NGM completed the conversion of the Goldstrike autoclave processing facility to conventional carbon-in-leach. Additionally, it completed the first phase of the Gold Quarry roaster to increase throughput by 15% to 20%, with improvements in the grinding and roaster circuits.

NGM is investing not only in infrastructure but also in its fleet to improve efficiency and safety. "In our underground operations, we utilize remote mucking, where operators control loaders from the surface using joysticks and cameras. This method proves to be efficient, safe and highly productive. The absence of operators on the equipment allows us to extend operating hours, even during activities like blasts and shift changes," commented Richardson.

Komatsu is set to supply Nevada Gold Mines (NGM) with 62 Komatsu 930E-5 haul trucks between 2023 and 2025: 40 trucks assigned to the Carlin Complex and the remaining 22 designated for use at the Cortez mine.

As per S&P Global data, majors and gold producers have taken the forefront in driving drilling activities within the gold segment. In alignment with this trend, the JV between Barrick and Newmont is actively pursuing growth opportunities by drilling near existing targets and extending exploration efforts further. "Noteworthy projects include the 100% Barrick-owned Fourmile project adjacent to Cortez's Goldrush, which is considered the best-underdeveloped asset in its class. Additional focus areas include drilling around Robertson to uncover potential mergers of small pits and expansion to the West at Distal. Turquoise Ridge is a key site for drilling to expand the Cricket Corridor and close gaps in the south zone (BBT Corridor). The Greater Leeville area is also a priority, with active drilling in targets such as Little Boulder Basin, Western Spur, and North Leeville," continued Richardson.

Image courtesy of Elevation Gold Mining

Tim J. Swendseid
CEO
ELEVATION GOLD MINING

> Investors are increasingly supporting large mining companies, and we believe this positive sentiment will filter down to junior companies once the recognition of the disconnect between intrinsic values and current market capitalizations becomes clear.

For Tim Swendsaid, Elevation Gold Mining's CEO, the "re-shoring" sentiment among investors is significant. Like many others, he believes investors are increasingly favoring large mining companies. This sentiment will eventually extend to junior companies as the disconnect between intrinsic values and current market capitalization becomes more apparent: "I believe there has never been a better time to invest in American producing gold assets. We are experiencing the most turbulent geopolitical situation in a generation," he said.

The company produced 31,094 oz/y of gold at its Moss mine in Arizona: "An improvement over the 29,107 ounces produced in 2021," stated Swendseid. "Because of our efficiency improvements and mine plan optimizations this year, we expect to produce between 34,000 and 36,000 oz/y of gold," he added.

Elevation has spent around US$9.5 million to construct a new 3A-Ph2 leach pad, finalized on November 2023, which will provide the company with sufficient leach pad capacity until the end of 2025.

On the other side, Elevation Gold has been focusing exploration on the Reynolds Pit and the Mordor area adjacent to the Moss mine. Both targets, situated on the fully permitted ground, would enable Elevation to commence mining operations promptly, a relevant fact considering how challenging the permitting landscape can be.

Another company that plans to invest in infrastructure is Idaho Strategic Resources, which operates the Golden Chest gold mine in the Murray Gold belt area of the Coeur d'Alene mining district in Idaho. The company shifted to underground operations at the beginning of 2023, producing 5,000 to 10,000 oz/y. "Our focus lies in building a new mill at our mine, which would not only open up exploration opportunities but also give us control over the entire gold district and would be highly beneficial to our bottom line, leading to cost saving, increased revenue, and higher production capacity," explained John Swallow, president, and CEO of the company.

Despite being a gold producer, Idaho Strategic Resources has an RRE story coming to light with three projects spanning the southern to the northern regions of the underrecognized Idaho Rare Earth Element-Thorium trend: "On the REE side, our upcoming work includes trenching, which is set to commence in July 2023. We have also obtained permits for drill plans, with drilling expected to occur later in 2023. These activities form a crucial part of our exploration efforts to understand further and assess the potential of our REE projects," added Travis Swallow, stakeholder and corporate development of the company.

Gold development: The opportunity in the market

Alaska, the second gold producing US state, has seen plenty of activity in terms of gold, not only in production but also in the market. Contango Ore is a US-listed company developing and constructing the Manh Choh project in Alaska through the Peak Gold Joint Venture, an association with Kinross. Contango is 30% owner, with Kinross managing and owning the remaining 70%. The Manh Choh project boasts a 1 million oz gold deposit with grade ore averaging 8 g/t. To process Manh Choh's ore, the company will leverage Kinross' underutilized mill at the Fort Know mine in Fairbanks. According to Rick Van Nieuwenhuyse, president and CEO of Contango Ore: "Our decision not to build another mill and

tailings facility has significantly expedited the project's progress, reduced capital requirements, and shortened the permitting timeline." The company announced on August 30, 2023, that mining operations started at Manh Choh.

Despite the perception of unfavorable market conditions in the precious metal segment, Hycroft Mining is a Nevada-based company with a solid financial status with US$117 million in cash. According to Diane Garret, president and CEO: "With a robust treasury and the ability to raise additional capital, we are actively exploring potential M&A to expand our portfolio." Hycroft has been actively drilling its Hycroft mine to determine higher-grade intercepts and better define the starter pit of its ultimate mine plan. Hycroft is a past producing mine and is transitioning from heap leach operations to milling operations to process the sulfides: "We have a large amount of infrastructure already in place, from crushers to a refinery and on-site laboratory, which puts us well ahead of any other development company in that regard. We will need to install mills and autoclave for processing the sulfide ore," explained Garret.

Much like Hycroft, but in Idaho, Revival Gold has recently updated a resource estimate and completed a PFS for the first stage of restarting operations at its Beartrack-Arnett gold project. The company is pursuing a two-phase strategy, commencing with heap leach production and exploring the possibility of transitioning to a milling scenario for sulfides: "Resulting in an increased resource of 4.6 million oz and a strong 25% after-tax internal rate of return (IRR) on a modest US$109 million Capex for the first phase of development, it is important to note that this project represents the largest past-producing gold mine in Idaho, with existing infrastructure that saves us considerable time and money," commented Hugh Agro, president and CEO of Revival Gold.

Amidst market challenges where new investment is not flowing, companies find substantial support in understanding shareholders. That is the case of i-80 Gold, which, according to Ewan Downie, CEO of the company, has received strong support from Orion Mine Finance.

i-80 has been able to navigate current market conditions while moving forward with three different projects in Nevada: Granite Creek, the most advanced, where it recently completed mining on the first four levels and started shipping to Nevada Gold Mines for processing; McCoy-Cove project, where it established underground access for depth drilling; and Ruby Hill, the most drilling-active project, were it plans to develop both gold and base metal deposits. Besides the support of Orion Mine Finance, the company has extended its prepay facility, allowing it to sell gold forward instead of issuing shares: "We will continue to explore this approach with our assets and may even consider pre-sales on silver or base metals. We plan to utilize what I refer to as mezzanine financing methods to continue growing our business. Given that we expect to produce multiple metals, including gold, silver, lead, zinc and copper, we could consider streaming or royalty initiatives," explained Downie.

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"The lessons learned at Turquoise Ridge, mainly about the critical importance of teamwork and planned maintenance, are now being rolled out at the other Nevada mines."

Mark Bristow

President and CEO
BARRICK GOLD

How would you assess Barrick's performance in 2023?
As we disclosed at the time of our Q3 results, we expect our annual gold production to be marginally below the 4.2 to 4.6 million oz guidance range we announced at the start of 2023. This is primarily due to the delay in receiving the "Record of Decision" from the United States Bureau of Land Management in relation to the permitting of the Goldrush Project, changes in the Crossroads open pit model and some process interruptions to address long term maintenance requirements (all in Nevada). Turquoise Ridge had a stronger performance relative to 2022, thanks to a successful turnaround exercise by its new management team and the commissioning of its third shaft. The lessons learned at Turquoise Ridge, mainly about the critical importance of teamwork and planned maintenance, are now being rolled out at the other Nevada mines.

The "Record of Decision" at Goldrush was eventually received in late December 2023 and we are expecting to complete the ramp up at Pueblo Viejo by the end of Q1 2024 meaning these issues are largely behind us.

In the LATAM region, equipment issues hindered the ramp-up of our expansion project at our Pueblo Viejo gold mine in the Dominican Republic.

In Africa, we have had another steady performance with production at the 1.5 million oz/y mark, consistent with prior years and with all mines in the region expected to deliver on their guidance for the 2023 year.

As previously communicated, our 2023 copper production is expected to be within guidance, albeit at the low end of the 420 to 470 million lb/y range.

Can you discuss the importance of copper in Barrick's future strategy?
We plan to double our copper production by the end of the decade and continue to increase it to an estimated 1 billion lb/y by 2031. This will assist Barrick in delivering on its mission to build and operate world-class assets but at the same time continue to diversify our earnings as well as add to the global drive for a more sustainable, green economy. We believe that there remains significant upside potential in the gold industry and the copper operations are strategic and additive to that.

Reko Diq in Pakistan is positioned to rank as one the world's Top 10 copper mines when it reaches full production, and the pre-feasibility study on the Lumwana Super Pit Expansion is projected to deliver a potential of 240,000 t/y over a 36-year life of mine, from a plant expansion that will increase our processing capacity to 50 million t/y.

The accelerated Lumwana work program is scheduled to deliver a full feasibility study by the end of 2024, and following construction we are expecting production from the Super Pit to start in 2028. The Reko Diq project also remains on track to deliver an updated feasibility study by the end of 2024.

What factors could lead to a boost in gold production in Nevada?
Nevada Gold Mines has quality assets and enormous potential, making it the value foundation on which we intend to grow the business, but it is impacted by processing constraints which need to be overcome by boosting operational flexibility.

We see multiple opportunities at each of Carlin, Cortez and Turquoise Ridge to strengthen the life of mine with near-mine growth using the current infrastructure in the midterm (Leeville, Ren), new projects that can extend the use of the processing facilities (Robertson), and a long-term portfolio targeting significant brownfields and greenfields (Fourmile, Turquoise Ridge underground) to sustain current production past our 15-year plan.

We are planning to achieve this by increasing processing and mining run times, stepping up development at all the underground mines, improving and standardizing maintenance management, identifying and implementing efficiency initiatives, and tightening control of compliance with mine plans. ■

> We have tested autonomous trucks and underground battery-driven equipment, and currently we have several open-pit drills at Carlin operating autonomously.

Peter Richardson

Executive Managing Director
NEVADA GOLD MINES (NGM)

Can you provide an overview of Nevada Gold Mines (NGM) key achievements in 2023?
In the first half of 2023, we successfully executed planned outages at our Carlin processing facilities, including the roasters and autoclave. We also completed the conversion of the Goldstrike autoclave processing facility back to conventional carbon-in-leach in January and February, with production starting in March. The first half of 2023 was lower in production due to planned processing restrictions, but we anticipate a stronger second half.

Other significant milestones include ongoing expansion projects at the Gold Quarry roaster to increase throughput by 15% to 20%, with improvements in the grinding and roaster circuits. Our safety campaign "Journey to Zero" has been relaunched across Barrick, contributing to our second-ever injury-free month in April. We have made strides in proactive maintenance, particularly at the Turquoise Ridge Sage Autoclave, with plans to implement learnings at Turquoise Ridge UG mine and Goldstrike Autoclave. Despite challenging winter conditions in Q1, we have focused on rebounding through enhanced underground delivery at Carlin, Cortez, and Turquoise Ridge, and emphasizing stability in our process plants. Additionally, we have initiated the delivery of a new truck fleet, with nine trucks in operation by the end of Q3 and a total of 62 Komatsu 930E-5 haul trucks to be delivered between 2023 and 2025 for Cortez and Carlin. Overall, we are seeing positive trends in safety and performance across Nevada Gold Mines.

Can you provide an overview of NGM's exploration strategy and plans for the current year?
Our exploration efforts involve drilling near existing targets and extending further out. Noteworthy projects include the 100% Barrick-owned Fourmile project adjacent to Cortez's Goldrush, which is considered the best-underdeveloped asset in its class. Additional focus areas include drilling around Robertson to uncover potential mergers of small pits and expansion to the West at Distal. Turquoise Ridge is a key site for drilling to expand the Cricket Corridor and close gaps in the south zone (BBT Corridor). The Greater Leeville area is also a priority, with active drilling in targets such as Little Boulder Basin, Western Spur, and North Leeville.

How does Nevada Gold Mines approach ESG factors and sustainability?
Our approach involves the development of the NGM owned TS solar plant, a 200 MW solar facility, with 150 MW already installed. Additionally, we are transitioning our light vehicle fleet to electric vehicles, having deployed over 50 and planning to add 50 more in 2024. We are also building charging stations to support this transition. In terms of community engagement, we have invested in Nevada Gold Mines Early Learning Centers, allocating over US$4.5 million to establish high-quality, affordable childcare facilities. Furthermore, we are committed to the NGM Recreation Center in Elko, including a new state-of-the-art swim arena and recreational facilities.

Can you discuss Nevada Gold Mines approach to utilizing new technologies?
Our initiatives have included testing autonomous trucks and underground battery-driven equipment. Currently, we have several open-pit drills at Carlin operating autonomously, with the capability of remote control. In our underground operations, we utilize remote mucking, where operators control loaders from the surface using joysticks and cameras. This method proves to be efficient, safe, and highly productive. The absence of operators on the equipment allows us to extend operating hours, even during activities like blasts and shift changes.

We have invested in a new truck fleet designed to be autonomous-ready. While we are in the early stages, we are actively exploring opportunities to test and integrate autonomous trucks.

In our processing facilities, we are working to enhance control systems, improving reliability, productivity, and stability.

What are Nevada Gold Mines' goals for 2024?
We emphasize four pillars: license to operate including safety, environmental performance, GHG reduction, and community engagement. Another pillar focuses on people and culture, involving employee development and fostering our desired culture with the Barrick DNA at the core. Operational excellence is crucial, encompassing target delivery, cost management, and technological development, particularly in autonomous and remote operations. The final aspect is growth, which involves ensuring a solid 10–15-year plan through proactive exploration drilling, studies, and facility expansion to sustain our strategic pillars. To summarize our continued goals; safely producing while developing our people and being a responsible community partner with a continued focus on long-term growth. ■

> Our expansion to a rate of 2,600 tpd has led to lower production costs, establishing Greens Creek as one of the most cost-efficient silver mines globally.

Phil Baker

CEO
HECLA MINING

Since when has Hecla Mining been operating in Alaska and Idaho?
Hecla began operating in Alaska and Idaho 133 years ago, and since then, we have continuously operated within a four or five-mile radius from our starting point. Greens Creek, which has been operational since 1987, has experienced a significant increase in silver production. In 2023, we anticipate producing 9.8-10 million oz, a substantial ramp-up from just a few years ago when the mine produced 7 million oz. This growth primarily results from our efforts to expand the ore we mine and process, with our current daily rate now at 2,600 t. This expansion has led to lower production costs, establishing Greens Creek as one of the most cost-efficient silver mines globally.

On the other hand, the Lucky Friday mine, which has been operational since 1942, faced production challenges due to a labor strike by the union, which significantly reduced output. Fortunately, we resolved the strike in 2020, and since then, we have consistently increased production thanks to the adoption of a new mining method for which we recently obtained a patent. This transformation is propelling the mine toward becoming a 5 million oz/y producer, doubling its traditional output.

What is the Underhand Closed Bench mining method?
The Lucky Friday mine, situated nearly two miles below the surface, ranks among the deepest mines, subjecting it to considerable geological stress, which historically limited mining speed, causing the mine and stopes to shut down approximately 25% of the time. To address this limitation, we developed the Underhand Closed Bench (UCB) mining method. It allows simultaneous destressing of a substantial area, facilitating faster mining and ensuring continuous operations. The UCB method relies on advanced blasting technology, a development of the past decade, enabling us to blast a sizable ground section nearly 300 feet deep, inducing controlled seismic-like ground closure.

What technological advancements is Hecla implementing to enhance mining operations?
One of the key technologies we are currently utilizing involves the development of autonomous jumbo drills. We have seamlessly integrated this technology into our operations, and the results have been noteworthy. We have achieved a remarkable 10% reduction in overbreak, all while maintaining precise control to prevent underbreak. This improvement holds immense importance, enabling us to extract ore efficiently while minimizing waste.

What are some of Hecla's exploration projects in the US?
Our most advanced project is in Montana, where we have access to an extensive deposit of over 300 million oz of silver across two deposits, along with a substantial 3 billion lb of copper. This project essentially checks both the silver and copper boxes, and we are currently in the final stages of obtaining exploration authorizations. In the past, this project was known as Montanore, and our request was primarily for mining authorization. However, we have re-evaluated our approach and decided to focus more on exploration. This project is now called the Libby Exploration project, and we aim to advance from resource to reserve; subsequently, we will seek permission to commence mining operations.

In Colorado, we have made significant progress on the Bulldog deposit. However, we are actively negotiating with the government to ensure that our additional efforts do not lead to any unexpected liabilities. In Nevada, we have substantial exploration projects underway, and we are steadily advancing on those as well.

What is Hecla's strategy for achieving and sustaining growth?
We are actively seeking opportunities that align with our existing operations, and we have a versatile approach to the type of metal we are considering. Whether it is silver, gold or other hard rock metals like cobalt and nickel, we are open to exploration as long as there is synergy with our current operations.

Additionally, our interest in silver extends worldwide. We are currently in the process of developing a mine in Yukon, specifically in Keno Hill. As we continue to expand, Latin America is likely to be our next growth destination. To highlight our commitment to the region, our vice president of operations has been with our company for 27 years, and 17 of those years were spent working in Latin America. Our extensive history in the region positions it as a strategic area for our future growth. ■

> We consciously shrunk our footprint back to North America to mitigate geopolitical risks and stick to where we can leverage our deep relationships and knowledge to grow the company.

Mitchell Krebs

President and CEO
COEUR MINING

Can you give an overview of Coeur Mining's activities and milestones achieved over 2022?
Coeur Mining is on track to produce between 10 million and 12 million oz of silver and 300,000 to 350,000 oz of gold in 2023. When we acquired the Wharf mine in Western South Dakota in 2015 for US$99 million, it had an approximate five-year mine life. Today, it still has a mine life of eight years, and we have taken out nearly US$400 million of free cash flow from this asset. Wharf has been the unsung hero of our operations and seems to continue to generate milestones for us every year.

Coeur's Palmarejo mine in Mexico is our largest mine, producing approximately 7 million oz/y of silver and about 110,000 oz/y of gold. The mine has continued to operate consistently, which is greatly appreciated, especially when we are undergoing a significant transformation and expansion at our Rochester mine in northern Nevada.

How did Coeur manage high inflation to have a lower impact on the company's operations?
Inflation in the labor component of our business is the stickiest given the scarcity of the labor pool.

Coeur has an operating excellence team focusing on identifying new opportunities to be more productive and whose target this year is to identify and implement US$25 million of business improvement savings to try and offset inflation. Over the past two years, while inflation is up, metals prices remain at fairly stable levels, but they have not risen enough to offset the impact of inflation, so you have to be ruthless regarding your cost structure, efficiency and consumption of crucial consumables and inputs to try and maintain your margins.

Can you elaborate on Coeur's expansion activities at the Rochester mine?
By the end of August 2023, the Rochester expansion was 99% complete. The expansion project comprises a stage VI leach pad, a Merrill-Crowe processing plant, and a three-stage crushing circuit and related infrastructure, which is now substantially complete. We are enthusiastic about ramping up the Rochester mine on the back of this significant expansion, which is expected to deliver mining and processing rates approximately 2.5x higher than historical levels. We expect to reach a run-rate processing rate of approximately 32 million t/y in the first quarter of 2024.

The project's overall cost is expected to be about US$710 million. That is a big project for a company our size that poses many risks. As a result, it's critical that we continue to de-risk the project by wrapping up construction, ramping up the operation, and then starting to show free cash flow in 2024. With a lot of exploration to be conducted in the coming years, we hope to further extend and enhance the current 13 year mine life.

What is Coeur's exploration strategy?
Over the past five years, we have invested approximately US$250 million into exploration, which has added close to 8 million gold equivalent oz across all categories – reserves are up by approximately a third, measured and indicated resources are up by about 80%, and inferred resources are up by 26%.

Most of our exploration investment is done around our existing infrastructure, which tends to be lower risk and higher return. This year, we will spend nearly US$50 million, with approximately 60% spent at Kensington in Alaska and the high-grade Silvertip polymetallic deposit located in British Columbia.

Is there an advantage of being a North America-focused company?
Over the past decade, we consciously shrunk our footprint back to North America to mitigate geopolitical risks and uncertainties and stick to where we can leverage our deep relationships and knowledge to grow the company. The permitting predictability, infrastructure, access to capital, and quality workforce make it a no-brainer for us to stay focused only in North America. Operating in lower-risk jurisdictions comforts investors when they look at a company like Coeur.

Do you think investors' sentiment has shifted to critical minerals projects rather than precious metals?
I believe that battery metals and rare earth elements have shined a spotlight on the need for mining, and it has brought new investors into the industry, which has been a positive for the mining sector overall. Accelerating the amount of investment and streamlining the permitting process for critical minerals will benefit other aspects of the mining sector. ■

Tim J. Swendseid

CEO
ELEVATION GOLD MINING

What were some of the investments you have made, and control measures the company has implemented?
In June 2023, we commenced the construction of a new 3A-Ph2 leach pad. This involves an approximate expenditure of US$9.5 million and is expected to be finalized by October 2023, providing us with sufficient leach pad capacity until the end of 2025. Moreover, in 2022, we constructed two water wells, enhancing our on-site water production capabilities to meet all our operational needs. We have improved our control measures for the heap leaching processing, focusing on pH levels and cyanide dosage. By fine-tuning our lime dosage, we halved the cyanide consumption compared to the beginning of 2022. Additionally, we integrated advanced and sophisticated leach models that enable us to forecast and anticipate gold recovery more accurately, providing valuable insights into both the expected yield and the timing of the recovery process.

Can you speak about the exploration potential of Reynolds Pit and Mordor Area?
We recently drilled intercepts that were the best-ever encountered at the property and were much better than we hoped to find at the more-remote Florence Hill exploration area. The Reynolds pit and the Mordor Area are adjacent to the Moss mine, and that area can be mined much sooner than Florence Hill.

These targets are situated on fully permitted ground, enabling us to commence mining operations promptly upon discovery and adequate definition, making them more favorable locations than remote areas. The exploration results in these areas have exceeded our expectations, revealing higher-quality ore than initially planned for our 2024 budget.

We now anticipate remaining within the currently permitted ground for a number of years, during which time we can construct leach pads and waste dumps and carry out mining activities. This time frame allows us to pursue permit applications and secure approval for expanding our boundaries, allowing us to extend mine development for an additional time period.

The assay results for Mordor and Reynolds Pit areas are very promising, and we have already begun preparations for mining in the Mordor area as part of our 2023 plans. Regarding Reynolds, although further drilling is required, the indications suggest a more continuous mineralization with a higher grade than the West Pit mining area. Once additional drilling is completed, we will incorporate these findings into our 2024 mining plan.

What is the company's immediate focus on exploration?
For the short term, we will focus on the Reynolds Pit and Mordor area. Following that we will resume exploring the mineralized material beneath the Moss Mine crusher facility. Our drilling efforts have intersected significant ore grade material in the Ruth Vein, and in-between the Ruth vein and the Moss Vein to the north is not adequately drilled. We think the area is very promising.

How has the performance of gold been in recent months?
I believe there has never been a better time to invest in American producing gold assets. Investors are increasingly supporting large mining companies, and we believe this positive sentiment will filter down to junior companies once the recognition of the disconnect between intrinsic values and current market capitalizations becomes clear. ■

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Silver production: The unsung hero of the electricity transition

According to the Silver Institute's figures, 2022 saw a deficit of 237.7 million oz of silver. This is the most significant deficit recorded, and even though the Silver Institute forecast that in 2023 global silver demand is predicted to fall, lower output from Mexico and Peru are expected to ensure that the global market is set to see another deficit for the third year in a row.

In 2022, the US produced 1,100 t, slightly above the 2017 peak production of 1,020 t. Nevada, known as the 'Silver State,' is no longer the leading state for silver production since Alaska overhauled it in 2022. Coeur Mining is a company that has assets in both jurisdictions. Mitchell Krebs, Coeur Mining's president and CEO, stated that the company is on track to produce between 10 and 12 million oz of silver and 300,000 to 350,000 oz of gold in 2023. During the last few years, Coeur has been in the spotlight because of the expansion at Rochester mine, where it allocated between US$710-730 million. By the end of August 2023, the expansion at Rochester was 99% complete, comprising a stage VI leach pad, a Merrill-Crowe processing plant, and a three-stage crushing circuit. "We expect to reach a run rate processing rate of approximately 32 million t/y in the first quarter of 2024, which will drive production levels up and costs down and is expected to generate free cash flow, not only at Rochester but for the company, which we can then use to reduce the debt we have incurred to partly fund this expansion," explained Krebs.

Another company with links to Alaska is Hecla Mining. The company operates the Greens Creek underground mine, which has operated since 1987. According to Phil Baker, CEO of Hecla, the company anticipates a significant ramp-up, targeting a production of 10 million oz for 2023. This marks a notable increase compared to the average output of 7 million oz/y in the preceding years.

The other producing asset of Hecla in the Western US is the Lucky Friday underground silver-lead-zinc mine, located in the Coeur d'Alene mining district in northern Idaho. Baker explained that the Lucky Friday mine, situated two miles below the surface (approximately 3.21 km), is subjected to considerable geological stress. This stress has historically constrained mining speed, resulting in the mine being shut down approximately 25% of the time. To overcome this limitation and enhance operational efficiency, Hecla has introduced a novel underground mining technique known as the Underhand Closed Bench (UCB) mining method. This method enables the simultaneous destressing of a significant area through advanced blasting technology, ultimately facilitating faster and more efficient mining operations: "We have consistently increased production, thanks to the adoption of a new mining method for which we recently obtained a patent. This transformation is propelling the mine toward becoming a five-million-ounce producer, doubling its traditional output," he explained. ■

Rick Van Nieuwenhuyse

President and CEO
CONTANGO ORE

Can you introduce us to Contango Ore and its under-construction Manh Choh Project?

Contango Ore is a US-listed company (NYSE-A: CTGO). We are currently constructing the Manh Choh Project, a discovery we made on land owned by the Tetlin Tribe in Alaska, which boasts a 1-million-oz gold deposit with a high-grade ore of averaging 8 g/t. To develop the project, we established the Peak Gold Joint Venture (PGJV) with Kinross, whereby Contango is a 30% owner with Kinross managing and owning the remaining 70%.

To process Manh Choh's ore, we will use Kinross' underutilized mill at the Fort Knox Mine in Fairbanks. Our decision not to build another mill and tailings facility has significantly expedited the project's progress, reduced capital requirements, and shortened the permitting timeline. We anticipate commencing production by July 2024, with an estimated annual gold output of 225,000 oz.

What is Manh Choh's exploration upside?

The Manh Choh Project is on an expansive property of 675,000 acres. Because of its extent, we have explored less than 5% of the area. The project's location is strategically significant as it lies within the Tintina Gold Belt, a geologic province that has yielded over 100 million oz of gold. We expect to uncover substantial additional gold ounces through extensive baseline stream geochemistry and diligent follow-up on numerous anomalies. The PGJV has a US$3 million budget for exploration this year. However, once the mine is operational, we anticipate augmenting this budget significantly.

Could you speak of Lucky Shot, the company's other project?

Between Coleman and Lucky Shot we believe our currently planned drilling will outline in excess of 400,000 oz. Like the Manh Choh Project, our plan will evaluate the possibility of transporting the ore to the Fort Knox Mill for processing. The proximity of the railroad, a mere 20 miles from Lucky Shot, would significantly reduce transportation costs. ■

Ewan Downie

CEO
I-80 GOLD CORP

How has i-80 Gold Corp been advancing its three projects?

The first project, the Granite Creek operation, is the most advanced. We recently completed mining on the first four levels and built a substantial gold mineralization stockpile, which we have begun shipping to Nevada Gold Mines for processing. Moreover, we have also successfully delineated a new deposit, the South Pacific zone, which we plan to begin mining in the first quarter of 2024. This is the first project for our company that we are targeting to become cash flow positive.

The second project, the McCoy-Cove Project, is our flagship gold project. We have made significant progress in 2023, including establishing underground access for depth drilling and completing the necessary infrastructure for an underground drill program. We are currently performing definition drilling to upgrade our inferred resources to indicated ones and expect to deliver a full feasibility study in 2024.

Finally, the Ruby Hill Project is our most active in drilling. We plan to develop both gold and base metal deposits at this site. The gold mineralization will be transported to our processing facility. At the same time, we plan to convert the existing gold leach plant at Ruby Hill into a base metal flotation plant producing both zinc and lead concentrate.

What should we expect in the upcoming months from i-80?

The most significant catalyst for i-80 is obtaining the final permits for Cove and for Ruby Hill to begin the underground development program. Once we secure the permit for Ruby Hill, all three of our projects will be permitted for underground development or production by mid-2024. Given the increasing difficulty in obtaining permits to build mines due to ESG factors, achieving this at all three sites is a significant milestone for our company. We also anticipate a continued ramp-up of production at Granite Creek. ■

Diane Garrett

President and CEO
HYCROFT MINING

Can you elaborate on the 2022 and 2023 drilling campaigns at Hycroft?
Phase One drilling at Hycroft aimed to determine whether the higher-grade intercepts were individual intercepts or if there was continuity between them. Our drilling determined there was indeed continuity, and this understanding of where the higher grades occur within our system has also aided in infill drilling, improving the economics of the mine's first 10 years by converting waste to ore and reducing our strip ratio. The resource currently sits at approximately 15 million oz of gold equivalent in the measured and indicated category, plus an additional 5 million oz of inferred. It is one of the largest precious metals deposits in the world and we have nearly 500 million oz of silver.

Despite the vast resources at Hycroft, only 10% of our land package has been explored. We see a huge opportunity to tap into possible high-grade feeder zones or new higher-grade deposits by applying first principles to our land package and systematically doing the exploration work to test those targets.

What led Hycroft to acquire claims near the past-producing Rosebud mine?
These claims, acquired from Newmont and held in a 50-50 undivided interest with Hecla Mining, came with a wealth of data, including historical drilling, geophysics, soil sampling, and geochemical analysis. This data filled the gap between Hycroft and Rosebud, saving us millions of dollars if we were to conduct that work today. By combining this data with our own data in the area, we have identified three priority targets outside our existing resource at Hycroft: Wild Rose, adjacent to our high-grade silver deposit Vortex, Oscar and School Bus, both adjacent to Rosebud. These three targets hold great potential for future exploration. We have a large amount of infrastructure already in place, which puts us well ahead of any other development company in that regard. ■

John Swallow and Travis Swallow

JS: President and CEO
TS: Stakeholder & Corporate Development
IDAHO STRATEGIC RESOURCES

Can you introduce us to Idaho Strategic Resources?
JS: Our business comprises two segments: We operate as a gold producer, being the sole underground primary gold producer in Idaho, and we have a significant focus on Rare Earth Elements (REE) and critical minerals, owning the largest land package for these resources in the country, with the majority located within Idaho. As of the beginning of 2023, we have shifted our focus to underground mining at Golden Chest - producing between 5,000 to 10,000 oz/y.

TS: Regarding our gold operations, we control an entire gold district and are vertically integrated, handling everything from exploration and drilling to our final concentrate production.

What makes your RRE side of the business interesting?
JS: With a watchful eye on critical minerals in Idaho, we waited for the situation involving China to unfold. Just before the onset of COVID, we took proactive measures by staking and acquiring REE properties, expanding our portfolio. Since then, we have intensified our focus on this side of our business and are advancing the Lemhi Pass, Diamond Creek, and Mineral Hill projects. To support this advancement of the REEs side, we have been utilizing cash flow generated from our gold operations.

TS: Our REE projects encompass approximately 18,000 acres distributed among our three projects. The exciting part about the central Idaho area where they are located is the renowned Idaho Cobalt Belt.

What is the focus of the company for the upcoming months?
TS: On the REE side, our upcoming work includes trenching, which is set to commence in July 2023. We have also obtained permits for drill plans, with drilling expected to occur later in 2023. These activities form a crucial part of our exploration efforts to understand further and assess the potential of our REE projects. ■

Precious Metals Exploration

Capital drought for junior players

Gold prices in the past months have been subjected to a dynamic interplay of economic, geopolitical and market forces. The Federal Reserve's strategic move to raise interest rates 11 times aimed at taming inflation profoundly impacted the precious metals segment. As interest rates increased, the dollar strengthened, and gold faced intensified competition from other investments, leading to shifts in demand and subsequent price fluctuations.

On the other hand, the outbreak of the Israel-Hamas conflict in October changed the direction of gold prices, showcasing the market's immediate response to geopolitical events. Ongoing tensions globally tend to elevate the appeal of safe-haven assets like gold. On the other hand, many assume that the Federal Reserve has concluded its interest rate hikes and may initiate rate cuts in the first half of 2024, weakening the dollar and spurring gold prices, flirting with records.

Despite this favorable recent trend in gold prices, the markets have not been the best for the junior precious metals segment. There is a weak sentiment prevalent among investors in this segment, in part driven by the boom on the green energy minerals. "The spotlight has undoubtedly shifted towards critical minerals, primarily due to the initial rush associated with new opportunities, much like the gold rush or Klondike days of the past. The current market sentiment is not particularly favorable regarding precious metals," stated Darcy Marud, president and CEO of Western Exploration, a Reno-based Nevada-focused precious metals exploration company.

John Watson, CEO of NV Gold, agrees with Marud. NV Gold has been focusing during 2023 on its Triple T project in Nevada, where it has successfully drilled 14 holes, intersecting potentially economic grades of gold. Additionally, it conducted an on-site field program to identify new drill targets. However, the company decided to put several upcoming drill programs on hold, both in the Triple T as well as in other projects like the SW Pipe Gold and Slumber Gold project, until market conditions improve: "Considering the current market conditions, which, in my opinion, have not improved enough for financing, coupled with our low stock price, raising funds without substantial dilution is challenging. Consequently, we are currently on pause and internally financing the company through loans from insiders to sustain operations," explained Watson.

Low valuations present an opportunity for investors to explore and many C-executives from the junior segment remain bullish on the fundamentals of gold. "The flattening out of rate hikes in the past couple of months indicates a potential shift, which may lead to a significant upswing in gold prices," stated James Hesketh, president and CEO of Viva Gold.

Viva conducted an RC drill program at its Tonopah project where it encountered shallow, high-grade gold zones. "These discoveries included 9 m at 2.4 g/t ; 9 m at 3.0 g/t; and 41 m at 1.5 g/t, all starting at 24 m of the surface," shared Hesketh.

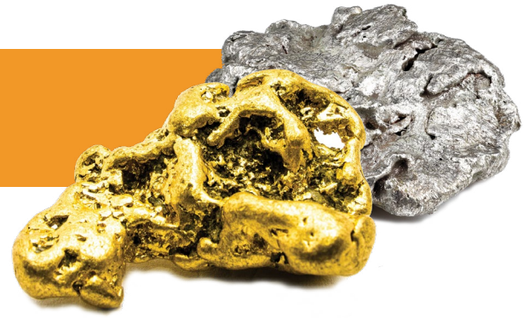
The perks of the US as a mining jurisdiction
To attract investors, the sole value of the deposits is not enough. Juniors must showcase a clear strategy and pathway for de-risking operations with minimal capital expenditure. While there is no perfect recipe for success, the triangulation of a proven team, a safe jurisdiction, and a promising deposit works as a strong foundation.

Chelsea Hayes, director of business development at North Peak Resources, explained that what sets the company apart from other juniors is its team's track record. The company was founded in 2020 by the same team that founded Kirkland Lake Gold. After promising drilling results in Nevada's Eureka district, they decided to acquire, in 2023, the Prospect Mountain property. North Peak also owns the Kenogami Lake project in Ontario. "One of our critical criteria when identifying potential targets is securing assets in politically stable environments. Ontario and Nevada are known for their solid regulatory environments and mining-friendly communities," explained Hayes.

Another company that bet in the Western US is U.S. GoldMining. The Alaska-focused junior is a spinout of GoldMining and completed an IPO at the end of April 2023, listing on NASDAQ and raising US$20 million to explore the Whistler gold-copper project in Alaska. "With gold trading in the range of US$1800-2000 over 2022, GoldMining saw the opportunity to launch the U.S. GoldMining 'spinco' to unlock value in the Whistler project," commented Tim Smith, president and CEO of the company. The Whistler project is a gold-rich copper porphyry style and has indicated resources of approximately 3 million oz and inferred resources of around 6.45 million oz. ■

Image courtesy of American Pacific Mining

Highlighted Projects: Precious Metals



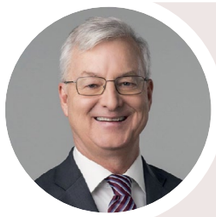
What strategies have juniors adopted?

John Watson, CEO, **NV GOLD**

“In 2023, our main focus was the Triple T Project. We drilled 14 holes, expanding a known mineralization zone; 13 holes showed potentially economic gold grades. We grew the project's land holdings and plan further expansion. An on-site field program from August to October, involving surface sampling and small-scale mapping, aimed to identify drill targets. The drill program is on hold, awaiting market improvement for fund securing. After the field program, we obtained promising results, including multigram surface samples that strongly suggest that the mineralization system extends approximately 1 to 1.5 kilometers to the north and further south.”

James Hesketh, President and CEO, **VIVA GOLD**

"At the Tonopah Gold Project, our tests indicate up to 94% recoveries by grinding higher-grade gold and tank leaching. The residual pulp, combined with lower-grade mineralization, undergoes final heap leaching. Efficient recovery requires grinding the high-grade material to about 75 microns or approximately 200 mesh for full liberation. Gold recovery, ranging from 68% to 94%, depends on the fineness of the crushed/ground material. The decision on the most economic and positive cash flow return involves engineering considerations, determining the extent of this process. For higher-grade materials above 1 g, the additional size reduction step seems advantageous, offering a rapid economic payoff."



Darcy Marud, President and CEO, **WESTERN EXPLORATION**

“We currently envision our projects in Nevada as standalone but with the potential for shared infrastructure. Specifically, Doby George, being an oxide deposit, is suitable for a standard open-pit heap leach operation, making it relatively straightforward. However, as it deepens, it will transition into sulfide mineralization. Conversely, Gravel Creek represents an underground sulfide deposit, necessitating a different processing approach. Nevertheless, there may be an opportunity to incorporate additional sulfide resources from Doby George, should exploration show promise in expanding this deposit. This flexibility provides us with multiple options for exploration, development, and maximizing the value of our assets.”

Corrado de Gasperis, CEO, **COMSTOCK**

"Comstock Inc. fully owns Comstock Fuels, Comstock Metals, and Comstock Mining, and holds less than 50% of GenMat. Comstock Mining possesses assets covering 12 square miles, hosting around one million ounces of gold and eight million ounces of silver. While these are substantial assets, I anticipate that GenMat's mineral discovery technology will establish a global presence with a vast market. GenMat's Physics AI engine, ZENO, can simulate existing materials and their characteristics at the atomic level at unprecedented speeds and scales, facilitating optimization of existing materials and discovery of new solid-state materials."

Copper Production and Development

The imperative for new copper projects to satisfy domestic demand

In 2022, copper production in the US was estimated at 1.3 million tons (t), an increase of 6% compared to 2021. Arizona, the copper state, where major copper mines belong to big players such as Freeport-McMoRan, Asarco, Carlota Copper (a subsidiary of KGHM International), Taseko Mines' Florence Copper asset, and Excelsior Mining, maintained its position as the leading copper-producing state, accounting for approximately 70% of domestic output (copper was also mined in other Western States like Nevada, New Mexico and Utah).

The most significant increase in 2022 in copper production was due to Rio Tinto's Bingham Canyon mine in Utah —more commonly known as Kennecott, but 2022 also saw a significant rise in copper production thanks to Freeport-McMoRan's Morenci and Safford mines in Arizona, which offset Asarco's decline. However, during the first half of 2023, most US copper mines have declined in production compared to the first half of 2022. According to USGS's figures, Freeport produced 7% less than during the same period in 2022 (362,000 t of copper vs. 391,000 t), mainly due to unplanned maintenance and lower ore grades and mining rates.

KGHM's Robinson Mine in Nevada also decreased its production by 66% because of lower-grade copper ores from inventories and the transition zone of the mine deposit. Rio Tinto's Kennecott produced 55,100 t of copper in concentrates during the first six months of 2023, 25,900 t (32%) less than 811,000 t in the first six months of 2022, mainly due to record snowfall in the first quarter and a conveyor belt motor failure at the concentration plant in March. What is interesting about this first half of 2023 compared to the first half of 2022 is that these decreases were partially offset by higher production at Asarco's mines in Arizona, where total copper output increased by 5% from that in the first half of 2022 (60,900 t).

According to a report by McKinsey & Company, the demand for copper is expected to reach 36.6 million t/y by 2031 due to electrification. However, current supply projections offer only 30.1 million t/y, leaving a significant gap. In response to this challenge, many copper-producing companies are developing new techniques and implementing innovative technologies to ramp up operations by producing from brownfield settings, tailings ponds, or stockpiles. One example is Freeport-McMoRan. Freeport's president and COO for the Americas, Joshua Olmsted, unveiled that the Phoenix-headquartered company had adopted a 'leach to the last drop' approach, looking for incremental copper growth through the solvent extraction, electrowinning, and leaching processes: "This initiative is about leveraging our resources in stockpiles. With innovative leaching technologies, we can tap into 38 billion pounds (lb) of copper contained in our stockpiles that were previously deemed unrecoverable and now produce incremental copper with the benefits of not having to mine," said Olmsted.

According to Olmsted, in the US Freeport is targeting production of 200 million lb/y of copper for 2023 with the 'leach to the last drop' approach and then driving that growth up to 800 million lb/y.

In the meantime, the company continues to spend significantly in the Safford district around the Lone Star project to understand the resource. "Several years ago, we decided to go after incremental copper at Safford via the Lonestar oxide project to take the production capacity up to approximately 300 million lb/y. We are well on our way to that, and in the longer term, as we develop and invest in exploration, we are developing a model to help us define the potential for a much broader footprint at Safford," explained Olmsted.

Another major player in Arizona is Asarco, part of Grupo Mexico, which possesses the Ray, the Mission Complex, and Silver Bell mines in the copper state. The largest operation is Ray, which consists of an open-pit mine with a concentrator and a solvent extraction-electrowinning (SX/EW) operation that generates copper concentrates, followed by the Mission Complex, which also has its concentration plant. According to Grupo Mexico's fourth quarter and annual results published in February 2023, Asarco's Arizona production totaled 112,232 t/y of copper in 2022, an 11.4% decrease compared to 2021. It is imperative that major copper producers like Freeport and Asarco ramp up operations to meet the previously mentioned decarbonization goals; however, this is not an easy task. Copper producers face not only permitting obstacles and rising costs due to inflation but also labor shortages. Asarco, in particular, has experi-

Image courtesy of Resolution Copper

enced the impact of a shrinking workforce in its operations. "We confront a scarcity of personnel, resulting in operations functioning below our desired capacity. Nevertheless, we are adeptly adjusting to the projected pace and have successfully met our financial targets for 2022 and the initial half of 2023," said Óscar González Rocha, Asarco's CEO.

Besides the mines in Arizona, Asarco owns the Hayden smelter and the Amarillo copper refinery in Texas. Because both assets had been operating at a low rate, Asarco decided to suspend the Amarillo refinery. At the same time, the Hayden smelter recently started processing slag in 2023 to recover the remaining copper from the company's operations: "We are primarily selling the concentrates we send to the northern border of Mexico, specifically the port of Guaymas, where they are shipped to Asia and, to a lesser extent, Europe," added Rocha.

According to several media outlets, at the end of October 2022, Asarco was in talks with Freeport-McMoRan for a potential smelter sale. However, it seems that no agreement was forthcoming. When asked about Asarco's goals for the upcoming years, González responded that they have a long-term work horizon by sustaining Asarco's operations for another 10 to 15 years by leveraging existing reserves: "We aim to restore operations at the Hayden smelter and the Amarillo refinery to produce copper cathodes and rod, which are primarily sold in the eastern region of the US."

Near Freeport's operations in Arizona's Globe-Miami district, we find Capstone Copper's Pinto Valley Mine. This copper-molybdenum mine yielded a copper production of 57,000 t in 2022, and has a mine plan that extends through to 2039, with mineral resources exceeding 1.3 billion t. According to Lyndsay Potts, the general manager of Pinto Valley, exploration has not been a primary focus for the company due to the substantial resource endowment. Instead, they have alternative plans to enhance production. This includes evaluating sulfide leaching to unlock value from their underutilized SX-EW plant and, like Freeport, recover copper from waste via sulfide leaching technologies. One particularly interesting aspect highlighted by Potts is Pinto Valley's commitment to maintaining an open dialogue with its neighbors in the Globe-Miami district, including Freeport and BHP. "We believe that by working together, we can expand production over the medium-term while also lowering costs and bringing significant benefits to many stakeholders in the district," she concluded.

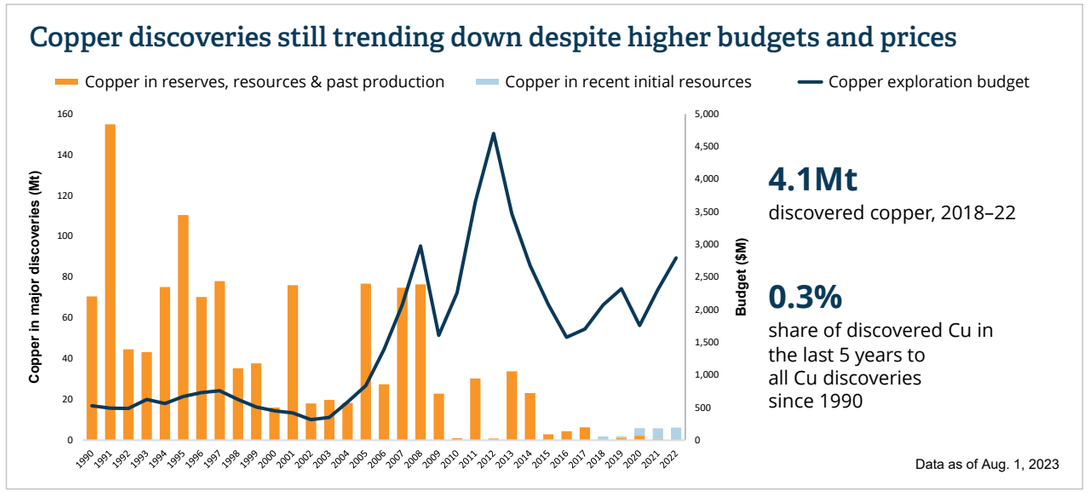
Recognizing that each company has unique objectives regarding profitability and corporate strategies, Potts' statements make one wonder about the potential implications for Arizona and, more broadly, the US if the Globe-Miami district were to undergo consolidation. While conversations about hub-and-spoke models have mainly centered around junior companies, it would be interesting to delve into the advantages of a semi-integration without a merger. The potential benefits and synergies are clear: combining financial resources for exploration, sharing infrastructure, knowledge, and deposits. This collaborative approach could boost US production and align with Washington's objectives.

Copper development

With the scarcity of new copper projects coming online to meet the looming deficit, companies are making strides to advance their existing projects. Arizona Sonoran Copper (ASCU), an emerging SX/ EW and heap leach copper developer on private land, is focusing on developing its brownfield Cactus project, including the new Parks/Salyer deposit. The Toronto-headquarter company is working on the forthcoming PFS for the first quarter of 2024. According to George Ogilvie, president and CEO of ASCU: "The upcoming PFS promises to be transformational for Arizona Sonora. In contrast to the 2021 PEA, which excluded Parks/Salyer, this PFS will integrate the deposits and target a 45,000-50,000 t/y heap-leach and SX/EW processing to produce copper cathodes over a mine life of 25-30 years."

In September 2022, ASCU released the maiden mineral resource estimate on Parks/Salyer that boasts a 2.9 billion lb resource with a grade exceeding 1% of total copper. Since then, it has completed a 105,000 feet infill drilling program targeting the indicated category, completed in March 2023 with all assays confirming robust thickness and aligning with the inferred mineral resources announced in 2022.

Copper producers and developers not only play a pivotal role by supplying the red metal but also bear the responsibility of sticking to the highest socio-environmental standards. This responsibility ensures that the increasing demand for copper does not result in the environmental damage that it is supposed to reduce. Thus, technology is leveraged to enhance production and make it more sustainable and environmentally friendly. In this context, ASCU, like many other



Source: S&P Global Market Intelligence

copper projects worldwide, collaborates with Nuton, a Rio Tinto company, to research copper recovery from primary sulfides. The goal is to reduce water consumption and lower GHG relative to traditional milling, while ultimately opening the door for an additional 1.7 billion lb of copper.

Another company with quite advanced-stage projects and close ties with Nuton is Excelsior Mining, which, in February 2023, announced an updated PEA on Johnson Camp mine (JCM), incorporating sulfide leaching technology. Nuton's technology would enable Excelsior to access the previously unmined 1% sulfide copper at the bottom of the JCM open pit, which saw its last mining activity in 2010, when the high-grade oxide was depleted. "If all the test work proves favorable for our commercial mine design, we aim to break ground at JCM sometime in H1 of 2024," explained Stephen Twyerould, president and CEO of Excelsior Mining. "At the end of the three to five-year trial, Nuton can exercise an option to establish a joint venture for the remaining 15 years of the mine's life," continued Twyerould.

Excelsior's other project, the Gunnison Copper project, Twyerould describes as "distinctive" due to its in situ recovery method, a mining extraction process widely used for uranium, but gaining momentum for its reduced environmental footprint: "The process eliminates traditional mining activities, resulting in no excavation, tailings, and minimal waste. It significantly reduces water consumption and greenhouse gas emissions, making it an environmentally unparalleled approach in the mining industry," commented Twyerould.

Excelsior developed a well-stimulation approach akin to hydraulic fracking, to increase permeability and flow rates in rock formations. "We successfully amended our EPA operating permit in 2023 to allow for well stimulation and plan to conduct field trials in H1 2024. If the trials prove successful, we plan to optimize and integrate this approach into our commercial production plan, ultimately getting back into production and regaining the value of our Gunnison Copper project," concluded Twyerould.

Locating high-quality copper deposits is becoming more complex. Mature jurisdictions have already been exploited, deposits are found in more remote and economically challenging areas, or ore grades are declining. According to Victoria Peacey, president and general manager of the Resolution copper project, a joint venture between Rio Tinto and BHP, US mines are often a century old with low and declining copper grades: "New supply is needed to replace lost and declining production and meet current and future domestic demand. Copper deposits such as Resolution are rare and exceptional."

Located in the Copper Triangle, the Resolution Copper project has a projected LOM of 60 years. It could generate approximately 3,700 direct and indirect jobs, not to mention the potential to fulfill up to 25% of the current US copper demand. The JV between Rio Tinto and BHP has faced opposition from several Native American groups and a delay in the Final Environmental and Social Impact Statement (FEIS) by the USFS. It continues to engage with several neighboring local communities and 11 Native American tribes, as well as numerous federal and state agencies: "The collective voice of communities, Tribes and regulators have driven major changes to the original mine plan, including the relocation of major project facilities and foregoing mining some sections of the ore body to avoid hundreds of areas of traditional importance, ancestral sites, seeps, springs and medicinal plants," explained Peacey.

Resolution has recognized the current labor shortage and understands that, given the 60 LOM for the project, it is imperative to start developing a skilled local workforce. It has invested in K-12 education, technical colleges, and apprentice programs to achieve this. Moreover, this should benefit local communities: "We want our employees to be able to live and thrive in the local communities they were born and raised in," commented Peacey.

One of society's concerns about the project is the mining method selected: block-caving. Resolution Copper's deposits boast around 1.5. billion t, containing copper at about 1.5%, and the depth reaches 7,000 feet below ground level. According to Peacey, the deposit's characteristics dictate the mining method, and block-caving has been successfully utilized, serving as the initial mining technique employed in the Copper Triangle and worldwide. Moreover, it would have several benefits: "Firstly, being underground eliminates the need for a large open pit and no permanent waste rock dumps, resulting in a significantly less disturbed footprint," said Peacy. ■

Joshua Olmsted

President and COO Americas
FREEPORT-MCMORAN

Can you give an overview of Freeport-McMoRan's (Freeport) performance over the past year in the western USA?
Despite some challenges associated with weather at the beginning of 2023, Freeport-McMoRan has performed well over the past 18 months. We have been extremely focused on executing our safe production plan over the past few years. We have also remained focused on what we have coined as 'leach to the last drop,' looking for incremental copper growth through the leaching processes. A third pillar to the company's success has been our focus on the fundamentals of maintenance and reliability, ensuring that our operations are reliable, allowing us to execute our plans.

Can you comment on Freeport's expansion activities at the Bagdad asset?
Bagdad is a huge growth opportunity for Freeport, and we currently are evaluating the feasibility of doubling the concentrator capacity at the site. We expect the feasibility study to be completed by Q4 2023, after which we will decide about building a new concentrator facility. In advance of an expansion, we must progress work on a new tailings facility. Work on this new facility is underway. Meanwhile, we have divided the new concentrator project into two phases: design and feasibility, and construction of the mill itself.

Can you comment on Freeport's plan to advance Lone Star?
Several years ago, we decided to go after incremental copper at Safford via the Lonestar oxide project to take the production capacity up to approximately 300 million lb/y. We are well on our way to that, and we are developing a model to help us define the potential for a much broader footprint at Safford.

Is Freeport utilizing any advanced technologies such as machine learning or AI?
AI and data science are built into our 'leach to the last drop' effort, providing insights and driving some of the actions of this effort. When we started this effort, we identified that we had 38 billion lb of contained copper in our stockpiles that were previously deemed unrecoverable. With innovative leaching technologies, we can tap into this resource to produce incremental copper. This innovative leaching process is much more sustainable, requires less water and energy, and allows us to produce the lowest carbon footprint copper. We are targeting 200 million lb/y of incremental copper by the end of 2023, and then we want to drive that growth up to 800 million lb/y in a longer time horizon.

What is Freeport's approach to electrification and automation?
Regarding electrification, we have been testing Ultra Class trucks at our Cerro Verde operation in Peru to inform future decisions organizationally around the right haulage fleet for us, both from an economic perspective and ESG perspective. Freeport is also currently kicking off an effort to implement autonomous haulage at our Bagdad operation in Arizona. In approximately three years, we will be the first large-scale operation in the US to have a fully autonomous haulage fleet. ■

Óscar González Rocha

CEO
ASARCO

Could you introduce us to Asarco and its mines?
Asarco has been a part of Grupo Mexico since 1999 and operates primarily in Arizona, where it possesses the Ray, The Mission Complex, and Silver Bell mines. The Ray operations, our largest operation, consist of an open-pit mine with a concentrator and a solvent extraction-electrowinning operation that generates copper concentrates, along with The Mission Complex, which also has its concentration plant. On the other hand, Silver Bell has proven to be profitable as it produces copper cathodes by a solvent extraction/electrowinning (SX/EW) operation, which has been beneficial for Asarco as it allows the selling of two different products. Moreover, Asarco owns the Copper Basin Railway, a local railroad transporting ore to the Ray concentrator to the smelter and sulfuric acid to the leaching facilities.

How has Asarco performed during 2022, and how are you trying to solve labor shortage?
Asarco has achieved satisfactory production levels, however, when compared to other Grupo Mexico operations in Peru and Mexico, Asarco in US has been affected by cost implications stemming from labor availability concerns. Currently, we confront a scarcity of personnel, resulting in operations functioning below our desired capacity. Nevertheless, we are adeptly adjusting to the projected pace and have successfully met our financial targets for 2022 and the initial half of 2023.

What is the current state of the Hayden Smelter and the Amarillo Copper Refinery?
Both the Hayden smelter and the Amarillo refinery had been operating at a low rate; thus, the Amarillo refinery is currently suspended. On the other hand, the Hayden smelter recently started processing slag in 2023 to recover the remaining copper from Asarco's operations, as well as processing slag from the La Caridad metallurgical plant. As a result, we are primarily selling the concentrates we send to the northern border of Mexico, specifically the port of Guaymas, where they are shipped to Asia and, to a lesser extent, Europe.

In addition to Asarco's slag, we intend to process the slag generated at the La Caridad metallurgical plant in Mexico. Although this slag contains copper with a lower grade than the one from Asarco's, we want to evaluate its economic viability so that once the Hayden smelter no longer produces sufficient slag in Arizona, we can transport it from La Caridad there.

What are Asarco's goals for the next years?
In Arizona, our goal is to sustain Asarco's operations for another 10 to 15 years. While Silver Bell has shown more favorable results than Mission and Ray, all three operations have demonstrated positive performance, albeit with slightly higher costs than nearby mines. ■

Lyndsay Potts

General Manager at Pinto Valley
CAPSTONE COPPER

Can you provide an overview of Capstone Copper's operations in Arizona?
Pinto Valley is a copper-molybdenum open-pit mine and the only operating mine located in the historic Globe-Miami mining district of Arizona, one of the oldest and most productive mining districts in the USA. Pinto Valley is currently the second-largest private employer in the district. Pinto Valley has a current life of mine plan that extends through 2039 but is being assessed for possible extension and expansion. Pinto Valley produced 57,000 of copper in 2022, and mineral resources stood at over 1.3 billion t or ore at year-end.

What opportunities is Capstone Copper evaluating to expand the potential of the Pinto Valley District?
Pinto Valley is located in one of the most prolific copper mining districts in the USA. Our land package contains private, patented land, with a very large resource endowment. Given this large resource, exploration for more copper has not been a priority. However, we continue to study opportunities to expand our operation including the evaluation of sulfide leaching to unlock value from our underutilized SX-EW plant. Finally, we maintain good dialogue with our neighbors in the Globe-Miami district, including BHP and Freeport-McMoRan. We believe that by working together we can expand production over the medium-term while also lowering costs and bringing significant benefits to many stakeholders in the district.

Is labor shortage affecting Pinto Valley's operation?
In mining specifically, we struggle with the underrepresentation of women in our workforce, and at Pinto Valley we have launched an on-site chapter of Women in Mining Arizona. We also have a dedicated program to hire more veterans at Pinto Valley. Our focus is on recruiting locally. We are doing a lot of career fairs at local high schools and using social media. We've been successful, with the proportion of local workers now topping 70% from the nearest four towns.

What impact do you think the recent inclusion of copper as a critical material by the DOE will have on the US copper segment?
The inclusion of copper as a critical material will hopefully provide for a clearer permitting pathway to allow companies to grow production, while also educating people that mining critical metals such as copper is essential for the world's future.

What is Capstone Copper's strategy for Pinto Valley in the upcoming 12 months?
Our strategy is to improve our consistency of safe production while reducing costs through operational excellence. We have a talented workforce and are confident in our ability to attract more great workers to drive our results. ■

> Resolution has the potential to fulfill up to 25% of the current US copper demand, with a projected lifespan of 60 years.

Victoria Peacey

President and General Manager
RESOLUTION COPPER

What is the status of Resolution Copper?
We are awaiting the re-publication of the Final Environmental Impact Statement (FEIS), a document that discloses the comprehensive environmental and social impacts, alternatives and mitigation measures of the proposed mine plan, which will serve as the definitive framework for the project. The development of the FEIS involved a multi-year co-design process completed in good faith with six neighboring local communities, 11 Native American tribes with ancestral ties to the area, and a dozen federal and state agencies. The collective voice of communities, Tribes and regulators have driven major changes to the original mine plan including the relocation of major project facilities and foregoing mining some sections of the ore body to avoid hundreds of areas of traditional importance, ancestral sites, seeps, springs riparian areas and medicinal plants. This includes the preservation of Apache Leap which contains one of the most significant western Apache ancestral sites in the region and maintaining access to the Oak Flat campground for decades.

What makes block-caving the selected method for the project?
The deposit is very large, approximately 1.5 billion t with an average ore grade of 1.5% copper, but deep ranging between 5,000 and 7,000 feet below ground. Block caving is the most reasonable and technically suited method to mine the ore body.

This method offers several benefits. First, being underground eliminates the need for an open pit mine and no permanent waste rock dumps, resulting in a significantly less disturbed footprint for a similar size open pit mine. Being underground and with the implementation of the latest proven water recycling technology for large scale copper mining, the project would require less water and will reclaim impacted areas concurrent with operations.

How much water will Resolution Copper use compared to other copper mines?
At maximum production, Resolution will use approximately 4.5 gallons of water per pound of copper, compared to other operating copper mines that consume approximately 10 to 50 gallons of water per pound of copper. As a new mine, we can incorporate cutting-edge technology like deep cone thickeners, which would enable us to recover and recycle 65% to 75% of the water we use. This, coupled with the higher-grade of the deposit and our underground approach, allows us to utilize less and recycle more water.

What will be Resolution Copper's socio-economic impact on Arizona?
A significant challenge lies in the aging nature of copper mines in the US. In the Copper Triangle, only two copper mines remain in operation. New supply is needed to replace lost and declining production and meet current and future domestic demand. Copper deposits such as Resolution are rare and exceptional. Remarkably, it is situated within the Copper Triangle, a region that already boasts existing mining infrastructure, and it resides within the footprint of the historic Magma copper mine. Resolution has the potential to fulfill up to 25% of the current US copper demand, other metals and critical minerals and materials like molybdenum, silver, bismuth, rhenium, indium and tellurium.

With a projected lifespan of 60 years, Resolution would generate approximately 3,700 direct and indirect jobs. Today we have a workforce of 300 people, and the majority are local from the town of Superior to the San Carlos Apache tribe, and our commitment to hiring locally underscores our dedication to investing in the future of Arizona, especially in rural communities that have seen limited investment and high unemployment rates in recent times. Moreover, it would contribute around US$1 billion annually to the state's economy, resulting in Arizona's total economic value of approximately US$ 61 billion over the life of the mine.

How does copper's current supply and demand gap reflect the need to recognize copper as a critical mineral?
Today, we rely on net imports for almost 50% of our copper supply and our net import reliance is projected to increase well beyond 50% with the energy transition. Although copper may not be officially categorized as critical today, its significance stems from its role in all energy transition technologies and as a gateway to essential and critical mineral co-products, such as indium, tellurium, bismuth, and rare earths.

Today the US utilizes approximately 2 million t/y of copper while producing only 1 million t/y, but these figures are expected to rise to 4 or 5 million t/y. At the same time, other countries are also rapidly decarbonizing and increasing their demand for copper. The Department of Energy, Arizona's Senators and members form the Congressional Delegation have all recognized the critical nature of copper and importance of domestic production. Elevating copper's status as a critical mineral would be the next logical step. ■

> ASCU is the third largest independent copper developer in the US with the potential to see first copper cathodes in 2026.

George Ogilvie

President and CEO
ARIZONA SONORAN COPPER

Can you give us a quick introduction to the company?
Arizona Sonoran is an emerging SX/EW and heap leach copper developer on private land in Arizona. The company is focused on developing its brownfields Cactus project, inclusive of the new Parks/Salyer deposit. Competitive advantages unique to ASCU include locally available infrastructure, onsite infrastructure, an advanced and streamlined permitting process, access to a permitted water source, and the support from the local community. ASCU is the third largest independent copper developer in the US with the potential to see first copper cathodes in 2026.

Can you speak about the PFS scheduled for the beginning of 2024?
The PEA we published in 2021 showed a production profile of 28,000 t/y of cathode production with a mine lifespan of 18 years. The forthcoming PFS, scheduled for the first quarter of 2024, in contrast to the 2021 PEA, which excluded Parks/Salyer, will integrate the deposits and target a 45,000-50,000 t/y heap-leach and solvent extraction/electrowinning processing to produce copper cathodes over a mine life of approximately 30 years. By integrating Cactus East, West, Parks/Salyer and the stockpile, we would expect to benefit from economies of scale through leveraging the existing infrastructure and layering in the sources of mineralized material.

What were some of the permits acquired by Arizona Sonoran Copper over the last months?
Our team has completed all major permitting as it pertains to the Cactus PEA in the first half of 2023. Most recently, we rounded out the major permits with the Industrial Air and the Mined Land Reclamation permits. From the moment of application to the receipt of these permits, the entire process was accomplished within five months. Such efficiency instills confidence in the market, signifying a streamlined permitting process for this project, considering its location on private land, devoid of federal implications.

Upon final PFS mine planning, our team will begin the application process for minor permits and proceed to amend the permits impacted by a larger operation, including the air, dust and MLRP, which currently align with the 2021 PEA mine plan. Water usage is permitted to 2070 from onsite wells. Importantly, the company has secured the original Aquifer Protection Permit as well as an amendment based on the 2021 PEA, which is a crucial step in demonstrating our social license and our dedication to protecting the water source.

What kind of drilling has the company been conducting in Parks/Salyer?
In September 2022, we released the maiden mineral resource estimate (MRE) on Parks/Salyer, which boasted 2.9 billion lb of copper with a grade exceeding 1%. Since then, we have completed a 105,000 feet infill drilling program targeting the indicated category. We completed it in March 2023, with all assays confirming robust thicknesses, and aligning with the inferred mineral resource previously announced in 2022. Our goal is to convert resources further into the measured and proven reserve category, a crucial step as we advance toward the definitive feasibility study anticipated by the end of 2024.

What advantages does Nuton's technology bring to the project?
With our substantial global resource of 1.9 billion lb of copper in the indicated category and 4.6 billion lb of copper in the inferred category, 25% reside in the primary sulfide or chalcopyrite. Thus, the potential success of Nuton's technology opens the door to an additional 1.7 billion lb of copper. On another hand, Nuton's technology also revolutionizes the recovery of copper from primary sulphides by reducing water usage and lowering GHG relative to traditional milling; Nuton's leaching solution also eliminates the need to transport concentrate to smelters and undergo further refining. This aligns with our ESG commitment to reduce greenhouse gas emissions, which is especially crucial to providing cleaner copper used in EVs and the green energy sector.

How will Arizona Sonoran address the water concerns in the southern US?
While water remains a critical concern in the arid southwestern US, our project benefits from a unique advantage: we have tapped into an independent and natural aquifer that provides water to fulfill all our operational and processing requirements throughout the mine's lifespan. ■

Copper Exploration

Looking for American copper

The copper price began 2023 on a positive note, reaching a peak of US$4.28/lb in January amid optimistic expectations for a robust rebound in Chinese demand. However, prices then followed a consistent downward trajectory until October, when they dipped to around US$3.54/lb. Subsequently, copper experienced a recovery. The pressure on copper prices may have intensified due to the impact of rising interest rates and persistent concerns about the Fed's policy. These factors contributed to a rally in the dollar, thereby increasing the cost of raw materials for buyers in other currencies.

There is no doubt that the fundamentals for copper are solid, especially in the US: The world needs to electrify its energy sources, a deficit is looming, and the DOE has designated copper as a critical material. So, why has the market been so challenging? According to Joshua Olmsted, president and COO for the Americas at Freeport-McMoRan, the reasons we saw fluctuations and variability in the copper price on a short-term basis is that the Chinese economy has been struggling, having a downward pull on the copper price and the EV market, and electrification and infrastructure projects are taking off at a faster pace than expected, putting upward pressure on the copper price.

While executives from companies with developing projects and a strong market capitalization emphasize that it is essential to maintain a broader perspective on the long-term dynamics of copper fundamentals, it seems that short-term considerations have blinded investors, and 2023 proved to be a tumultuous year. "It is a great challenge when you have a market where people are uncertain about inflation, interest rates and geopolitical conflicts. In these scenarios, investors tend to go to cash as they do not want to take market risks. Even though the fundamentals for copper are phenomenal and better than ever, investors are still holding off on putting money into the market due to significant risks," elaborated Dan Weir, co-founder and CEO of Copper Bullet Mines.

Capital remains a constant concern for junior companies, which are often perceived as 'cash-burners'. This cyclically restricted flow of funds into the market could have lasting effects, particularly on the timelines of bringing new mines online in the future: Without exploration, there are no mines.

Weir considers that the current complex scenario in the mining industry is a double-edged sword. On the one hand, it presents the best time to acquire assets as market valuations are low; however, on the other hand, companies face challenges in raising capital. This is a dilemma that Copper Bullet Mines faces, as it considers additional acquisitions in the Arizona Copper Triangle while aiming to raise approximately US$5 million for drilling to build out the oxide mineralization at the surface of its Copper Springs project to bring the historical resource to a 43-101 compliant state and test deeper holes to see if there is a deposit at depth. Copper Bullet Mines owns the Copper Springs and Gibson projects, which join each other and are essentially one project of approximately 9,000 acres at the heart of the Copper Triangle, surrounded by Resolution Copper, Capstone Copper's Pinto Valley, South 32, Asarco,Freeport-McMoRan, and KGHM. The historical open pit resource from Copper Springs boasts 47 million t at around 0.4% copper. However, Weir sees significant upside potential and compares it with Resolution Copper: "The Resolution mine to the southeast of Copper Springs will be the largest in North America once it gets into full production - it is almost 2 billion t, grading about 1.5% copper. However, the Resolution deposit is deep, making it expensive to mine and put into production. Fortunately, we have a historical open pit resource of approximately 47 million t at about 0.4% or approximately 400 million lb of copper. There is also significant potential to find higher grades deeper, as the deepest hole drilled on the Copper Springs project is only approximately 500 m; the Resolution deposit next door starts at about 1,500 m," he explained.

Idaho Copper is a company that finds the market challenging, especially in Canada. Andrew Brodkey, COO of Idaho Copper (IC), explained that the saturation of the Canadian market with mining companies posed a challenge for IC to distinguish itself. Additionally, the stringent regulatory reporting requirements in Canada contributed to the decision to cut ties with the northern neighbor and separate from its parent company, American CuMo Mining: "The US market is orders of magnitude larger than Canada, and investors are less acquainted with mining companies, offering better investment opportunities. Lastly, we emphasized our status as a US company, operating from and headquartered in Boise, Idaho, and not subject to foreign control. This decision also stemmed from a perceived negative connotation associated with foreign ownership of US properties," Brodkey argued.

Image courtesy of Ivanhoe Electric

IC operates the CuMo project in Idaho, with a current M&I resources of almost 4 billion lb of copper, 1.6 billion lb of molybdenum, and 170 million oz of silver. When asked about the potential of the deposit, particularly given its low-grade nature, Brodkey highlighted the significance of ore sorting, an approach that has reduced the need for a large mill and minimized tailings, and emphasized that the mineralization is contained within narrow stock veins: "Thin veins carry the minerals, making it easier to differentiate between veins containing metals and the surrounding gangue (waste) material. This deposit type lends itself to efficient processing using ore sorting, a technology that has gained prominence in recent years," continued Brodkey.

IC expects an updated PEA by Q1 2024, reducing the project capex to approximately US$1 billion (US$ 2 billion less than the 2020 PEA) with a 25-30,000 t/d mill.

New ways of doing business

Junior companies in the US are exploring new business models where partnerships among juniors or producers take precedence. "Typically, juniors focus on individual resources and strive to be the first to bring them to fruition," said Morgan Lekstrom, Blackwolf Copper and Gold CEO.

Blackwolf Copper & Gold is a Vancouver-based company that operates in the Golden Triangle of Alaska, with a particular focus on the Cantoo project, which boasts a 30-m-wide vein rich in gold, silver and copper, and Niblack, a copper-gold-zinc-silver project located on Prince of Wales Island in southeast Alaska. The company signed a Memorandum of Understanding with Dolly Varden Silver, New Moly, Goliath Resources and Coast Copper to explore the feasibility of utilizing New Moly's Kitsault project as a potential location for a centralized polymetallic processing facility by feeding Kitsault's mill with ore from their projects in British Columbia. In the case of Blackwolf, ore from its Niblack project in Alaska would also be included. Through this shared mill approach, the companies can collectively optimize the use of resources. "This hub and spoke model offers immense potential, particularly for projects that may be orphaned or stranded individually but collectively poses significant resources. By linking multiple companies, the possibilities expand and capital requirements are reduced," explained Lekstrom.

Another emerging collaboration model is an informal consortium of companies that pool resources below the same CFO level, allowing for a shared financial officer overseeing the different companies. An example of this approach is the Metallic Group of companies comprising Metallic Minerals, Stillwater Critical Minerals and Granite Creek. This model enables companies to maintain independence while leveraging a diverse skill set similar to that of a mid-major or mid-tier producer, allowing for a more extensive technical team.

Metallic Minerals' flagship asset is the La Plata project, a copper-silver-gold-platinum-palladium project located in Colorado. In July 2023, the company announced an updated mineral resource estimate of 1.3 billion lb of copper equivalent and currently continues to drill this project. "So far, we have completed over 2,000 m, and we are focusing on offsets of hole 22-04, which last year intersected 816 m of 0.41% Cu Eq from the surface and ended in 5.39% CuEq over 5.2 m with significant precious metal content including high-grade PGEs," shared Scott Petsel, president of Metallic Minerals.

Another Vancouver-based junior that has managed to secure partnerships, but this time with three big players, is American Pacific Mining, which is focused on high-grade assets across the Western US. The company partnered with Dowa Mining and Metals, investing US$25.5 million to explore the Palmer project in Alaska, a 12-million t VMS deposit containing copper, zinc, gold and silver. In Montana, American Pacific has a joint venture with Rio Tinto, where the Australian producer has the potential to invest US$30 million to secure a 70% stake in the Madison copper-gold project, and, to date, it has invested US$6.8 million. Furthermore, for the Ziggurat project, located at the northern end of Round Mountain Trend (an active mining region in Nevada), American Pacific partnered with Centerra Gold, investing US$1.3 million in 2023. According to Warwick Smith, CEO of American Pacific, partnering with major industry players offers a mutually beneficial arrangement since they provide the financial resources required for exploration while benefiting from discovering new reserves: "To put this into perspective, some larger mining companies like Hecla and Coeur Mining spent US$29 and US$27 million on exploration last year. Hecla has a market capitalization of US$3.5 billion, and Coeur Mining is a billion-dollar company. This highlights how we stand out among junior mining companies due to our substantial exploration and development investments relative to our market capitalization," he explained. ■

> We believe that the US remains significantly underexplored, particularly for the critical metals.

Taylor Melvin

President and CEO
IVANHOE ELECTRIC

Can you introduce us to Ivanhoe Electric?
Ivanhoe Electric is a US company focused on finding and developing new sources of critical metals. The company completed its initial public offering in June 2022 on the New York Stock Exchange (NYSE: IE) and a secondary listing on the Toronto Stock Exchange (TSX: IE).

Ivanhoe Electric's key projects in the US are the Santa Cruz copper project in Arizona, the Tintic exploration project in Utah and the Hog Heaven exploration project in Montana. In addition, we operate a groundbreaking 50-50 joint venture with Saudi Arabian mining company Ma'aden to explore for minerals across a vast, underexplored land package on the Arabian Shield.

What are the main highlights of the recent initial assessment for the Santa Cruz project?
Our Santa Cruz Project, located west of Casa Grande, Arizona, has a significant defined resource with contained copper of approximately 2.8 million t in the indicated category and an additional 1.8 million t in the inferred category. The average grade of both the indicated and inferred resources is 1.24% copper. We believe that Santa Cruz is one of the largest, highest-grade, undeveloped copper projects in the US, entirely situated on private land. In May 2023, we acquired 5,975 acres of land, consolidating surface rights with pre-existing mineral rights obtained through option agreements. This comprehensive ownership encompasses the entire Santa Cruz project.

The Initial Assessment, published in September 2023, outlines the economic and technical potential of an underground copper mine at Santa Cruz. The study includes a 5.9 million t/y underground copper mining operation with estimated initial project capital expenditures of US$1.15 billion. The study incorporates modern mining technologies, including an electrified underground mining fleet and phased renewable power, resulting in estimated carbon dioxide emissions among the lowest in the global mining industry. With a projected total production of 1.6 million t of copper over a 20-year mine life at an estimated average cash cost of US$1.36/lb, the Santa Cruz oroject has the potential to become a significant, low-cost copper producer. Our estimated life-of-mine production includes approximately 1 million t of pure copper cathode and 0.6 million t of copper in concentrate that is 48% copper by weight.

It is important to note that our Initial Assessment is based solely on approximately 2.1 million t of high-grade soluble copper domains at our Santa Cruz and East Ridge Deposits. We have additional defined resources at the project, including oxides and primary sulfides, that provide the potential for future growth beyond the current Initial Assessment.

Can you speak of your other exploration projects in Utah and Montana?
Our Tintic copper-gold project in Utah is situated in a historically significant mining district that yielded substantial amounts of silver, copper and gold during the late 1800s and early 1900s. Leveraging the geological insights gained from our Typhoon survey, we are actively exploring the project, which is entirely located on private land.

Additionally, we are actively drilling the Hog Heaven copper-gold-silver project in Montana, with promising early drill results received in October 2023 from depths well-below historical mining operations. We recently completed a Typhoon survey at Hog Heaven and will incorporate the results of that survey into our future exploration efforts.

Can you tell us more about Ivanhoe Electric's proprietary exploration technology?
Typhoon is a geophysical surveying technology and system developed by Ivanhoe Electric's former parent, I-Pulse in France. This powerful ground-based system can perform both induced polarization and electromagnetic surveys, enabling the coverage of extensive land areas at considerable depths in a short amount of time.

Ivanhoe Electric's subsidiary, Computational Geosciences Inc. (CGI), has proprietary machine learning-based software that translates the massive amounts of data provided by Typhoon into detailed three-dimensional images of underground geophysical anomalies, which guide future exploration drilling.

What does Ivanhoe Electric hope to achieve in its joint venture with Ma'aden?
Our joint venture holds exclusive rights to explore an expansive 48,500-square-kilometer area of the Arabian Shield in Saudi Arabia. Thanks to our 50/50 partnership with Ma'aden, we have the unique opportunity to deploy our Typhoon technology on a wide scale.

What are the advantages of being a US-focused exploration company?
We believe that the United States remains significantly underexplored, particularly for the critical metals. ■

> The Gunnison copper project is distinctive in the world of copper mining due to its in situ recovery method.

Stephen Twyerould

President and CEO
EXCELSIOR MINING

What are the most recent updates regarding the Johnson Camp Mine (JCM) project?
The JCM open pit saw its last mining activity in 2010, when the high-grade oxide was depleted and the high-grade sulfide was encountered. Back then, the technology for sulfide leaching was not advanced enough to continue operations. However recently we partnered with Nuton, a Rio Tinto venture, to explore a combined approach of oxide and sulfide leaching at JCM using Nuton's suite of bio-leach technologies.

Nuton's sulfide leaching technologies have significantly advanced, enabling us to access the previously unmined 1% sulfide copper at the bottom of the pit. Our plan involves extracting the high-grade sulfide alongside the surrounding oxide to revive the open pit. We are well-positioned for this endeavor as we already possess the necessary infrastructure, including a fully permitted solvent extraction-electrowinning (SX/EW) plant and ponds. If all the test work proves favorable for our commercial mine design, we aim to break ground at JCM sometime in H1 of 2024. This would be a great outcome for our company and Nuton.

Can you explain the conditions of the partnership with Nuton?
The initial phase of our program involves mining sufficient sulfide material from the pit's bottom to create a large-scale commercial demonstration of the Nuton technologies. Nuton funded this initial phase, including the drilling and other activities, totaling approximately US$3 million, with Excelsior remaining the operator. It is important to note that Nuton has neither purchased shares of Excelsior, nor is it providing a loan. Instead, they have made direct payments for the work being carried out. As we bring the mine into production and generate cash flow, that income will be used to repay Nuton's initial construction costs for the commercial demonstration. The intellectual property rights to the Nuton technologies remain with Nuton. At the end of the three to five-year trial, Nuton can exercise an option to establish a joint venture for the remaining 15 years of the mine's life.

What are the environmental benefits of Nuton's technologies?
By moving directly to leaching, we avoid the energy-intensive processes of grinding and concentrate production, along with the associated tailings disposal and water consumption required for concentrate creation. Furthermore, eliminating tailings means we avoid managing large piles of potentially environmentally hazardous material. Additionally, because we generate copper on-site through a SX/EW plant, there is no need for downstream processing like roasting or smelting, which consumes energy and can produce emissions.

What are the advantages of ISR that you plan to adopt in the Gunnison copper project?
The Gunnison copper project is distinctive in the world of copper mining due to its in situ recovery method. This approach involves drilling a network of closely spaced injection and recovery wells to circulate a mining solution underground, dissolving the copper. The process eliminates traditional mining activities, resulting in no excavation, tailings and minimal waste. It significantly reduces water consumption and greenhouse gas emissions, making it an environmentally unparalleled approach in the mining industry.

While in situ mining is well-established for uranium, lithium, and other commodities, it is relatively rare in copper mining. We successfully amended our EPA operating permit in 2023 to allow for well stimulation and are planning to conduct field trials in H1 2024. If the trials prove successful, we plan to optimize and integrate this approach into our commercial production plan, ultimately getting back into production and regaining the value of our Gunnison copper project.

What are the challenges associated with copper projects in the US?
The US has ample domestic reserves, especially in states like Arizona. Numerous large-scale copper projects within the country can meet a significant portion of the domestic copper demand. Therefore, the challenge for copper, from a critical minerals' perspective in the US, is not so much about developing new projects or technologies to secure the supply chain. Instead, it is about government agencies supporting and facilitating the development of existing projects within the country.

In our case, the in situ copper recovery method aligns well with the green objectives of the current administration and the Department of Energy, making our project unique. However, for standard copper projects, the focus should be on promoting and streamlining the development of the abundant copper resources available in the US. ■

Andrew Brodkey

COO
IDAHO COPPER

> CuMo is among the largest undeveloped copper projects in the Americas, and likely the largest undeveloped molybdenum project in the world.

What led Idaho Copper to become an independent public company in 2023?
Idaho Copper Corporation (IC), formerly known as International CuMo Mining Corp., owner of the CuMo project, was formed as a subsidiary of the Canadian company American CuMo Mining Corporation in 2008. In 2023, IC separated from its parent company, which renamed itself Multi Metal Development Corporation, and IC merged with a shell company on the OTC Exchange, changed its name to Idaho Copper, and now trades under the symbol COPR.

What makes the CuMo project interesting in terms of infrastructure and size?
The CuMo project is in the Boise National Forest. This area boasts a pool of skilled workers with industrial and mining experience. The project site is easily accessible and enjoys an abundant water supply from local sources, and power is readily available.
CuMo is among the largest undeveloped copper projects in the Americas, and likely the largest undeveloped molybdenum project in the world. Our current reported and drill-indicated measured and indicated resource contains almost 4 billion lb of copper, 1.6 billion lb of molybdenum, and 170 million oz of silver, with comparable numbers in the inferred resource category.

What work have you conducted so far, and what is the importance of ore sorting for the project?
We are awaiting final approval from the Forest Service for our Plan of Operation before proceeding with drilling. This deposit type lends itself to efficient processing, using ore sorting, a technology that has gained prominence in recent years. Our waste reduction plan will likely include three ore sorting stages: Bucket-level sorting using the shovel's X-ray fluorescence (XRF) sensors, penetrative scanning using neutron gamma-ray scanners, and particle sorting.

This approach reduces the need for a large mill and minimizes tailings, and substantially raises the head grade of the ore material introduced into the concentrator. Our updated PEA, expected in Q1 2024, is anticipated to reduce the overall project initial capital expenditures to approximately US$1 billion.

What funding opportunities related to the US government is the company exploring?
We actively explore funding opportunities under the Infrastructure Act of 2020 and the 2021 Inflation Reduction Act (IRA). We are engaged in discussions with the Department of Energy (DOE) and the Department of Defense (DOD) regarding potential funding avenues. One viable method for securing funding is Funding Opportunity Announcements (FOAs), where companies can bid on specific projects outlined by the DOD or DOE. Another approach involves the White Paper process, where a company presents its project to access undedicated funds. ■

Dan Weir

Co-founder and CEO
COPPER BULLET MINES

> Copper Bullet Mines is considering additional acquisitions in the Arizona Copper Triangle – as we believe the opportunities are huge in this area.

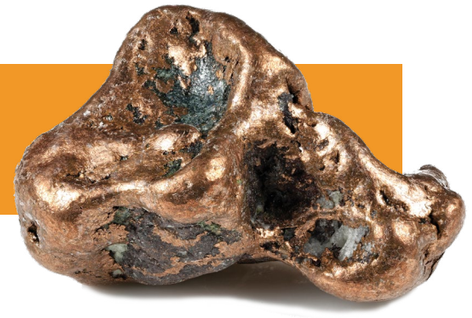
Can you give an overview of Copper Bullet Mines?
Copper Bullet Mines (CBM) was established in 2021 focused on copper projects in the Americas, specifically the US. We wanted to focus on a jurisdiction where there is a rule of law and a pathway to permitting to get into production, and there is a massive need in the US for copper.
We decided to focus on Arizona, due to the rule of law, and the huge historical and current copper production. Arizona continues to be on the Fraser Institutes top 10 list every year. Copper Bullet Mines has built a fantastic Arizona project, intending to raise capital and start drilling to move the project forward. Arizona is an easy jurisdiction to work in, with enormous opportunities.

Can you elaborate on the Copper Springs project in the heart of Arizona's Copper Triangle?
The Arizona Copper Triangle is approximately one hour east of Phoenix Airport. Rio Tinto and BHP's Resolution mine is at the top western corner of the triangle, Asarco's smelter is at the bottom, and in the top eastern corner isFreeport-McMoRan's smelter. To put this in perspective, there are only three copper smelters in the US, and two are in the Copper Triangle. To date, the triangle has produced approximately 37 billion lb of copper, and there are still believed to be over 95 billion lb of known reserves and resources. The Resolution mine has about 60 billion of these resources, so there is still another 25 billion on top of that.
Copper Bullet Mines owns the Copper Springs and Gibson projects, which join each other and are essentially one project. Our primary focus and where we will do the initial exploration will be the Copper Springs project.

The Copper Springs project is approximately 9,000 acres. Although we are already one of the most significant permit holders in the triangle, we plan to stake additional land to grow our property significantly. Fortunately, we have a historical open pit resource of approximately 47 million t at about 0.4% copper. There is also significant potential to find higher grades deeper, as the deepest hole drilled is only approximately 500 m. We aim to continue building out the extensive oxide near-surface resource of 400 million lb of copper to get closer to 6 billion lb of copper. If we hit something deeper and it is a high grade like that of Resolution, there could be multiple billions more tons of ore on our project. Our main goal now is to raise the capital to continue to build out the oxide mineralization at the surface to bring the historical resource to a 43-101 compliant state, as well as drill some deeper holes to see if there is a deposit at depth.

What are Copper Bullet Mine's objectives for 2024?
Copper Bullet Mines is considering additional acquisitions in the Arizona Copper Triangle as we believe the opportunities are huge in this area. We are now in a complex scenario where it is the best time to acquire assets as market valuations are low, but on the other side, the markets are not there to raise capital. ■

Highlighted Projects: Copper



The cornerstone of the electricity transition

Lynn Ball, VP Corporate Affairs, **COPPER FOX**

"At the Van Dyke Project, a hydrogeological modeling program is underway, meeting EPA and ADEQ requirements for copper project permits. This 24-month study is progressing as planned. Simultaneously, we monitor Taseko's Florence Copper project, which is an in-situ copper recovery, the same format that Van Dyke will be operating. Our Arizona projects include Sombrero Butte and Mineral Mountain. Sombrero Butte, south of Faraday's Copper Creek project, is undergoing additional geophysical surveys to pinpoint porphyry copper locations, with a forthcoming drilling program for validation. For Mineral Mountain, a recent geophysical survey completion anticipates results by the end of 2023, guiding us towards a subsequent drill program based on obtained information."

Graham Richardson, CFO, **FARADAY COPPER**

"In Q2 2023, we published a PEA and updated the mineral resources estimate for Copper Creek that outlines a payable production of 51,100 copper-equivalent t/y for 32 years, generating 3.4 billion lb of payable copper equivalent metal. Since taking over the company in late 2021, we have released two mineral resource estimates and established a comprehensive geological model for the property. The updated mineral resource estimate includes about 4.2 billion lb of copper in the measured and indicated category, with a total resource of approximately 4.8 billion lb across all categories."

Mike Haynes, CEO, **NEW WORLD RESOURCES**

"In November 2022, we announced Antler Copper Deposit's second resource estimate, marking a 50% increase from 7.7 million t to 11.4 million t. A scoping study conducted in the first half of 2023 focused on the updated resource, emphasizing a low capital cost development using a single decline. The mine design foresees a 13-year life mine with a consistent production rate of 1.3 million t/y. Over the past three and a half years of Antler ownership, all drilling activities concentrated within a 600 m corridor, revealing improved mineralization with depth. Despite the deposit remaining open at depth, recent mining studies confirm that discovering more ore at depth will not impact production until year 10 or later."

Warwick Smith, CEO, **AMERICAN PACIFIC MINING**

"Palmer is the most advanced project, and we completed a Preliminary Economic Assessment (PEA). Madison is another key asset in our portfolio, probably the one we are most known for. What makes Madison interesting is its high-grade skarn surface; we firmly believe there is substantial potential beneath it. Rio Tinto has noticed and acquired significant land around the project, indicating their interest in the area."

Lithium Production and Development

Pioneering extraction beyond brines

Jonathan Evans
President and CEO
LITHIUM AMERICAS

> "Sedimentary lithium clay deposits present a promising and environmentally friendly source of lithium, with potential for global application as demand grows. They are cost-effective, requiring lower capex and avoiding energy-intensive steps like calcining, crushing/flotation and solvent extraction, thus reducing the carbon footprint."

For decades, lithium producers have extracted this white-gold mineral by pumping the water to the surface, creating brines, and letting it evaporate until the lithium becomes concentrated enough to filter. This form of lithium extraction has been the only method used in the US, a country that relies almost entirely on lithium imports, with a small fraction of supply sourced domestically from a brine operation in Nevada (the Silver Peak mine).

According to the USGS, the US has predominantly imports lithium from Argentina and Chile, accounting for 51% and 40%, respectively. Moreover, the US depends on lithium-ion batteries from China. In an article published by the World Economic Forum, the data from the UN Comtrade Database shows that in 2022, the US imported US$13.9 billion of lithium-ion batteries, and China accounted for US$9.30 billion of this. However, as global economic superpowers vie for supremacy in securing their critical mineral supply chain, the US has taken strategic measures to revert these figures. Initiatives such as the Inflation Reduction Act, the Infrastructure Investment and Jobs Act and the Bipartisan Infrastructure Law have been enacted to propel lithium-focused projects forward to achieve electrification goals and reduce dependence on foreign sources. In this context, all eyes are turned to Nevada, the Mecca of lithium production and exploration in the Western US.

Silver Peak, operated by Albemarle, has continuously operated since 1965, producing technical-grade lithium carbonate. Located in Nevada's Esmeralda County, the mine has consistently yielded an annual average of 3,500 to 4,000 t/y of lithium carbonate. In resonance with Washington's objectives to enhance and fortify the domestic supply chain, Albemarle has been actively pursuing an expansion strategy to boost its production to approximately 7,500 t/y by 2025. "We have completed several projects to help us reach that goal, one of those being the expansion of our brine production well field where, over the past two years, we have drilled another 22 production wells and now have the pumping capacity to produce 20,000 acre-feet of brine, equivalent to roughly 7,000 t of lithium carbonate equivalents (LCEs). Due to the time it takes for the brine to come through the system and reach the plant, this increased lithium production will not be realized until roughly 2025." commented Scott Thibodeaux, Silver Peaks' operations manager.

Silver Peaks concentrates the lithium for 18 to 24 months through evaporation. While effective, this natural method renders lithium extraction a time-consuming process that hinders the urgency of obtaining lithium faster. The DOE is thus strategically investing in new lithium extraction technologies from other deposits, like geothermal brine sources or claystone. Besides brines and spodumene (hard rock mineral ore, prominent in Australia), lithium can be found in lithium-bearing clays, abundant in Nevada, like in the McDermitt Caldera. A recent study published in Science Advances by a group of US geologists suggests that an ancient supervolcano on the Nevada-Orgeon border may contain claystone containing between 20 to 40 million t of lithium. To put this into perspective, the Salar de Uyuni salt flat on the Bolivian side of the "lithium triangle" is estimated to host around 21 million t of lithium.

Image by simonkr at iStock

Within the southern end of the Mcdermitt Caldera, Lithium Americas operates the Thacker Pass project, which currently holds a measured and indicated estimate of approximately 19 million t of lithium carbonate equivalent, and its plan to release another resource update by the end of 2023. "The updated resource estimates expected for this year will likely be in the mid to upper 20 million t range in terms of LCE. This would position Thacker Pass as one of the largest reported LCE resources in the world," stated John Evans, president and CEO of the company.

Despite encountering challenges from environmental groups, the construction of Thacker Pass began in early 2023. The project is anticipated to require an estimated capital expenditure of US$2.3 billion, with mechanical completion projected for late 2026 and a ramp-up scheduled for 2027. According to the project's website, it aims to achieve an annual production capacity of up to 40,000 t/y of lithium carbonate.

Even though it falls under the category of a mining project, the extraction of lithium from clay deposits is more accurately described as a chemical process. When discussing the mineralogy of Thacker Pass, Evans highlighted the benefits of sedimentary lithium clay deposits from an environmental point of view, with the potential for global application as lithium demand grows: "These deposits are cost-effective, requiring lower initial investment and avoiding energy-intensive steps like calcining, crushing/flotation and solvent extraction, thus reducing the carbon footprint," he stated.

Evans revealed that Lithium Americas is in advanced discussion with the US government to secure a loan from the Department of Energy under the Advanced Technology Vehicles Manufacturing Loan Program (ATVM Loan Program).

A company that has already successfully secured the ATVM fund is Ioneer, the owner of the Rhyolite Ridge lithium-boron project located in Esmeralda County. Currently in the final stages of permitting, Ioneer anticipates receiving the Record of Decision by the first half of 2024, with construction scheduled to commence around the same period, and the project is set to reach its first lithium production in the second half of 2026.

Many questions arise when considering the intricacies of permitting and government funds, particularly within the US' commitment to securing its lithium supply. Bernard Rowe, the managing director of Ioneer, emphasized the importance of addressing the misconceptions surrounding the DOE and the ATVM funding program: "Contrary to belief, it does not specifically fund mining activities; it focuses on chemical processing plants. The funding is earmarked for the chemical processing plant at Rhyolite Ridge, a critical distinction given that most of our project's capital investment is allocated to this phase."

In April 2023, Ioneer increased the mineral resources by 168% for the South Basin, which now ups to 3.4 million t of lithium carbonate equivalent. Rowe explained that the deposit's mineralogy of Rhyolite Ridge resembles a "pancake," with the uppermost layer containing lithium and clay, followed by the layer with lithium and boron, and the deepest layer with lithium only, all falling under the same permitting area expected by 2024.

Ioneer's current processing plant is tailored for high lithium and high boron, which are incompatible with clay-rich material. Thus, it expanded its partnership with EcoPro, a Korean-global leader in battery grade high purity lithium hydroxide conversion. This Research and Development Memorandum of Understanding will be dedicated to developing clay resources with novel chemical technologies: "By partnering with EcoPro Innovation (EcoPro), a Korean company specializing in cathode manufacturing and chemical processing technologies that is also an offtake partner for lithium carbonate produced from our lithium and boron layer, we are developing a production process for our specific, high-carbonate lithium and clay material," explained Rowe.

Also capitalizing on the abundance of claystone in central Nevada is the American Battery Technology Company (ABTC). Its unique approach with two vertically integrated business units sets this company apart. On the one hand, ABTC focuses on recycling lithium-ion batteries; on the other, it is engaged in the Tonopah Flats lithium project. This integrated strategy allows leveraging synergies between the two business units. "Our personnel bring the same skills to both business units. We utilize many of the same laboratory facilities and unit operations across both units. Additionally, we produce products to the same specifications in both business units, allowing us to sell similar products to the same customers. The synergies between our business units are indeed significant," declared Ryan Melsert, president and CEO.

ABTC has developed a technology named "selective lithium leaching" that recovers lithium from solid material, leaving non-lithium components stable, eliminating the need for Direct Lithium Extraction that, according to Melsert, often faces challenges when scaling up. This could be a game-changer since, compared to conventional processes, ABTC's technology reduces environmental impact, the need for extensive infrastructure, and the use of chemical agents.

Direct Lithium Extraction (DLE)

In Southeast Utah and Western Colorado, the Paradox Basin has traditionally been renowned for its conventional oil and gas production. With exploration efforts dating back to the 1950s and a historical focus on oil and gas, Utah now hosts one of the most technologically advanced lithium projects in the Western US — the Paradox Lithium project. Named after the basin, this project is operated by the Australian-based company Anson Resources. The discovery of the Paradox Lithium project occurred during oil drilling in the 1960s at a depth of approximately 6,500 feet (around 1.98 km) with a pressure of 4,500 psi. Bruce Richardson, the CEO of Anson Resources, highlighted that this pressure level is significantly higher than typical standards, providing a distinct advantage for the project. "This natural pressure enables the brine to reach the surface without requiring pumps," he said.

In addition to acquiring the Green River Lithium project, located approximately 80 km from Paradox and thereby strengthening its footprint in Utah, Anson Resources has undertaken, in 2022, a Definitive Feasibility Study in collaboration with Worley and SunResin. The DFS, with an estimated cost of around US$500 million, primarily centered on a chemical plant process, aligning with the approaches taken by operators like Ioneer and Lithium Americas. "Anson initially designed the plant for 10,000 t/y, based on a JORC resource of around 1 million t at 140 ppm. However, during the DFS, both tonnage and grade increased to about 13,000 t/y with an average grade of 180 ppm," shared Richardson.

But what is DLE? In contrast to conventional lithium production methods, Direct Lithium Extraction (DLE) employs filters, membranes, or resin materials to extract the so-called white-gold from brine water. It seems that this technology could be such a game-changer: Goldman Sachs suggests that DLE could do for lithium mining what the shale technologies did for oil. Anson Resources intends to apply DLE following thorough testing and finally opting for a resin-based approach. With this method, lithium in the brine is drawn to the resin, which is subsequently washed to extract the lithium suspended in water. Later it purifies the extracted lithium and eliminates trace elements such as calcium, iron, and magnesium. "Our DLE method is environmentally friendly as it avoids chemical use and contains the process. After lithium extraction, the waste brine is reinjected into the porous rock at about 2,000 feet underground. Unlike evaporation ponds, which take longer to produce a concentrate suitable for purification, DLE allows us to go from brine to the final product in just 24 hours," stated Richardson.

The 24-hour timeframe represents a significant reduction compared to the 18 to 24 months required for lithium extraction in the Silver Peak brines. Anson Resources has adopted this advanced technology through a partnership with Sunresin, a Chinese Direct Lithium Extraction (DLE) provider with a successful track record spanning over five years. The next stage for Anson Resources involves the front-end engineering design, slated for completion in Q1 2024. This phase aims to refine cost estimates further and advance the project.

ACME Lithium is another company exploring the possible use of DLE due to its superior recovery rates. While still in the exploration stage, the company owns the Clayton Valley project, a lithium brine project located in the southwestern region of Nevada, adjacent to Albemarle's Silver Peak operation. Stephen Hanson, president and CEO of ACME, emphasized: "Traditionally, lithium has been extracted from brine by using large evaporation ponds. This process can be time-consuming, and the recovery rates can vary and be as low as 50% in some cases. Conversely, DLE is a promising technology where lithium is extracted within a few days with improved recovery rates."

ACME is in discussions with several DLE companies and believes this emerging technology will revolutionize the industry for several reasons, including improved economics, and most importantly, addressing some ESG issues.

According to Goldman & Sachs, besides doubling lithium recoveries up to 70-90%, DLE reduces land usage, with the decline of pond requirements by more than 20 times, as well as improvements in water usage. ■

Scott Thibodeaux

Silver Peak's Operations Manager
ALBEMARLE

Can you give an overview of Albemarle's Silver Peak operation?
Albemarle's Silver Peak mining operation started in 1965 and has been running continuously ever since. For a long time, Silver Peak was one of the only lithium operations in the US. It is a unique basin with a naturally occurring brine resource located in central Nevada.

What were the main milestones for the Silver Peak over the past few years?
At Silver Peak, Albemarle produces a technical-grade lithium carbonate. Historically, we have averaged around 3,500 t/y to 4,000 t/y of lithium. In 2021, Albemarle announced an expansion of our Silver Peak lithium production facility to produce 7,000 t/y to 7,500 t/y. Since then, we have completed several projects to help us reach that goal, one of those being the expansion of our brine production well field where, over the past two years, we have drilled another 22 production wells and now have the pumping capacity to produce 20,000 acre-feet of brine, equivalent to roughly 7,000 t of lithium carbonate equivalents (LCEs). Due to the time it takes for the brine to come through the system and reach the plant, this increased lithium production will not be realized until roughly 2025.

The Silver Peak facility is relatively old, and over the past five years, Albemarle has invested in new technologies to bring it up to modern times, improve equipment and increase efficiencies. The most significant has been the automation of the carbonate plant, and there are now many more controls throughout the process to improve raw material utilization, thus producing more lithium with as little as possible.

What are Silver Peak's goals for the next 12 months?
Silver Peak is still in the swing of the expansion, and our goal is to safely execute those projects, getting closer to running at full capacity of 7000 t/y. ■

Bernard Rowe

Managing Director
IONEER

In which stage of the permitting phase is Rhyolite Ridge?
Ioneer is now in the final steps of the federal permitting process, NEPA, which began in December 2022. We anticipate securing the Record of Decision in the first half of 2024, which will trigger construction at Rhyolite Ridge. In the second half of 2026, Rhyolite Ridge will begin lithium production.

Can you speak of the significance of the ATVM fund provided by the DOE?
We have achieved a significant milestone by securing a conditional commitment for a loan from DOE Loan Programs Office's Advanced Technology Motor Vehicle (ATVM) program, making us the sole lithium mining-inclusive project in the US to receive such support. The process lasted two years and mirrors the thoroughness of a commercial bank's project financing. The conditional US$700 million loan's conditions precedent requires permits and equity funding. We aim to finalize these conditions by mid-2024 in collaboration with Sibanye-Stillwater to ensure funds are available upon completion.

I would, however, like to address a common misconception about the ATVM program. Contrary to belief, it does not specifically fund mining activities; it focuses on chemical processing plants. The funding is earmarked for the chemical processing plant at Rhyolite Ridge, a critical distinction given that most of our project's capital investment is allocated to this phase.

In April Ioneer increased the mineral resources by 168%, can you shed some light on this milestone?
The substantial 168% increase in the resource estimate can be attributed to the presence of three types of ore at Rhyolite Ridge. The project focuses on extracting lithium and boron, which are found together. The other two types of ore at Rhyolite Ridge lack boron, with one containing high clay content and the other being clay-free, the three types being vertically stacked. When we announced that resource update, we included all three types of mineralization in the resource estimate.

Deposits of this substantial size and the distinctive mixture of lithium and boron are truly unique and sets it apart globally. Rhyolite Ridge is the only sedimentary deposit known to have non-clay mineralization, a distinctive feature that adds to its importance.

The estimated 3.4 million t of lithium carbonate makes this one of the world's largest deposits. We anticipate further growth within the existing permitted area as drilling expands to the basin's edges.

How are offtake agreements in the mining industry reshaping the supply chain?
Ioneer's partnerships tear down the silos and align with our commitment to keeping lithium within the US, exclusively for American-made EVs. This is why we have secured substantial offtake agreements, including 7,000 t/y with Ford, 7,000 t/y with EcoPro, and 4,000 t/y with Toyota, totaling 18,000 t/y. ■

Jonathan Evans

President and CEO
LITHIUM AMERICAS

What progress has Lithium Americas made since the commencement of construction at Thacker Pass in 2023?
We have made significant progress on-site, including extensive mobilization and site clearance. We have established a water pipeline from our off-site wells to the east, improved road security, and set up on-site offices with Bechtel and NewFields' assistance. The progress of the final engineering phase has been ongoing since early November 2022, running parallel to our on-site mobilization.

We are also building a temporary workforce hub near Winnemucca to house up to 2,000 construction workers. In collaboration with Bechtel and the unions, we are developing training programs focusing on skilled trades for tribal members and locals.

What are the current resources at Thacker Pass, and could you provide some insights into the updated feasibility study?
The Thacker Pass project currently holds a total M&I estimate of approximately 19 million t of lithium carbonate equivalent (LCE). We plan to release another resource update by the end of 2023, which will significantly increase these figures. Our exploration drilling activities to the east and west of the initial phase one area have consistently provided encouraging results, reinforcing our confidence in the project's resource potential. The updated resource estimates expected for this year will likely be in the mid to upper 20 million-t range in terms of LCE. This would position Thacker Pass as one of the largest reported LCE resources in the world.

Our feasibility study was updated in 2023, and presents a current Capex estimate of US$2.3 billion.

Could you explain the cost-effectiveness and reduced carbon footprint associated with sedimentary clay deposits?
Our chemical process recycles 85% of water and does not require extensive evaporation ponds, minimizing freshwater input and land use. Furthermore, the operation is simplified by eliminating the need for absorbents or ion exchange processes. The use of renewable or self-generated power can further decrease the carbon impact.

Can you elaborate on the off-take agreement with GM?
GM adopted a unique approach, essentially leveraging its balance sheet. They initially invested US$320 million in common shares of our company and secured a board seat within the newly separated entity. This was the first tranche of their investment. The second tranche, contingent on announcing a conditional loan guarantee, amounts to an additional US$330 million. These funds will be allocated to the capital required for the project's first phase. In return, GM secured a 10-year off-take agreement with an option to extend it another 5 years.

How will the DoE loan contribute to the growth and innovation of Thacker Pass?
We are in advanced discussions with the government to secure a loan from the DoE. They are nurturing companies like ours to foster the industry's growth over the next five to ten years. Such support is evident in Redwood Materials' US$2 billion loan and Ford's US$9 billion loan. ■

Ryan Melsert

President and CEO
AMERICAN BATTERY TECHNOLOGY COMPANY (ABTC)

What are ABTC's business units and how are they vertically integrated?
ABTC is tackling domestic critical material challenges by recycling lithium-ion batteries and reintroducing constituent elements to the market. Leveraging expertise from the initial Tesla Gigafactory design team, our team has devised a strategic de-manufacturing system for end-of-life materials. From recycling a lithium-ion battery, we generate nine different products, which are then sold back to manufacturers. Collaborating with strategic partners such as BASF, a primary battery materials company in the US, we distribute these products, including critical materials, within the domestic market.

Could you share more about the Tonopah Flats lithium project?
The Tonopah Flats project is unique because it involves a sedimentary material from which lithium has not been traditionally recovered. The resource report we released in spring 2023 indicates an estimate inferred resource of 15.8 million t of lithium carbonate equivalent (LCE). The challenge lies in developing a set of processes that can access lithium and produce battery-grade material competitively. We have successfully developed and proven our extraction and purification technologies to liberate lithium from this claystone sediment and are currently constructing our pilot demonstration system. This system will be scaled-up, and we are now in the process of designing to build the first commercial-scale facility to reflect this.

Following successful bench-scale testing, we secured a grant from the US Department of Energy to construct an integrated pilot showcasing the process. In 2022, another Department of Energy grant was awarded for developing a commercial-scale refinery to produce lithium hydroxide directly at our lithium claims in central Nevada. Currently, we are constructing commercial-scale facilities for both business units to address these domestic needs on a larger scale effectively.

Can you shed some light on selective lithium leaching and its benefits?
Our technology differs significantly from direct lithium extraction (DLE). Instead of selectively recovering lithium from dissolved elements in brine or leachate, we use a selective leaching process to recover lithium from solid material, leaving non-lithium components stable. This creates a simple leachate, eliminating the need for DLE.

Does ABTC collaborate with any universities or R&D groups in Nevada for technology development?
We have a robust partnership with the University of Nevada, Reno (UNR), where our laboratories operate on campus. We actively collaborate as research affiliates, working closely with UNR students and professors to advance our technologies. UNR students and faculty are sub-recipients on some DoE grants, promoting collaboration on federally supported projects. It's worth noting that many of our team members are UNR alumni, further strengthening our longstanding positive relationship. ■

Lithium Exploration

Juniors harness lithium's future inspired by automakers

Jason Latkowcer
President and CEO
PAN AMERICAN ENERGY

> "I believe we will witness increased government support for early-stage companies. While the current allocation of incentives tends to favor later-stage projects, there is a growing awareness of the potential benefits of investing in earlier-stage ventures."

In the junior segment, peering at more advanced-stage projects, especially in the surrounding areas, has traditionally been the benchmark for assessing deposit potential. However, in today's lithium segment, a convergence of new technologies and growing interest from both Washington and the private sector suggest that companies on the development phase and brink of production are now paving the way for those in earlier stages of exploration.

A relatively recent entrant into Nevada's lithium sector, Pan American Energy, has made notable strides. The company acquired the Horizon Lithium project in the Big Smokey Valley in October 2022. Since then, Pan American Energy has completed its maiden drill program, consisting of 21 drill holes and covering 14,342 feet, leading to a lithium cluster discovery: "The combined cumulative total is over 10.2 million t with an average grade of 678 ppm lithium, based on a conservative 300 ppm Li cut-off," stated Jason Latkowcer, president and CEO of the company.

The Horizon project is situated adjacent to the Tonopah Flats project owned by American Battery Technology Company (ABTC). Latkowcer expressed excitement about ABTC receiving approximately US$57 million in funding from the Department of Energy under the Bipartisan Infrastructure Act to establish a lithium hydroxide plant designed explicitly for claystone extraction, the same mineralogy present at Horizon. In line with this, Pan American partnered with Integrity Mining and Industrial (IMI), a subsidiary of Integrity Bio-chemicals. This partnership involves providing samples and enabling metallurgical tests on core samples from claystone and hard rock. "We are now actively evaluating geophysical exploration techniques such as passive seismic and resistivity and focus on Phase 3 drill planning and permitting. In tandem with ongoing exploration, we are actively working on the necessary steps to complete a Preliminary Economic Assessment (PEA) for the Horizon Lithium project," concluded Latkowcer.

In a less advanced stage and boasting a decade of experience in Nevada, Grid Battery Metals is a notable player with assets including the Clayton Valley, Texas Springs, and Volt Canyon projects. As part of its strategic plans, the company intends to separate its nickel and lithium properties into two distinct publicly traded entities: "This strategic move aims to give shareholders the advantage of an equity interest in two publicly traded companies at no additional cost to the current Grid shareholder. We anticipate listing the new company in February 2024," commented Tim Fernback, president and CEO of Grid Battery Metals.

Fernback, previously the president and CEO of another Nevada-based lithium junior, Surge Battery Metals, played a key role in the team that discovered Surge's Northern Nevada Lithium project. His belief in the significant potential of the southern area of that project, located adjacent to the Texas Spring border, underscores the strategic importance and promising prospects of this region. "We have conducted comprehensive soil sampling and geophysics assessments, and the results strongly indicate that this project could evolve into a flagship property due to its high prospect and the presence of lithium deposits like those found in Surge's Northern Nevada lithium project," commented Fernback.

Image courtesy of Ioneer

Greg Reimer, the president and CEO of the parent company of Grid Battery Metals, revealed that the results from the 2022 drill campaign at the Nevada North project, received in late January 2023, were the most promising to date. Encouraged by these findings, the company expanded drilling beyond the state's five-acre disturbance limit for mineral exploration. The company initiated a Plan of Operations, conducted metallurgical testing on soil samples to identify the type of clay present, and performed a preliminary test on lithium recovery rates. More recently, in spring 2023 it executed another drill program, indicating a commitment to further exploration and advancement in their lithium endeavors. "The initial five holes yielded significant results, with one hole averaging 4,067 parts per million Li and reaching a high of 8,070 parts per million Li. The program's objectives included extending the strike length from 1.6 km (as per the 2022 program) to 3.5 km, expanding the resource area by 2 km, and broadening the project width from 400 m to slightly over 900 m," commented Reimer.

The US government has taken significant steps to support lithium projects nationwide, exemplified by initiatives such as Ioneer's Rhyolite Ridge, Lithium America's Thacker Pass, and ABTC. However, in a capital market environment constrained by sentiments not aligning with fundamentals and considering the financially demanding nature of junior companies, questions arise about potential government assistance for the exploration segment. In discussions with Reimer, he clarified that while IRA provides credit for EV purchases and loans for mine development, companies must meet specific financial requirements to qualify for these benefits. Unfortunately, Surge does not meet these criteria. As a result, they have been advocating for government grants to expedite project development, recognizing the potential challenges posed by the current financial landscape and the nature of exploration projects: "We have entered contracts with Kemetco Research and renowned lithium processing expert, and Surge Board member Vijay Mehta, to develop the necessary flow sheet. This is where the government of the US government can support mining companies like ours, helping us prove that lithium can be extracted from clays and developed commercially in the current environmental context," he concluded.

Noram Lithium is a Canadian-based company advancing its Zeus lithium project to production in the Clayton Valley. Zeus has measured and indicated resources of approximately 6 million t of LCE – 1,034 million t at 941 ppm lithium – and inferred resources of 1.09 million t LCE – 235 million t at 871 ppm lithium at a 400 ppm Li cut-off. According to Noram Lithium's CEO, Greg McCunn, the project has a PFS underway. He envisions a plant processing 6 million t/y of ore, which will translate into almost 33,000 t/y of lithium carbonate. "This will be approximately 5% of the world's lithium carbonate supply today, but maybe only 1% if we fast forward to the forecasted demand in 2030," explained McCunn. ■

> Nevada's strategic location within North America offers supply chain advantages thanks to legislation like the US Inflation Reduction Act.

Tim Fernback

President and CEO
GRID BATTERY METALS

What was the reason behind the re-branding into Grid Battery Metals?
Grid Battery Metals is a company with a team that boasts a decade of experience in lithium exploration in Nevada. We own three projects in the region: Clayton Valley, Texas Spring and Volt Canyon. In early 2023, the company rebranded, changing its name from Nickel Rock Resources to Grid Battery Metals to reflect our focus on EV battery metals, particularly lithium. As a result, we are planning to separate our nickel and lithium properties into two publicly traded entities. This strategic move aims to give shareholders the advantage of an equity interest in two publicly traded companies at no additional cost to the current Grid shareholder. We anticipate listing the new company in February 2024. Grid's nickel property in British Columbia is adjacent to FPX Nickel's Baptiste nickel project, one of the top 10 nickel resources currently being developed worldwide. Ee expect it to be integrated into the FPX project as it transitions into a mine, potentially becoming one of the leading nickel-producing mines in Canada.

Could you provide more information about your projects in Nevada?
Grid Battery Metals has been actively exploring the Clayton Valley project for several years. This area is renowned for its lithium extraction potential, being the sole lithium brine-producing area in Nevada and stands poised for significant future developments. Our other project, Texas Spring, is located on the southern border of Surge Battery Metal's Northern Nevada lithium project, which has been gaining considerable attention. I previously served as the President and CEO of Surge, and I was part of the team that discovered the Northern Nevada lithium project. We firmly believe in the substantial potential of the southern area. To date, we have conducted comprehensive soil sampling and geophysics assessments, and the results strongly indicate that this project could evolve into a flagship property.

Additionally, we have the Volt Canyon lithium project in Monitor Valley, an area that shares signature characteristics with other lithium deposits found in claystone. Our team is currently on-site, assessing its lithium potential.

What will be the company's focus in 2023?
We will focus on analyzing the assay lab results. Once we receive these results, we will combine them with the data from the soil samples and geophysics work, enabling us to develop a multi-phase test drilling program. The initial phase will likely entail drilling six or seven holes, and depending on the outcomes, we may consider expanding to a 20- or 30-hole program later in 2024.

What is Grid Battery Metals' financial status?
In 2023, we completed three financing rounds, ensuring sufficient funds for our exploration campaigns in 2023 and 2024. Drawing from my background in investment backing, we prioritize maintaining a financial buffer of 18 to 24 months of operating capital. This approach sets Grid apart from other companies that often run out of funds. In addition to our cash reserves, we have strengthened our financial position by divesting non-core nickel assets to Surge Battery in exchange for a valuable 6 million share equity position in Surge. Furthermore, we intend to separately finance the spin-off of our nickel assets in British Columbia separately, safeguarding Grid's current treasury.

What do you think sets Grid Battery Metals apart from other juniors?
We selected Nevada due to its highly favorable conditions. We prefer to operate in areas with low political risk, reliable crews, and a guarantee that funds raised will be directly invested in exploration. Nevada perfectly aligns with these criteria.
Nevada's strategic location within North America also offers supply chain advantages thanks to legislation like the US Inflation Reduction Act and Canada's Critical Minerals Act.

How are automakers reshaping mineral supply chains for EVs?
In the past, automakers such as Tesla and GM primarily engaged with metal brokers like Glencore, who dealt with refined metals. However, they have now extended their reach into the supply chain by establishing connections with producers and junior mining companies. This shift is motivated by their desire to secure future supplies of critical minerals, such as lithium. This evolving approach opens exciting partnership opportunities for companies like Grid. It's a win-win situation that benefits both parties and ensures a steady supply of critical minerals for the growing EV market. ■

Highlighted Projects: Lithium

Shaping the future supply of the "white gold"

Bruce Richardson, CEO, **ANSON RESOURCES**

"For the Paradox Project, Anson partnered with Worley and technology provider Sunresin for a US$500 million DFS. The study focused on a chemical plant process, diverging from conventional hard rock mining methods. Initially designed for 10,000 t/y based on a JORC resource of 1 million t at 140 ppm, the DFS revealed an increase to 13,000 t/y with an average grade of 180 ppm. The project boasts an IRR of 47%, an NPV of US$1.3 million, and a payback period of about two years. The next stage, front-end engineering design, is expected to be completed in Q1 2024."

Jason Latkowcer, President and CEO, **PAN AMERICAN ENERGY**

"On November 2023, we announced our inaugural MRE for the Horizon Lithium Project, one of the largest identified lithium deposits in the US, exceeding 10.2 million t with an average grade of 678 ppm lithium (cut-off at 300 ppm Li). The deposit shows potential for expansion through step-out drilling in any direction and at greater depths. We are currently assessing geophysical exploration techniques, including passive seismic and resistivity, and progressing with Phase 3 drill planning and permitting. Simultaneously, we are actively advancing steps to complete a PEA."

Stephen Handson, President and CEO, **ACME LITHIUM**

"The Clayton Valley Project, situated in an ancient lakebed near a longstanding lithium source since 1966, underwent a Phase 2 evaluation program by ACME. Indications of potential lithium deposits emerged in the northwest area of the lakebed. The brine well and pumping test aim to determine system activity, productive flow, and gain insights into lithology, including permeability, porosity, and grade. Our goal is to comprehend flow dynamics, reservoir characteristics, and dimensions, crucial for resource identification and estimating lithium content within the project area."

Greg Reimer, President and CEO, **SURGE BATTERY METALS**

"In spring 2023, we executed a drill program at the Nevada North Project, identifying eight new drill sites. The program is now complete, and assay results are being received. The initial five holes yielded significant results, with one hole averaging 4,067 ppm Li and reaching a high of 8,070 ppm Li. The program's objectives included extending the strike length from 1.6 km (as per the 2022 program) to 3.5 km, and broadening the project width from 400 to slightly over 900 meters."

Richard Leveille, Chief Consultant, **IGX MINERALS**

"We created a methodology for processing satellite imagery that highlights minerals associated with lithium brine deposits and we expanded our search to Utah. We quickly identified three areas that met our criteria: they lit up with the satellite imagery, had historical data suggesting they were prospective for lithium, and had mineral rights available for staking under US law. We have secured claims on two of these areas and are staking another, all under IGX Minerals."

Rare Earths, Graphite and Nickel Development and Exploration

Reducing dependency on foreign minerals

The Western US mining industry is living a transformative period in the realm of rare earth elements (REEs) and green-critical minerals like graphite, nickel and cobalt. According to the International Energy Agency, clean energy technologies will demand an increase from today's levels of over 40% for copper and REEs, 60-70% for nickel and cobalt, and almost 90% for lithium by 2040.

China currently has the largest reserves of REEs and is poised to contribute significantly to the projected increase in both supply and demand. Economic and soft-power competition between China and the US is not new, but given that Beijing controls these REEs, they could be weaponized economically. Washington is therefore taking proactive measures to reverse this situation: For instance, in June 2022, the Biden Administration invoked the Defense Production Act (DPA) to address US dependence on imports of critical minerals, which gives the Department of Defense funding to support the supply chain for minerals like lithium, nickel, cobalt, graphite and REE.

In this context, from the "Americanization" of companies to the exploration of tailings for byproducts and reuse of abandoned mine sites, several dynamics have unfolded within the junior segment across the Western US to leverage government incentives and unlock the potential of mineral deposits.

The opportunity of REE while holding to environmental stewardship

With the surge in demand for critical minerals and the policies of the US Government, many companies have recognized an opportunity to realign their corporate narratives with Washington's political interest. Such is the case of American Rare Earths (ARR), an Australian company.

Melissa Sanderson, ARR's board member and spokesperson, explained that ARR intend to be listed at the highest level of the OTC and, eventually, on the NASDAQ. "As we embraced the motto of 'mined and made in America,' we are confident in the security and reliability of our supply chain. We envision ourselves at the heart of the US strategy as we anticipate the surge in demand from 2030 onward when hopefully ARR will be in full production," she said.

ARR possesses four assets: Halleck Creek, the flagship in Wyoming; Beaver Creek, also in Wyoming; Searchlight in Nevada; and La Paz, in Arizona. In March 2023, the company published a JORC report for Halleck Creek of 1.43 billion t of rare earths, enabling it to produce approximately 4 million t of crucial materials, namely neodymium and praseodymium. "Halleck Creek and La Paz share a critical characteristic: They are low in thorium and uranium. This becomes especially advantageous during the permitting process as we will not require special permits from the National Regulatory Agency nor need to implement elaborate storage methods, which translates to significant cost and time savings as we venture toward production," explained Sanderson.

This low level of thorium and uranium is a game changer since, historically, the mining and production of REE was associated with heavy environmental impacts, a reason why China and some other countries with lower environmental standards have monopolized the segment. In this context, REE companies have the opportunity to demonstrate that domestic production of these elements can be done efficiently, responsibly and sustainably.

Through collaboration with US Government-funded research through the DOD, DOE, the Critical Materials Institute, the Lawrence Livermore Laboratories, and a consortium of US universities, ARR is seeking an innovative method for sustainable rare earth extraction employing genetic manipulation of biological agents. "If proven successful, these biological agents would be introduced at the concentrate stage, bonding for instance with the neodymium in the concentrate, allowing for the selection and isolation of pure neodymium, significantly streamlining the process, and resulting in considerable time and cost savings," concluded Sanderson.

Rare Element Resources, a company focused on Northeast Wyoming with its Bear Lodge project, completed a PFS showing a mine life of over 30 years, and has been focusing on collecting bulk samples for purposes of advancing its technology into a demonstration-scale processing and separation plant: "We plan to produce up to 10 t of neodymium-praseodymium (Nd/Pr) oxide at a high purity of 99.5%. In addition, we will also produce lanthanum, SEG (a combination of samarium, europium, and gadolinium), and heavy rare earth element concentrate for further refining," shared Brent Berg, president and CEO of the company.

To advance the technology, Rare Element Resources has forged partnerships with the Department of Energy (DOE), which provided half of the funding for the US$44 million demonstration-scale project in Upton, Wyoming. Additionally, the company has collaborated with General Atomics, its majority shareholder. "Our process prioritizes environmental sustainability by recycling major chemical reagents, thereby reducing waste. We have streamlined our approach by eliminating the stripping step in solvent extraction, setting us apart from conventional methods used in countries like China," explained Berg.

Laurel Sayer, CEO, **PERPETUA RESOURCES**

> "The Stibnite Gold Project, in its initial six years, could fulfill 35% of US antimony demand."

In the Stibnite mining district in central Idaho, a unique narrative is unfolding as the demand for antimony catalyzes the restoration of an abandoned mine site. Over a century of mining activities, which contributed to the discovery of critical minerals during World War II, has left behind environmental challenges that are now being addressed while bringing the district back alive. Once operational, the Stibnite gold project, being developed —or restored— by Perpetua Resources, will be one of the country's highest-grade, lowest-cost open-pit gold mines in the US, with 4.8 million oz of gold reserves. But what is moving the project forward is the antimony component: "The Stibnite Gold Project is primarily a gold project, with antimony playing a pivotal role in the permitting process given its status as a critical mineral. In total, there are 6 million ounces of measured and indicated resources, with an additional 1.2 million oz of inferred resources." explained Laurel Sayer, CEO of Perpetua Resources.

The Department of Defense has granted Perpetua up to US$24.5 million in Defense Production Act Title III in Defense Production Act Title III funds to advance through the permitting requirements and, more recently, it received a US$15.5 million award to study military-grade antimony trisulfide development from on-site materials. Perpetua is expecting the release of the final EIS and draft Record of Decision, with a final Record of Decision expected in 2024, and its goals are to secure the final NEPA stamp of approval and all ancillary permits to be ready for construction, aiming to start production in 2027.

Cobalt, Nickel and Graphite: Critical for EVs

Champion Electric has adopted a different approach from ARR. Initially established in 2016 under the name Idaho Champion, the company primarily focused on assets in Idaho. However, in 2023 it rebranded itself as Champion Electric to better represent its expansion into Québec and its focus on battery metals like lithium and cobalt.

In Idaho, Champion Electric owns the cobalt Twin Peaks project, a past producing mine located next to Electra Battery Materials' Iron Creek project. "The geologic structure at Twin Peaks is perceived as an extension of the Iron Creek project. As a result, we anticipate similar levels of success. In addition to Twin Peaks, we own other properties, including Victory, Fairway and Ulysses. Three of our properties are adjacent to the Jervois Mining ICO project, ready to go into production," said Jonathan Buick, president and CEO of Champion Electric Metals.

Buick believes that despite its importance, investors often misunderstand the importance of cobalt, whose primary function in batteries is stabilizing nickel. "Establishing a domestic cobalt supply becomes critical as we advance the electrification of the world. The geopolitical aspect is also a concern, as state control over cobalt supplies could become political," he concluded.

On the other hand, nickel in lithium-ion batteries lends a higher energy density and more storage capacity. The US is home to only one nickel mine, Lundin Mining's Eagle Mine in Michigan, that produced 18,000 t of nickel in concentrate in 2022, which was exported to smelters in Canada and overseas. Alaska Energy Metals intends to add another: the Nicolai project in Alaska. Gregory Beischer, president and CEO of Alaska Energy Metals, said: "Despite challenging market conditions, we demonstrated the project's quality and raised an additional US$9.5 million in the summer of 2023, promptly investing it in drilling activities. Recognizing the extensive historical drilling and disseminated nickel mineralization over significant distances, we strategically drilled on a grid pattern to initiate the first resource calculation," explained Beischer, who added that, by March 2024, he anticipates announcing the completion of the resource calculation.

Another critical component of lithium-ion batteries is graphite, which is used to intercalate lithium ions efficiently. This makes it a suitable material for the reversible electrochemical reactions that occur during lithium-ion batteries' charging and discharging cycles. In 2022, China was the world's leading graphite producer, producing an estimated 65% of world production, and recently announced its decision to restrict graphite exports, days after Washington released new controls to limit semiconductors chips to Chinese companies. Beijing's decision shows the current geopolitical dynamics surrounding minerals and how they can be weaponized between hard and soft power.

To bridge this gap, Westwater Resources, a company based in Denver, Colorado, but with projects in Alabama, plans to establish a fully integrated graphite production in the US by developing its Coosa graphite project to feed the Kellyton graphite processing plant. "Our mining operations are set to provide all the graphite needed for our processing facility. We recently announced a 33% increase in the processing plant's capacity. In Phase I, our capacity is 10,000 t/y, which is expected to double when processing graphite for Coated Spherical Purified Graphite (CSPD) due to a 50% efficiency rate," shared Frank Bakker, president and CEO of the company.

By the end of 2023, the Westwater expects to conclude the PEA for the Coosa project and commence the development of the mine to have it operational by 2028. In the meantime, it has an agreement with Syrah Resources to feed the processing plant with graphite from Mozambique. ■

Image by Dane Rhys, courtesy of American Rare Earths

Melissa Sanderson

Board Member and Spokesperson
AMERICAN RARE EARTHS

> We envision ourselves at the heart of the US strategy as we anticipate the surge in demand from 2030 onward, when hopefully ARR will be in full production.

What is American Rare Earths' current asset portfolio?
American Rare Earths possesses four assets: Halleck Creek, our flagship asset in Wyoming; Beaver Creek, also in Wyoming; Searchlight, situated in Nevada, currently held as an asset rather than operational; and La Paz, in Arizona, which a 2021 JORC report showed holds 170 million t and has not been fully explored and could contain around 900 million t of Rare Earths Elements (REE). La Paz boasts a significant concentration of scandium, which proves particularly beneficial for EV manufacturers, since lighter cars translate to increased battery efficiency in electric cars.

Could you highlight the results of the recent JORC report for Halleck Creek?
In March 2023, we published a JORC report of 1.43 billion t of rare earths, enabling us to produce approximately 4 million t of crucial materials, namely neodymium and praseodymium. The JORC report accounts for just 25% of the entire Halleck Creek concessions, signaling an immense potential for a world-class asset.

Halleck Creek and La Paz share a critical characteristic: They are low in thorium and uranium.

What does the timeline look like for an upcoming PEA for Halleck Creek?
We recently completed a new drilling round. While our current findings have been consistent from the surface to a depth of 305 m, we want to explore even deeper. As we progress, we are in the pre-permitting study stage, with the scoping study nearing completion. We hope to have our PEA by the first quarter of 2024.

We possess abundant reserves of neodymium and praseodymium, pivotal in manufacturing batteries for various applications ranging from EVs to wind turbines. Equally crucial, these elements are integral components of permanent metal magnet motors found in semiconductors. As part of our drilling program, we aim to quantify other essential elements, such as terbium, a vital stabilizing component of the battery production process, preventing overheating and extending the battery's lifespan.

What are your thoughts on the role of the US Government regarding critical minerals and REE?
An uncommon bipartisan consensus has emerged supporting permitting reform, signaling a significant development for the industry. The existing uncertainties and prolonged duration of the permitting process have hindered investment and impeded the growth of mining in the US. However, the Democratic party recognized the importance of REE in achieving a cleaner, greener economy. On the other hand, the Republican Party's primary focus on enhancing national security, mainly by reducing reliance on China, which also drives the urgency to accelerate the development of new mines. The convergence of interest from the Democratic and Republican parties has fostered approximately six draft versions of a mining reform. Hopefully, these drafts will coalesce into a single unified version approved before the upcoming presidential elections.■

Jonathan Buick

President and CEO
CHAMPION ELECTRIC METALS

> In 2023 we rebranded to Champion Electric to reflect our expansion into Québec and our focus on battery metals.

What was the impetus behind the company's rebranding to Champion Electric Metals?
Champion Electric Metals is an exploration company focused on battery metals. We own four cobalt properties in Idaho, one of which includes the past producing Twin Peaks mine, and a lithium exploration project in Québec. Our company was established in 2016 under the name "Idaho Champion", since initially we focused solely on Idaho-centric assets. However, in 2023 we rebranded to Champion Electric to reflect our expansion into Québec and our focus on battery metals.

Could you elaborate on the company's lithium project in Québec?
Since September 2022, we completed nine acquisitions, resulting in our control over an expansive area of 530 km2 in the James Bay region. What sets our project apart is the advantage of existing infrastructure. We are diligently progressing with our field program, sampling and mapping exposed pegmatites, a crucial step ahead of our planned drilling in the fall of 2023 and winter of 2024.

What work have you been doing in your Idaho cobalt project?
Over the last 12 months, we have conducted two successful field programs, and a third is currently underway, involving sampling and mapping, with plans for drilling in the fall of 2023.

Adjacent to our Twin Peaks property lies Electra Battery Metals' Iron Creek project. The geologic structure at Twin Peaks is perceived as an extension of the Iron Creek project. As a result, we hold high expectations for our upcoming drill program, anticipating similar levels of success that Iron Creek achieved. In addition to Twin Peaks, we own other properties, including Victory, Fairway, and Ulysses. Three of our properties are adjacent to Jervois Mining's ICO project ready to go into production.

What makes Idaho an appealing jurisdiction for exploration?
While cobalt is typically found as a complementary metal accompanying nickel or copper, Idaho stands as one of the three locations globally, along with Finland and Morocco, where cobalt is the primary metal. However, copper and gold are among the metals coexisting, contributing to the economic viability of the projects. This combination creates a treasure trove of opportunities within the Idaho Cobalt Belt, making it a remarkable jurisdiction.

On the other hand, Idaho is an attractive destination for mining due to its well-established mining code, a strong foundation of the rule of law, and a supportive environment for the mining industry.

Do you think that investors often misunderstand the role of cobalt?
One of the significant challenges lies in the location of cobalt production, mainly in jurisdictions like Russia and Congo, which may not be as friendly to Western interests. Therefore, establishing a domestic cobalt supply becomes critical as we advance the electrification of the world. ■

Highlighted Projects: Rare Earths, Graphite and Nickel

Gaining momentum as key pillars of the United States security

Laurel Sayer, CEO, **PERPETUA RESOURCES**

"The Stibnite Gold Project is primarily a gold project, with antimony playing a pivotal role in the permitting process given its status as a critical mineral. In total, there are 6 million ounces of M&I resources, with an additional 1.2 million ounces of inferred resources. The project is expected to yield approximately 300,000 oz Au/year over 15 years, generating a free cash flow averaging around US$500 million/year. Following six years of scientific study and exploratory work, and seven years of regulatory review under NEPA, the Stibnite gold project is approaching its final permitting stages. The goal for the next 12 months is to secure the final NEPA stamp of approval and all ancillary permits to be ready for construction, which we anticipate will take about three years."

Brent Berg, President and CEO, **RARE ELEMENT RESOURCES**

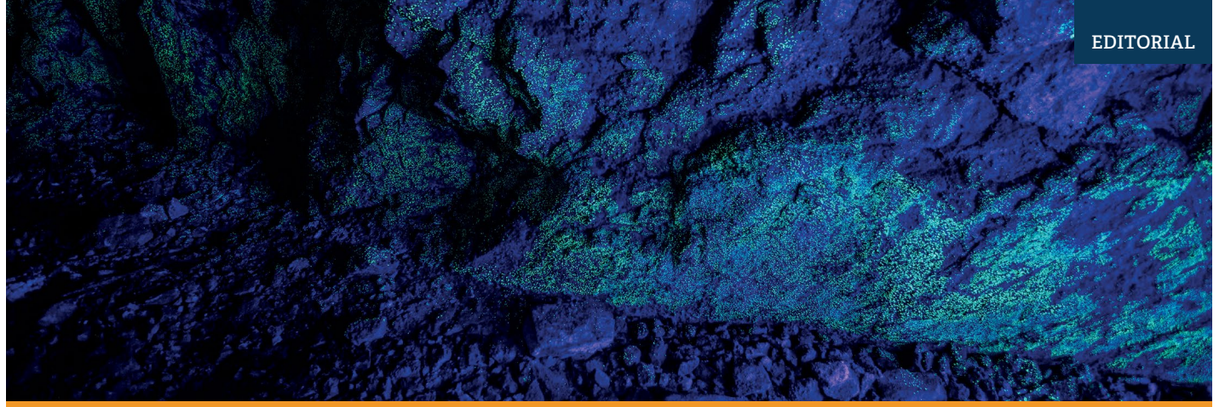
"Our Bear Lodge project has been extensively drilled, with over 500 core holes totaling over 285,000 feet of core. It is rich in the materials essential for producing high strength permanent magnets, predominantly neodymium and praseodymium. In 2014, we completed a pre-feasibility study that showed a 30 years LOM. We have collected a bulk sample from the Bear Lodge mineral deposit for purposes of advancing our technology into a demonstration scale processing and separation plant. We plan to produce up to 10 t of neodymium praseodymium oxide at a high purity of 99.5%. In addition, we will also produce lanthanum, SEG, as well as heavy rare earth element concentrate for further refining."

Michael Rowley, President and CEO, **STILLWATER CRITICAL MINERALS**

"In January 2023, at Stillwater West we expanded our mineral resources by 62%, reaching 1.6 billion lb of nickel, copper and cobalt; and 3.8 million ounces of palladium, platinum, rhodium and gold. This milestone was achieved through a relatively modest drill program, underscoring the rich mineralization of the district, where mineralization begins at the surface, resulting in cost-effective additions to our reserves. We are currently drilling, focusing on the Chrome Mountain target area, with a specific aim to extend the DR/Hybrid deposit areas located on the western edge that yielded a very impressive 13.2 m intercept of 2.3% nickel, along with significant PGEs, copper and cobalt."

Gregory Beischer, President and CEO, **ALASKA ENERGY METALS**

"The assay results from four of the eight drilled holes at the Nikolai project in Alaska confirmed our hypothesis and aligned with historical drilling. The zone is approximately 300 m thick in the initial drilled area, precisely exhibiting the mineralization concentration indicated by prior drilling—around 0.35% nickel equivalent. While not a high-grade deposit, it boasts continuity, homogeneity and a consistent grade across each drilling, including copper, cobalt, platinum and palladium. This wide and consistent nature aligns with the preferences of significant investors seeking large and stable deposits."



Uranium Development and Exploration

The renaissance of US uranium

If one looks at a map of the United States highlighting the primary uranium deposits, attention is immediately drawn to the West, particularly to the Wyoming Basins and the Colorado Plateau.

Uranium mining in the United States is carried out by a few companies; more precisely, in 2022, only five facilities in the US produced uranium. According to the US Energy Information Administration, Energy Fuels' White Mesa, the only fully licensed and operating conventional uranium mill in the US, accounted for 84% of the domestic production. The rest was produced at four in situ recovery facilities. The total output of triuranium octoxide (U3O8), or uranium concentrate, was 194,000 lb, an increase from the 21,000 lb produced in 2021 as White Mesa Mill in Utah resumed operations. Still, this figure is tiny compared to domestic production a decade ago.

Like many other minerals, the uranium material used in US nuclear power reactors is mainly imported from Canada, Kazakhstan, Russia and Uzbekistan. On the other hand, despite years of headwinds faced by uranium companies, the current tension between Moscow and Washington is favorable for uranium producers and developers. The US is keen to reduce its reliance on Russian uranium and post-Soviet satellite nations like Kazakhstan, which accounted for 43% of worldwide uranium production in 2022. Consequently, from exploration to production, players in the uranium industry are capitalizing on current spot prices and the projected supply shortfall.

Uranium production and ISR

Unlike other minerals and metals, uranium is not traded on an organized commodity exchange. Instead, it trades in most cases through contracts negotiated directly between a buyer and a seller. In recent years, low prices made it difficult for uranium producers to secure long-term contracts. "After the Fukushima incident, uranium prices fell significantly, making contracts scarce outside of Kazakhstan," explained John Cash, president and CEO of Ur-Energy, a company with a uranium in situ mine, the Lost Creek project, located in Wyoming's Great Divide Basin.

However, given the increasing recognition of nuclear power's carbon-free benefits and growing geopolitical concerns, uranium prices have risen during the last few months. Ur-Energy secured three long-term contracts that incentivized a ramp-up at its Lost Creek project: "180,000 lb of uranium are contracted for 2023, increasing to 600,000 in 2024 and 700,000 in 2025," informed Cash.

While the Lost Creek project is permitted to produce up to 1.2 million lb/y of uranium, the processing plant has a capacity of 2.2 million lb/y. "It provides the flexibility to process additional uranium from other sources, such as competitor mines or other facilities, allowing the Lost Creek to serve as a toll processing site," explained Cash.

Because of the in situ mine nature, the Lost Creek has no pits. In situ recovery (ISR), also called in situ leaching, is a process whereby small drill holes are made into the ground, and a mix of O2, CO2 and baking soda is injected to dissolve the uranium in the sandstone aquifer. Once liquid, recovery wells are used to pump the liquid containing uranium, and then the uranium-laden water is sent to a processing plant to purify and concentrate it. What sets this process apart is its reduced environmental footprint and the high recycling rate, with the potential to reach up to 99.5%, as highlighted by Cash: "In situ recovery has several advantages: low operating costs, minimal capital expenditure, and a negligible environmental footprint. Once mining activity ends, the land can be returned to its original use without any radiological concerns," he concluded.

The initial development of ISR dates back to the 60s and occurred in Wyoming, in the Shirley Basin. The US has large sandstone uranium deposits potentially amenable to uranium extraction by ISR, and many uranium exploration companies are considering leveraging this technology. One of them is Nuclear Fuels with its Kaycee project in Wyoming that covers a 43-square-mile claim package. Nuclear Fuels has been focusing on the Saddle zone, where it is undergoing a drilling campaign. The Kaycee project is a spin-off of enCore Energy, a uranium company with multiple projects spanning across Texas, Wyoming, South Dakota and New Mexico. Both companies maintain a partnership regarding this project: "Upon reaching a 15 million lbs measured and indicated combined resource, enCore gains a 51% interest, providing a clear roadmap to production with financial efficiency. This sets us apart from the typical dilutive path of exploration companies turned producers," explained Michael Collins, CEO of Nuclear Fuels.

Image by Mulderphoto at Adobe Stock

Uranium development: Leveraging mills

When discussing the role that the spot price of uranium plays in bringing new projects online, George Glasier, president and CEO of Western Uranium and Vanadium, said that prices must increase for production to commence. He also mentioned that if all ready-for-production projects in the US were activated, the US could meet half its demand within three to five years: "Developing new mines and justifying such investments require a sustainable price point and long-term contracts," he explained.

Western Uranium and Vanadium, located in Colorado, is focused on low-cost, near-term production of uranium and vanadium. Its flagship asset, the Sunday Mine Complex, has experienced intermittent mining activity and started stockpiling ore to feed an upcoming mill, which it plans to have fully operational by 2026. However, it halted stockpiling to focus on drilling and extracting core samples to identify more ore. The "State-of-the-art mill" will process high-grade ore using kinetic separation, a process that it is developing to remove non-uranium and non-vanadium bearing rock from the ore, reducing the quantity going to the mill: "By reducing the quantity milled, we cut costs and significantly reduce the mill's environmental footprint," concluded Glasier.

Hub-and-spoke model

Another company that plans to leverage a mill through a hub-and-spoke model is Anfield Energy, which owns the Shootaring Canyon Mill in Utah. "Our mill is one of only three licensed, permitted, and constructed conventional uranium mills in the US," said to Corey Dias, CEO, and Co-founder.

Michael Collins, CEO, **NUCLEAR FUELS**

> "US utilities aim to re-shore uranium supplies, creating a preference for domestically produced uranium."

Anfield has been conducting engineering and design studies for the refurbishment of the mill that includes a vanadium circuit: "A key part of this plan is the addition of a vanadium circuit, as our mines in Colorado are primarily vanadium mines with some uranium. This allows us to tap into a new market and take advantage of the growing demand for vanadium, especially for flow batteries," explained Corey.

As part of the hub-and-spoke strategy, the Velvet-Wood mine in Utah and the Slick Rock mine in Colorado will feed the mill first.

Corey explained the benefits of conventional uranium mining compared to ISR: "ISR has a lower cost of entry into uranium production, but its sustaining prices are higher than hard rock mining. The latter requires significant upfront capex to build a large mill, but its sustaining cost is lower as it does not require the creation of well fields every time materials run out. Over 20 years, the costs probably balance out."

Kraken Energy is another company that is following a hub-and-spoke model. Matthew Schwab, CEO, and Garret Ainsworth, chairman, brought to Nevada and Utah their experience from the Athabasca Basin. Schwab considers the Western US a "relatively unexplored uranium jurisdiction". Indeed, while Nevada is recognized as a mature jurisdiction for precious metals and is emerging as a hub for lithium projects, uranium ventures are not as prevalent in the region. "Uranium exploration in Nevada often goes unnoticed, given the state's reputation as the "Silver State" and the prevailing focus on lithium projects. However, our properties in Nevada hold substantial economic potential for various minerals, including uranium, gold, silver, copper, nickel and molybdenum, providing multiple reasons to invest in them," stated Schwab.

The company's flagship asset is the Apex property in Nevada, where it recently commenced a drilling campaign after receiving permits from the BLM. Kraken Energy has two other projects in Nevada: Garfield Hills, where it concluded the maiden drill program in March 2023, , and is already planning a phase II campaign for 2024; and Huber Hills, which requires baseline geophysical and radiometric surveys, and a maiden drilling program will start in 2024. The last project, in Utah and close to the White Mesa mill, is the Harts Points: "Harts Point represents our newest addition through an option agreement. We aim to progress with a maiden drilling program either at the end of 2023 or early 2024," concluded Schwab. ■

Highlighted Projects: Uranium

Rebuilding social acceptance for a greener future

John Cash, President and CEO, **UR-ENERGY**

"At the Lost Creek project, we have generated nearly 3 million lb of uranium. Post-Fukushima incident, uranium prices plummeted, reducing production due to scarce contracts outside Kazakhstan. However, the growing recognition of nuclear power's carbon-free advantages and increasing geopolitical concerns have revived uranium demand. Securing three long-term contracts has prompted a production ramp-up: contracted amounts are set at 180,000 lb for 2023, escalating to 600,000 lb in 2024 and 700,000 lb in 2025. Lost Creek's permitted production capacity is up to 1.2 million lb/y, while the processing plant can handle 2.2 million lb/y. This production flexibility allows Lost Creek to process additional uranium from diverse sources, positioning it as a toll processing site for competitor mines or other facilities."

Matthew Schwab, CEO, **KRAKEN ENERGY**

"Our flagship asset, the Apex property in Nevada, was a prime uranium producer in the 1950s. Recently, we swiftly obtained permits from the BLM and commenced drilling it. Additionally, in March 2023, we concluded the maiden drill program at Garfield Hills, which yielded promising results, with surface exploration revealing uranium grades exceeding 1%, and a phase II drilling program is planned for 2024. Huber Hills is in the early development stage, and it requires baseline geophysical and radiometric surveys. We aim to initiate the maiden drilling program on this property in 2024. Finally, Harts Point represents our newest addition through an option agreement. We aim to progress with a maiden drilling program either at the end of 2023 or early 2024."

George Glasier, President and CEO, **WESTERN URANIUM AND VANADIUM**

"At the Sunday Mine Complex, ongoing core sample extraction has unveiled significant ore. This process began in September 2023, when we acquired an underground drill that reached nearly 3,000 feet. We are drilling about 700 to 800 feet to identify more ore within the area we previously produced. We had been mining and stockpiling ore from one specific section of the mine, but we have paused mining there to focus on drilling."

Michael Collins, CEO, **NUCLEAR FUELS**

"The Kaycee project stands out as highly unique, with our control extending over 33 miles of the roll-front trend, showcasing a distinctive style of uranium mineralization. Mapped roll fronts span 110 miles, covering a 43-square-mile claim package, including BLM claims on private surface ground and BLM/state lease ground. Our focus on the Saddle zone has yielded promising results through ongoing drilling, which is expected to continue until December 2023 before resuming in spring 2024."

Engineering and Consultancies

“Transitioning from exploration to production takes more time and effort. Companies are opting to sustain existing operating mines for longer durations to adapt to this situation, exploring deeper or larger expansions at brownfield sites rather than investing in new greenfield projects.”

Scott Britton
US Director
MINING PLUS

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Water and Environmental Stewardship

How much water does really mining consume?

The only way to achieve the goals set by the Paris Agreement involves mining the minerals underneath the earth, and mining involves water. As NGOs and environmental groups lobby to prevent mining activities in certain areas, one might wonder how much water mining consumes compared to other industrial activities, such as agriculture or the fashion industry. According to a publication from The Energy Transitions Commission (ETC), a global coalition across the energy landscape, mining consumes around 4 billion m3 of water yearly. This is half of what is consumed by coal mining and only 0.1% of global agricultural water consumption. On the other hand, the fashion industry uses around 93 billion m3 of water yearly, a significant 2,225% more than mining.

The ETC also forecasts that a clean energy system will have a higher water consumption compared to relying on a fossil fuel matrix, approximately 58 billion m3 yearly compared to 37 billion m3 in power generation and extraction. However, the total consumption will still only equal around 2% of global agricultural water use. Comparing water consumption in mining and agriculture may appear unrelated, but as the old saying goes, "If it's not grown, it's mined." Both activities are essential: One sustains life, and the other supports the foundation of our modern society.

In this context, a fundamental question arises: Should the industry take a proactive role in educating society to address the misconceptions associated with mining while striving to reduce water consumption as technology permits? "People often overlook the importance of minerals, focusing more on agriculture and water. Therefore, education about the value of minerals is essential, and early communication with the community is crucial in mining operations. Mines are increasingly aware of their social impact and the importance of maintaining a balance with the environment," responded Robert Livermore, mining director at Civil & Environmental Consultants (CEC).

In a world where water resources were evenly distributed, concerns about water usage in mining might not be as pronounced. Paradoxically, it is essential to note that most mining activities take place in regions with water scarcity. This phenomenon is not limited to the arid Western United States but extends to other significant mining jurisdictions such as Peru and Chile. For Livermore, Arizona's open-pit mines often face criticisms but only represent 1% of the state's total acreage, making the perceived impact more significant than the actual one. The mining director also explained that persistent drought conditions have amplified the scrutiny from regulatory bodies and NGOs regarding water usage, resulted in mining operations proactively embracing new technologies such as dry stack tailings.

New approaches to sustain water stewardship

With climate change threatening ever-drier conditions, water management plans and solutions are gaining momentum in an industry that operates under the scrutinizing eyes of society, especially in the Western USA. Tom Meuzelaar, owner of Life Cycle Geo, sees room for improvement: "We are currently exploring water resource projects like aquifer storage and recovery, an area the mining industry should also consider."

Life Cycle Geo has been exploring the use of machine learning in water and materials management projects: "When properly implemented, machine learning can optimize the identification of different material types, leading to more accurate and efficient material sorting. Moreover, it offers opportunities to identify and classify more material types, opening doors to increased material reuse and recycling. The goal is to maximize the utilization of every material, minimizing waste and environmental impact," explained Meuzelaar."

Alan Driscoll, VP and director of mining services at Forsgren Associates, explained that water management in mining is a multifaceted challenge. "We explore options like using treated water for agriculture or ensuring compliance with regulations for water discharge. The challenge lies in making the most of this vital resource while preserving the environment and maintaining the economic viability of mining operations," he said.

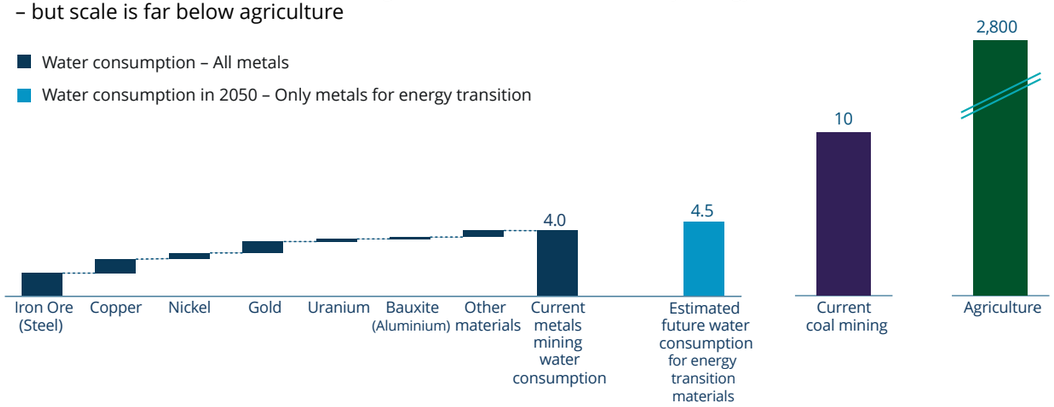
For Angela Persico, director of mining services business development at INTERA, the most significant challenge associated with water management is dealing with "unexpected surprises" that can considerably impact progress and a company's reputation. According to Persico, these unexpected surprises can occur during all stages of the mining life cycle, such as discovering more water than initially anticipated and discovering that dewatering operations are affecting a local water resource or stope stability. To mitigate surprises, INTERA aims to provide comprehensive information and understanding by leveraging data from different project stages. "Informed decision-making and effective communication with stakeholders, including the company, investors, neighbors, NGOs, and regulators, is crucial to avoiding surprises and reducing pain points across the board," she said. "Mining companies are trying to recover from the legacy of historical mining practices in the Western US that have left scars on the landscape and risks to humans and the environment," she concluded.

Responsible land and community stewardship

Ideas on how to remedy mining's environmental footprint and build a better relationship with society are rife amongst the community of engineers and consultants in the Western USA. They will be crucial in ensuring that the region can fulfill the vital mission with which it has been tasked: To provide the USA with the minerals and metals for a cleaner future in a cleaner manner. The mining industry must prove to society that more environmentally friendly mining practices can achieve a transition to cleaner energy.

Annual Water Consumption from Metals Mining

Water consumption* for metals mining could rise in future, driven by energy transition – but scale is far below agriculture



*Water consumption is water that is taken from a source and is not returned to the source.

Source: The Energy Transitions Commission (ETC) 2023

Image by ronnybas at Adobe Stock

In recent years, mining companies have undergone significant transformations in their journey to more responsible land and community stewardship. There is a heightened focus on closure processes and an increased awareness of potential impacts on surrounding communities. "Mining companies have increasingly prioritized embedding these values into their project planning and incorporating them during operations, recognizing the importance of obtaining and maintaining their social license to operate. Their efforts encompass active community engagement, hiring their workforce from the local communities, and addressing community concerns up front in the project planning process," commented Todd Glindeman, mining market sector director at Brown and Caldwell.

Brown and Caldwell offers a comprehensive suite of water and environmental solutions, including compliance and permitting, industrial water, and site investigation and remediation. It has participated in the Perpetua Resource's Stibnite gold project in Idaho, providing support throughout the permitting and NEPA process, which involves coordination with various federal and state agencies. Brown and Caldwell is also focused on R&D and partnered with multiple research foundations like the Water Research Foundation: "We understand that the environmental challenges confronting our clients are constantly evolving in scope and complexity. Our commitment is to continuously push the boundaries of science and conventional approaches, delivering tailored solutions that yield significant impacts," said Glindeman.

For Eric Mears, vice president of Haley & Aldrich, more rigorous international standards, such as the GISTM, and more federal funding for addressing abandoned mine lands have contributed to the increased emphasis on responsible environmental practices. Due to its expertise in mine closure, Haley & Aldrich has secured numerous significant private-sector projects and federal contracts for abandoned mine reclamation. This recognition has bolstered its reputation and prompted its expansion into Colorado, Montana, Idaho and Washington. "Our unique approach, analog reclamation, creates post-mining landscapes that closely resemble the natural environment. Although analog reclamation can incur higher costs during the design and execution phases, it ensures long-term environmental durability, reducing the need for extensive maintenance or repairs after reclamation is complete," explained Mears.

Jeff Parshley, corporate consultant at SRK, asserted that, in the Western US there has been an awareness of the significance of mine closure for decades. However, he mentioned that closures are not just an end-of-life consideration: "It demands early attention during the mine life cycle, especially during the development phase.... Even with a meticulously planned closure for a 20-year mine life, the development of new technologies is inevitable. Continuous review and modification of closure plans are essential as new data emerges, regulations evolve, community perspectives shift, and innovative technologies are developed," he explained. ■

Critical Minerals

Sustainable Sourcing of Critical Minerals from Unconventional Resources to Enable the Energy Transition

Expert Opinion Article by
Anne Thatcher, Senior Vice President, **ARCADIS**

Shifting the world's energy generation paradigm toward one based more heavily upon renewables (e.g., solar, wind, battery, hydrogen and nuclear) will require a significant increase in the supply of critical minerals. These include lithium, nickel and cobalt for battery cathodes; rare earth elements for electric vehicle (EV) and wind turbine motors (neodymium, boron, iron permanent magnets); and semiconductor metals such as gallium, germanium, indium and tellurium for photovoltaics. The International Energy Agency reported in their July 2023 Critical Minerals Market Review that, from 2017 to 2022, there was a tripling in demand for lithium, a 70% increase in demand for cobalt, and a 40% rise in demand for nickel. This same report pointed to China's export restrictions on gallium and germanium (the price of this element has increased 40% since 2020). Copper is also on the list of critical minerals, and concern is also growing about its availability to enable global electrification – S&P Global recently predicted a chronic shortfall of copper from 2024 onward of 20% of that required to achieve net-zero goals. For a successful energy transition, in terms of timeline (i.e., meeting the Paris Agreement greenhouse gas emission reductions of 43% by 2030 and net zero input to the atmosphere by 2050) and public adoption (i.e., EVs available at price points for most consumers), critical mineral sources will need to be abundant and diverse.

> "More attention needs to be focused on critical mineral recovery from aqueous mine wastes."

There are challenges on two fronts for a successful energy transition in the US that miners can address: Sourcing critical minerals, many of which are limited in terms of conventional ore sources within countries that are friendly trading partners with the US, and finding these elements in sufficient supply to meet demand and prevent deceleration of the pace of the transition. A third challenge for the US is the tension between constructing new mines (in 2022 domestic metal mine production was 6% lower than in 2021) and the ravenous need for metals that clean energy technologies require (this was highlighted in the editorial in Nature, May 2023 (Vol. 615)). A solution exists today, however, that requires close attention – the sourcing of critical minerals from unconventional resources such as solid mine wastes (waste rock, leached ore, tailings) and mill residues (e.g., copper and gold beneficiation wastes such as dusts, slags, and refinery slimes). These materials are currently stockpiled at hard rock mines across North America and managed as waste materials at operating and closed mines. The timeline to getting supply from these sources to the market can be fast, often with a favorable environmental footprint.

More attention also needs to be focused on critical mineral recovery from aqueous mine wastes (acidic leachates from these stockpiled solids). Current water treatment practices focus on "recovery" of metals (through lime neutralization of acidic waters) to limit impacts of metal constituents in waters that contact ore on the surrounding environment; the water treatment residues are typically landfilled. Why not go a step further to valorize the metals recovered from mine water treatment through thoughtful treatment and separation to meet the demand for these difficult to source critical minerals?

There is currently an entire value stream at operating copper, gold and other metal and non-metal mines, that can sustainably source critical minerals for the energy transition. A resilient supply of critical minerals exists within this value stream. Getting this supply to the market will require technical skills that combine the science and engineering disciplines – with geochemists and geologists working together with mineral processing engineers, metallurgists and water treatment engineers – to first understand the occurrence of critical minerals across the value chain and then to identify how to recover and concentrate these elements. Existing water treatment, extractive metallurgy, and beneficiation processes may be pressed into service or redirected to achieve critical mineral recoveries that support the costs of implementing these recovery approaches.

Other tangible benefits beyond the saleable value of the recovered elements need careful examination, however, as water treatment processes may be optimized, and long-term water treatment costs offset by capitalizing on these opportunities. Similarly, the environmental footprint of beneficiation wastes may be reduced through critical mineral recovery. All of these benefits to the mine operator and stakeholder community mean that unconventional resources of critical minerals should be closely evaluated – our clean energy future in North America may depend upon it. ■

> Continuous review and modification of closure plans are essential as new data emerges, regulations evolve, community perspectives shift, and innovative technologies are developed.

Jeff Parshley

Corporate Consultant
SRK (US)

What has driven SRK's business in the USA in the last few months?
Our North American operations have been remarkably active, particularly in the US. We have been extensively involved in several new projects and supporting existing operations. Some of the latest projects have included lithium, copper and gold. We have worked on resource and reserve estimates, mine planning, and comprehensive mine waste engineering and permitting exercises.

With the Biden administration's heightened focus on critical minerals, there has been a surge in activity and funding dedicated for critical minerals projects, including reprocessing old mine waste to extract minerals that were once considered of little to no value.

Additionally, despite recent lithium price fluctuations, long-term perspectives drive sustained interest.

What is the importance of mine closure plans?
Mine closure is not merely an end-of-life consideration; it demands early attention during the mine life cycle, especially during the development phase. Forethought in the design of mine and waste facilities can help avoid complications and higher costs during closure.

On the other hand, proactive engagement with communities and stakeholders has gained increasing importance. Asking for their input early in the process ensures their involvement in discussions about the future use of the mine property, considering potential repurposing of land and infrastructure for other uses. The overarching goal is to facilitate a transition from a mining-based economy to a post-mining one, emphasizing socio-economic transitioning.

How do you approach integrating new technologies into existing mine closure plans?
Current technologies to extract additional metals from mine waste is a good example. By extracting critical metals from mine waste, we can mitigate the potential environmental impacts from a closed site. However, it is crucial to acknowledge the constant evolution of mine closure technologies. Even with a meticulously planned closure for a 20-year mine life, the development of new technologies is inevitable. Continuous review and modification of closure plans are essential as new data emerges, regulations evolve, community perspectives shift, and innovative technologies are developed.

How do mine closures affect local communities from a socio-economic perspective?
Closure of mines will affect local communities, regardless of where they occur. However, in the US the impacts can be less than in many countries where community resilience is limited, government and community capacity is less, and workforce mobility more difficult. Socioeconomic transitioning is complex and despite efforts to mitigate the impacts of mine closure on communities and local economies, some level of impact will remain.

Mining jobs generally offer higher than average salaries. While some jobs may be replaced post-closure in other industries, rarely are all positions filled, and the new opportunities often come with lower salaries. This presents a significant challenge, especially considering the potential out-migration of skilled workers seeking employment in other mining regions. This dynamic not only alters the economic landscape but also impacts the character of local communities.

Finding alternative future uses for mine sites and infrastructure is one method for developing alterative economies and mitigating some of the impact of mine closure. For example, most mine sites in the US rely on the grid for power, utilizing high-capacity transmission lines. When a green energy component is part of the closure vision, there is potential to repurpose these transmission lines.

Where do you see gaps that should be bridged in mine closures?
I have been heavily focused on socio-economic transitioning in recent years. Historically, there has been a tendency to create silos between those working on community engagement and the technical aspects of closure. My focus is to bridge this gap and integrate the technological and social dimensions of mine closure. This integrated approach is personally exciting and fulfilling especially because it fosters a more holistic and practical path to success for closure initiatives.

What should we expect from SRK in the upcoming months?
At SRK, we strive to maintain leadership across various sectors within our scope of services. Considering the ongoing labor shortage in the mining industry, we are constantly seeking bright individuals. We actively seek talented people with innovative ideas, recognizing the industry's need for fresh perspectives. Internally, we are exploring the potential use of artificial intelligence in our work, though cautiously, ensuring it aligns with our commitment to excellence. ■

Industry Insights - Consultancies

Balancing water and energy consumption

Robert Livermore, Mining Director,
CIVIL & ENVIRONMENTAL CONSULTANTS (CEC)
"Mines are increasingly aware of their social impact and the importance of maintaining a balance with the environment. Moreover, there is a growing effort to educate younger generations about the significance of mining and the role of natural resources in our lives."

Alan Driscoll, VP and Director of Mining Services, **FORSGREN ASSOCIATES**
"Building strong relationships with regulators right from the outset remains a critical strategy. It fosters trust and transparency and paves the way for smoother project execution."

Brock Norwood, Head of Mining Business Development, **DHI GROUP**
"A water balance, coupled with a groundwater model, facilitates informed decisions on pumping locations, quantities, and water quality considerations. This includes assessing whether to redirect pit water to stormwater retention ponds or other pits or for on-site purposes such as in SX plants or dust suppression."

Doug Cannon, President and CEO, **NV ENERGY**
"Renewable energy projects may seem pricier upfront but offer long-term cost savings. Thus, it is not necessarily a matter of renewables being significantly cheaper today; instead, they provide cost stability and predictability over the entirety of the project's lifespan."

Chris Summers, CEO, **BURGEX MINING CONSULTANTS**
"It is unrealistic for small entities like ours to bear the entire burden of advocating and promoting responsible mining. We need to join forces with majors, juniors, and other consultancies to collectively help the public understand the transformative changes in the industry."

Angela Persico

Director of Mining Services Business Development
INTERA

Can you provide an overview of INTERA's history and the services you offer?
Our primary focus is assisting clients in addressing complex challenges related to characterizing and optimizing water resources. INTERA helps our mining clients to better understand the risks and opportunities associated with water throughout the mining life cycle by providing the tools and information to make well-informed decisions that reduce development and closure schedules, which reduces costs during the times mines are not profitable.

What are some of the most significant challenges associated with water management in the mining industry?
One of the most significant challenges associated with water management is dealing with unexpected surprises. These surprises can have a considerable impact on project progress and a company's reputation. Surprises can occur during all stages of the mining life cycle. For example, discovering more water than initially anticipated at the project's start, discovering that dewatering operations are affecting a local water resource or slope stability, or discovering that proactive modeling and investigations could have helped to avoid a large, expensive groundwater remedy during closure.

Given the complexity of regulatory frameworks in the mining industry, what advice do you offer to companies navigating these regulations?
To succeed, it is essential to start strong by assembling a multidisciplinary team of experts and investing in high-quality hydrogeological characterization and modeling upfront. This initial investment pays off by leading to optimizations during the operational stages, reducing project delays, reducing surprises, and minimizing the risk of regulatory backlash.

Building strong relationships with regulators, the public and local communities is vital. Demonstrating a commitment to responsible mining practices and showcasing a deep understanding of the site's environmental aspects, including water management, helps build trust and support among stakeholders. While the regulatory process can be lengthy, these strategies can help companies navigate it more effectively and establish a positive track record in responsible mining.

Can you explain the importance of mine closure plans and where you see opportunities for improvement in the industry?
Well-designed mine closure plans are key to responsible mining practices and essential to securing funding, social license and formulating long-term cost projections. Mine closure plans also serve to reduce risk during operations and provide transparency when interfacing with stakeholders. Accurate baseline characterization is indispensable to sound closure planning.

Legacy mines and cumbersome permitting processes in the US have dominated the mine closure narrative. Opportunities for improvement in closure planning lies in demonstrating to the public and to regulatory agencies successful mine closures, including the return of mined lands to beneficial use.

What trends do you see in mine closure?
Mining companies are trying to recover from the legacy of historical mining practices in the Western US that have left scars on the landscape. Modern mining and technologies are moving toward natural landscapes, native vegetation, and returning the land to pre-mining conditions. ■

Engineering

Boosting profitability

In October 2023, the global consultancy firm EY published its Top 10 business risks and opportunities for the mining and metals sector in 2024. According to the report, ESG factors remain paramount, ranking first. Capital takes the second spot, followed by license to operate, with climate change, digital innovation, costs and productivity, geopolitics, cyber security, new business models, and workforce in the last place.

Thus, across all five top trends, a segment comprising consultancy firms, engineering companies, and constructors plays a pivotal role in assisting mining clients navigate complex permitting frameworks, develop strategic approaches, and ensure compliance with environmental stewardship, all while fostering positive relationships with stakeholders with different interests.

Unlocking Tailings

Mining Plus' US director, Scott Britton, is noticing two major industry trends in the Western USA. First, the increased potential for expanding existing mines and rising mining costs outweigh the potential for developing new mines. The second is that the times required for new mining projects are becoming longer. Thus, companies opt to sustain existing operational mines for longer, exploring deeper or at brownfield sites rather than investing in new greenfield projects.

S&P Global reports that in the early 2000s nearly half of the world's exploration budgets were allocated to grassroots exploration, but this has declined in recent years. According to PDAC's 2021 figures, the last year grassroots exploration peaked was in 2008 (around US$5 billion), followed by a drop to US$2 billion in 2020 and another peak in 2021, reaching US$3 billion. "Even though it seems grassroots exploration is recovering, operating companies focus on expanding deeper and larger operations to capitalize on favorable commodity prices," said Britton.

Anne Thatcher, senior vice president at Arcadis, has noticed that mines that were supposed to be closed 10 years ago have stayed open. Clients are exploring more in those sites, a decision also driven by the premium of producing in North America. "They are investing in the West because they found that allocating their resources globally has not necessarily produced a return on investment," she said.

Arcadis, with expertise in tailings, is helping its clients to understand what type of critical minerals they have in their waste rock or tailings, as well as helping them to understand the geochemistry, how to reprocess it, and the chemical engineering needed to transform the waste into something profitable.

Tailings are a tricky asset or liability. They often contain harmful chemicals and heavy metals, and managing tailings is a critical concern. However, they can also contain value. In the Western USA, copper is the principal contributor to the total volume of tailings (33%). With a lack of new copper mines in the near term, technological advancements today have made it possible to extract value from what was once considered waste.

Arcadis has been busy helping its clients to meet the new Global Industry Standards on Tailings Management (GISTM) directrices: "Our clients are adapting to comply with the 77 requirements of the GISTM. Many of those requirements relate to geotechnical engineering, but some also relate to surveys for biodiversity or hydrogeological conceptual site models," stated Thatcher.

For Peter Kowalewski, Tierra Group International's founding principal, the GISTM represents a significant industry shift. "Companies have begun to understand the liabilities that tailing storage presents to operations, ranging from the risk they pose to workers and inhabitants around the facilities to the financial impact on the company. In response, companies have worked to reduce or eliminate (where possible) these liabilities", he explained.

Besides being an area where companies must comply with stringent regulations, especially after disasters like Brumadinho that affected the mining industry's reputation in the eyes of the international society, tailings represent an opportunity: They can be re-mined or processed to extract remaining ores that were previously deemed unprofitable. This approach could involve lower costs and risk than starting new grassroots or greenfield explorations.

Long-term relationship primes

Fostering long-term relationships has been the cornerstone of Practical Mining, a small geological and engineering service company based in Nevada that proves that size is not an impediment. "In the dynamic landscape of mining projects, needs often evolve over time. Our ability to

Image courtesy of Kappes, Cassiday & Associate (KCA)

swiftly address these challenges and keep the project on track is pivotal in benefiting all stakeholders," explained Dagny Odell, owner of Practical Mining.

In recent years, Practical Mining has been incorporating technology to enhance its LiDAR scanning capabilities, and with drones becoming more autonomous and capable of flying longer distances, they can now map inaccessible areas of underground mines without human intervention. "This convergence of technology is poised to revolutionize how we operate, making the mining industry more efficient, effective, and safer," explained Odell.

Another company that has seen the benefits of drones and LiDAR scanners is the high-tech geospatial engineering provider Darling Geomatics. The outcome becomes revolutionary when Artificial Intelligence is added to the equation. "When combined with other data sources, such as drone surveys with LiDAR and hyperspectral imaging coupled with exploration drilling, AI can be used for optimum pattern recognition for advanced geological mapping," said Mary Darling, CEO and principal owner of the company.

Richard Darling, the president and founding principal of the company, highlighted that with an AI model a company can monitor everything, from the motors and crushers in a mill to the pH levels in the ore: "AI and automation allow operators to sit in a control room and see exactly what is happening throughout an operation instead of being on the ground, taking tests, monitoring equipment, etc."

Improving operations amid rising inflation

When asked about the challenges she sees in the mining industry, Dagny Odell from Practical Mining argued that striking a balance between rising prices and escalating costs due to inflation is paramount to sustaining profitability. On the other hand, she also stated that permitting represents a significant challenge, regardless of location. To successfully navigate the permitting process, Odell emphasized that companies must customize the mine plan and design to align with the specific requirements of the permitting authorities, and the sooner this alignment is achieved, the better.

Inflation has posed a significant obstacle for junior and major mining companies, hindering their ability to unlock their full potential. For instance, juniors have faced challenges accessing dollars to fund activities such as drilling. On the other hand, inflation has lowered production margins for producers, impacting their profitability. "There has been a longstanding focus on pursuing higher yields with lower-grade ore in the realm of gold. However, inflation has affected this strategy. Many projects that made economic sense with this higher-ounce, lower-grade approach are currently facing financial challenges. As a result, there is a shift toward revisiting the concept of fewer ounces with higher-grade ore," commented Daniel Kappes, president and CEO of Kappes, Cassiday & Associate (KCA). "Operations managers often allow the ore to be stacked based on the tons stacked daily rather than the quality. If operations managers paid more attention to the stacking quality, they could produce more ounces at the same cost," he added.

Jim Norine, director of minerals and metals at Ausenco, noted that the traditional approach of clients seeking competitive bids from multiple firms solely based on price is becoming antiquated. The priority is to build long-term partnerships. Ausenco has been focusing on emerging mineral processing technologies to help its clients maximize the return on investment and minimize energy usage in the case of declining ore grades. One area gaining momentum is ore sorting, a process in which artificial intelligence and advanced instrumentation can improve. "It becomes possible to downsize the process plant. For example, mining 150,000 t/d can be sorted down to 50,000 t/d, reducing capital costs, lowering energy demand, and improving efficiency," Norine stated.

Another company that has been focusing on ore sorting is ABH Engineering. Besides working with Noram Lithium and Nevada Sunrise in Nevada with their NI 43-101 in Arizona, they have collaborated with MP Materials on ore sorting. Besides reducing capital costs, as Norine highlighted, Brent Hilscher, ABH's VP of mineral processing, pointed out that the technology could result in a smaller tailing pond and, in some cases, in eliminating tailings when coupled with co-disposal technology.

Ore sorting demonstrates that the industry can innovate to maintain profitability, and mining can be more sustainable. According to Hilscher: "This growing recognition could lead to political pressure on companies to consider this technology. While it may not be applicable 100% of the time, estimates suggest that around 80% of deposits could benefit from ore sorting system." ■

> "Operating within a local context like Nevada has afforded us connections with all the key players in the area; we are well-acquainted with their cost structures, operational parameters, and even their mines."

Dagny Odell

Owner
PRACTICAL MINING

What is one of the most recent projects Practical Mining has worked on?

We recently guided a client through conducting a feasibility study for a Nevada underground mine, focusing mainly on geologic modeling. This study involved extensive collaboration and iterative discussions with the client to ensure the creation of a realistic model, prioritizing accuracy over the quantity of resources. Subsequently, we developed a comprehensive mine plan that aligned with metallurgical specifications, geotechnical considerations, and the client's economic needs. We anticipate the final report's release in the last months of 2023.

What sets Practical Mining apart in working with public disclosure reports?

Our most demanded services are public disclosure reports, particularly the NI 43-101 and SK 1300. These reports have constituted most of our work for several years. Knowing the specific regulatory codes is paramount in our line of work; even minor oversights can pose challenges and complications for clients.

What are the challenges that the mining industry currently faces?

Current times could not be more opportune for the mining industry. Commodity prices are experiencing an upswing, although it is crucial to maintain a balance between these rising prices and escalating costs due to inflation.

However, the US mining industry confronts a severe labor shortage. The Colorado School of Mines predicts that approximately 50% of the American mining workforce will retire within the next six years. The pressing question arises: How do we plan to bridge this gap in our workforce since few professionals are in the pipeline, even as we anticipate a surge in demand for our industries products?

What are the benefits of being a small local company in Nevada?

Our niche has always revolved around long-term client relationships. Each project we undertake presents its own unique challenges, and finding a solution is what makes our work rewarding. Operating within a local context like Nevada has afforded us connections with all the key players in the area, from contractors to mining companies; thus, we are well-acquainted with their cost structures, operational parameters, and even their mines.

Additionally, it is crucial to note that the differences between mining operations in each jurisdiction are substantial. Each region presents unique challenges, requiring a considerable learning curve to adapt to the specific nuances of each mining environment.

What advice do you have for companies navigating through the permitting process?

Permitting represents a significant challenge in mining operations, regardless of location. Successfully navigating the permitting process entails customizing the mine plan and design to align with the specific requirements of the permitting authorities. The sooner this alignment is achieved, the more advantageous it is for the project, as permitting can be incredibly time-consuming. Streamlining the permitting process yields substantial economic rewards for any project aiming at further exploration or transition into production.

How is technology shaping the mining industry and your activities?

AI has dominated headlines in recent months, and when combined with the declining workforce in our industry, it becomes a compelling avenue for exploration. For instance, we are already incorporating robotic technology with improving LiDAR scanning capabilities. Drones are becoming more autonomous, capable of flying longer distances and mapping inaccessible areas of underground mines without human intervention. This convergence of technology is poised to revolutionize how we operate, making the mining industry more efficient, effective and safer.

One of the initial applications of a drone was in a mine where an old stope had been encountered. The challenge was determining the extent of the stope and its proximity to a mineralized area of interest. Our drone and Lidar mapping system precisely located the stope and provided clarity that facilitated the planning for mining the adjacent mineralization efficiently. Without this technology, the operation would have been a much more laborious and uncertain process.

What are Practical Mining's primary objectives for the upcoming months?

Our primary objective remains firm: Consistently delivering the utmost quality work product that has garnered our clients' trust over the years. This dedication constitutes the core of our business model, and as long as we uphold these standards, our business will continue to prosper. Furthermore, we want to broaden our presence in the LiDAR imaging sector. ■

Mary Darling, Richard Darling and Jon Heidmann

MD: CEO and Principal Owner
RD: President and Founding Principal
JH: 3D Scanning Project Manager
DARLING GEOMATICS

> Demand for AI engineers is growing exponentially. The automation of equipment and sensor technologies is evolving, allowing for more aspects of mining and processing to be monitored for maximum efficiency.

How has Darling Geomatics performed over 2022, and what market demand trends are you seeing?
MD: We are at the forefront of digital twins, so our customers can couple the mining process with artificial intelligence (AI). This is a big revolution for the industry, allowing tremendous savings on energy, water and manpower; predictive maintenance; supply chain efficiencies and increased safety as training simulations can be done virtually. With new technologies and AI, mines can maximize their digital twins in new ways, driving the industry towards increased efficiency, productivity, and safety.

JH: In 2022, we worked on a copper mine in Arizona where we digitized the entire mine, including the processing facilities. This mine had been shut down for approximately a decade and the company wanted to recommission it due to high commodity prices. We did four months of 3D modeling, and the entire project is now digitized.

Can you also apply AI technologies in the junior exploration space?
MD: Yes. As an example, we are using AI to navigate drones underground. Today's drones can memorize a route beyond where the pilot can safely go. The drone collects measurable images with LiDAR plus video and still camera technologies, without a human controlling it. When the battery gets to a certain percent, the drone automatically knows to stop, turn around, and come back out the route that it memorized on its way in. When combined with other data sources, such as drone surveys of the surface with LiDAR and hyperspectral imaging coupled with exploration drilling, AI can be used for optimum pattern recognition for advanced geological mapping.

RD: AI can also assist in taking a project from exploration to mining in the most efficient way. Mining engineers are great at identifying the best approach to mining, but if you have AI to wrap its arms around everything involved with creating a new mine, it is an incredible tool to use.

What challenges is Darling Geomatics observing?
MD: Permitting remains a major challenge for the mining industry. We have seen companies get over 95% through the permitting process, and then have everything shut down for political reasons. If we want to reach net zero by 2050 goals, we will need to find a way to improve and expedite the permitting process without lowering environmental standards.

What are Darling Geomatics' objectives and growth strategy for the next two years?
MD: We have added underground drone surveying to our services and have also teamed with another company to offer hyperspectral services with drones. We are also partnering with a company that is making photonic semiconductor chips needed for AI, primarily to facilitate more efficiencies with processing ores. ■

Industry Insights: Engineering

Nurturing responsible stewardship and sustainable partnerships

Jim Norine, Director Minerals and Metals, **AUSENCO**
"One area generating significant interest is ore sorting, which previously did not have much traction but is now being explored by almost every mining client. However, we still encounter some challenges at the study level regarding gaining acceptance for ore sorting programs from regulatory agencies."

Brent Hilscher, VP Mineral Processing, **ABH ENGINEERING**
"Compared to other technologies that offer incremental benefits, ore sorting stands out for its potential to make a dramatic difference. If half of the mining companies were to implement ore sorting, reduced CO_2 emissions would be greater than everyone turning off their lights at home."

Daniel Kappes, President and CEO, **KAPPES, CASSIDAY & ASSOCIATES**
"Historically, gold segment technology surpassed that of the copper segment. However, in recent years, the copper segment seems to have overtaken the gold segment technologically. Despite this advance, both sectors still pay insufficient attention to financial aspects."

Eric Mears, Vicepresident, **HALEY & ALDRICH**
"While we would like to expand in-situ mining opportunities, the ideal conditions for ISR are quite rare. Typically, only about one in ten potential sites qualifies, and rigorous and unbiased evaluation is needed."

Todd Glindeman, Mining Market Sector Director, **BROWN AND CALDWELL**
"The mining industry has driven a heightened commitment to responsible land and community stewardship. Mining companies have increasingly prioritized embedding these values into their project planning and incorporating them during operations, recognizing the importance of obtaining and maintaining their social license to operate."

Contractors

Labor shortages and falling ore grades push the tech revolution

The surge in ESG demands is driving the energy transition; there is no wonder why contractors have been busy in the Western United States. Challenges such as permitting complexities, declining ore grades, the scarcity of easily accessible deposits, and rising safety standards position the Western United States as an environment ripe with growth opportunities for construction companies to adopt new technologies to enhance their workforce efficiency. Furthermore, the boom in critical minerals may revive the appeal for greenfield exploration. Keaton Turner, founder and CEO of Turner Mining Group, noted that the demand for battery metals in the Western USA has surged: "This has sparked increased interest in capital expenditure projects."

A company that, against all the industry's odds, has not been affected by labor shortage and turnover is Small Mine Development (SMD). In the latter part of 2022, the company experienced significant workforce expansion, surpassing 600 employees, and successfully secured more than 10 contracts. However, upon entering Q1 2023, a sudden shutdown at Jerritt Canyon and the suspension of Jervois' Idaho Cobalt Operations reduced SMD's workload. Despite headwinds, Keith Jones, SDM's general manager, remains optimistic, particularly when considering underground mining opportunities, especially in Nevada. "Today, more than 50% of the gold production in Nevada is likely derived from underground mines. The reason behind this transformation is the increasing scarcity of open-pit deposits. Many easily accessible resources have already been tapped, leaving larger pits with lower grades and higher strip ratios. In contrast, underground mining allows us to concentrate on higher-grade ore bodies."

For SMD and Master Drilling, the global leader in providing drilling services to the mining industry and pioneer in raise boring equipment and services, inflation and cost pressures are always present. The elixir? Automation: "If we can implement more automated drilling solutions, the operations will become more efficient, it will reduce labor costs for sinking a shaft, and we will address both the labor shortage and inflationary pressure challenges," elaborated Robert Schumm, GM of Master Drilling in North America.

Master Drilling has pioneered large-diameter underground reverse circulation drilling, a technology developed and perfected in Mexico that is now introducing to the US market. ■

Image by Michael Evens at Adobe Stock

> "In the eighties, Nevada had just a couple of underground operations. This scenario has evolved, and now, more than 50% of the gold production in Nevada is likely derived from underground mines."

Keith Jones

General Manager
SMALL MINE DEVELOPMENT (SMD)

Can you give an overview of the last year for Small Mine Development (SMD)?
SMD has experienced an exciting year. By the latter half of 2022, we had expanded significantly, growing our workforce and exceeding 600 employees, and securing over 10 contracts. However, as we entered Q1 2023, a sudden development occurred at Jerritt Canyon, where we were responsible for the SSX and Lee Smith mines. This entailed an abrupt shutdown, resulting in a substantial reduction of our workload. Such occurrences are often unpredictable, and although we may anticipate them, we cannot reduce our commitment. This setback translated to approximately one-third of our work vanishing. Moreover, within a month, Jervois' Idaho cobalt operation suspended its activities, including the work we were engaged in.

Is there a boom in critical minerals in the underground segment?
Even though there is indeed an increase in critical minerals activity within the underground sector, it has not sparked an overwhelming rush yet.

What are the main challenges and trends affecting underground construction?
Cost pressures are always present. In the current inflationary climate of the last three years, we continuously seek ways to deliver value in the face of rising costs. Additionally, we are witnessing advancements in automation, particularly in autonomous mucking and other initiatives. Nevertheless, in underground mining, we are not as advanced in automation as our open-pit counterparts, who have achieved autonomous haulage and drilling. Consequently, the pressure to stay technologically competitive persists, driving us to explore autonomous solutions and enhance our technology in the underground sector.

What is SMD's approach to safety?
Over the past couple of years, our industry has observed a rising incident rate. Notably, it is not predominantly new workers affected; it often stems from complacency among experienced personnel. Thus, safety remains a paramount concern, and we discuss it more frequently than we did years ago.

While we have embraced some measures like autonomous mucking and long-haul open stoping to keep workers at a safe distance from hazards, the reality is that people still need to be underground for various tasks. Automation in these areas remains limited. Hence, our primary focus has shifted towards safety culture and individual responsibility. We have initiated safety journey sessions where we gather the entire workforce for a full shift, emphasizing safety and engaging in open discussions about their experiences and the issues they encounter in their workplaces. Furthermore, we are on the cusp of opening a training center to provide new employees with exposure to the environment without them being physically present underground.

What opportunities does underground mining in the US offer for SMD?
There is an opportunity, especially when considering Nevada's mining landscape. Looking back on my career, in the mid to late eighties, Nevada had just a couple of underground operations. At that time, the state produced approximately 6 to 7 million oz/y of gold, with only a small percentage coming from underground mines. This scenario has evolved, and now, more than 50% of the gold production in Nevada is likely derived from underground mines. The reason behind this transformation is the increasing scarcity of open-pit deposits. Many easily accessible resources have already been tapped, leaving larger pits with lower grades and higher strip ratios. In contrast, underground mining allows us to concentrate on higher-grade ore bodies.

Being in the underground mining segment is advantageous because we anticipate that the trend toward increased underground mining will continue.

How can underground contractors differentiate themselves?
The competition in the underground mining sector has intensified over the past decade. We all compete for the same workforce.

Relationships and trust can be pivotal factors in contractor selection, where prior connections between personnel may lead to a sense of reliability and familiarity. Moreover, contractors may differentiate themselves through innovative offerings, such as new equipment or alternative methodologies, like using a road header instead of traditional drill and blast techniques. These distinctions, in addition to price, can influence a client's choice of contractor. Factors like a contractor's safety record and reputation also hold significant weight in the private sector, reflecting the broader considerations beyond cost that come into play during the selection process.

We place a strong emphasis on offering our existing clients value, outstanding performance, and top-notch customer service. ■

Eric Smith

Managing Director
CEMENTATION AMERICAS

What is driving demand for Cementation Americas' services, particularly in the Western US market?
Demand for our services has been driven by the challenges faced by mining groups in initiating new projects, especially for juniors, more so in the US than in Canada. Major operating companies, however, have been funding projects and making improvements to infrastructure. In the Western US, the government's permitting process, marked by prolonged approval timelines with various agencies' involvement has been a driver of these limitations. Despite these hurdles, there is significant potential in the US, especially for precious metals and critical minerals. The US government's support is crucial, considering the nation's substantial mineral consumption and commitment to reducing greenhouse gas pollution and promoting clean energy technologies. Clients in the region are predominantly focused on upgrading existing operations, decarbonization, and enhancing productivity and efficiency. Our role has been pivotal in upgrading infrastructure, facilitating client development, and aligning them for low-carbon production in the future.

How would you compare Ontario and the Western US as mining destinations?
Despite challenges in both jurisdictions, Canadians typically display more support for mining, balancing economic benefits with stringent environmental expectations.

Have you struggled to find skilled labor?
We are anticipating a significant labor shortage due to retirements and less people entering the industry. To address this, we are exploring technological solutions, shifting towards mechanized equipment, and partnering with local stakeholders for enhanced and condensed training programs. In the US we are exploring partnerships with community colleges for new hire training to ensure a sustainable skilled workforce for the future.

How has the increasing trend of automation and digitalization impacted Cementation Americas as a contractor?
Safety is a top concern, so our digital adoption journey focuses on improving safety and overall performance. We have partnered with a software provider to implement short-interval control at our sites. Employees now use handheld devices to input real-time data, allowing supervisors to make immediate and informed decisions during shifts. This granular, constantly updated information not only facilitates continuous improvement, but also provides the ability to practice even more proactive safety measures and aggregates crucial records for assessing project costs and productivity. While we have not implemented this system everywhere due to network constraints, especially in areas without LTE or underground wireless networks, we are making remarkable strides as data continually becomes a valuable commodity for service providers like ourselves. The information on how work is done, costs, and resource requirements are essential for adding value to existing projects and bidding on future ones, enabling us to stay competitive and constantly refine our approach.

What are your priorities for the coming years?
In the Western US we are currently engaging with a major mining company in Nevada, marking an exciting opportunity for long-term collaboration. It can be difficult to secure large, new clients initially, but we aim to leverage our successful track record for repeat business. ■

Robert Schumm and Gareth Sheppard

RC: GM North America
GS: COO
MASTER DRILLING

Can you give an overview of Master Drilling and the company's presence in the US?
RS: Master Drilling established a US office approximately five years ago, aiming to broaden our reach for raise boring and blind boring drilling services. Our primary targets include metal mines in the Western US and coal mines in the Eastern US.

GS: Master Drilling has secured its first raise boring contract in Nevada and operates one rig with a significant mining company. We are also mobilizing a second rig for another Nevada-based contract. Out of our 160 rigs worldwide, only two are in the US. Despite this small footprint, we see substantial growth potential for Master Drilling in the US.

Which of Master Drilling's services are most in demand in the Western US mining industry?
RS: Master Drilling has pioneered large-diameter underground reverse circulation drilling that we are introducing to the US market. Additionally, our development of one of the largest dual-wall drill pipes allows us to undertake these large-diameter reverse circulation projects. We are also on the verge of launching our first North American remote drilling application with a major mining concern.

GS: While currently focused on raise boring in the US, Master Drilling is actively bidding on a wide range of services, including blind shaft drilling, tunnel boring, exploration drilling, and more. Adopting remote and automated solutions is critical in addressing safety and productivity challenges in mining, particularly in 24-hour operations with constraints like blasting re-entry.

Is the labor shortage also affecting Master Drilling in the US?
RS: Yes, HR has roared to the frontlines of businesses, everyone placing utmost importance on attracting talent.

What are Master Drilling's goals in the US?
GS: With our first two raise bore contracts in Nevada, we want to build a solid foundation for future growth, demonstrating the quality of our services and systems. ■

Keaton Turner

Founder and CEO
TURNER MINING GROUP

Could you share some details regarding Turner Mining's most recent fleet acquisitions?
In late 2021 and 2022, we acquired a significant fleet from Komatsu Road Machinery for a copper project in Arizona, including Komatsu HD-785 haul trucks, Komatsu WA 900 loaders, and D375 dozers. In early 2023, we added two Hitachi 1200-7B excavators with AMI Attachments' XMOR buckets. We also ordered twenty Volvo A60H trucks, receiving six so far, with the rest expected before 2024.

How have clients' demands evolve?
Clients engage us to provide a level of flexibility they can't attain due to their rigid business structures involving fixed costs, staffing and investments. Whether it's speed or the capacity to adjust resources, contractors need to outdo internal client capabilities in terms of flexibility. For instance, at a recent project in Texas, we move a million tons of earth monthly, demanding substantial flexibility from our team. We emphasize hiring locally to integrate into communities and avoid being seen as an outsider focused solely on operations to ensure a positive project startup. However, flexibility extends beyond project commencement. As client market conditions shift and sales dip, we must adapt while considering our fixed expenses.

What technologies is Turner Mining embracing to improve safety standards?
We are exploring autonomous drill programs with providers, targeting implementation in 2024. We're also looking into semi-autonomous and remote-operated equipment with Teleo. This tech would allow us to work in high-risk areas without endangering workers. The cost is a challenge, but it's expected to become more affordable over time.

What are some of Turner Mining's goals for 2023?
We plan to open a new office in the Western US in addition to our Utah and Indiana headquarters. We also announced a Turner Staffing Group acquisition in early August. We aim to have over 500 employees for Western US projects by 2024. ■

Equipment, Technology and Service Providers

“Technologies such as AI, autonomy and advanced sensor systems are being adopted, marking a departure from the previous resistance towards innovative solutions. Companies have developed a culture of practice that did not exist a few years ago.”

Ravi Sahu
CEO
STRAYOS

GBR Series • WESTERN USA MINING 2024

Image courtesy of Nevada Gold Mines

Mining Equipment and Drilling

From electrification trends to AI-centric exploration

In mining, each decision must be fine-tuned. The selection from tires to haul trucks must be scrutinized, since choosing them appropriately will directly impact costs, efficacy, productivity, and socio-environmental impacts. In this context, OEMs are making strides and funding research and development to improve their equipment. In today's mining landscape, mining companies strive to maximize ore extraction at minimal costs and balance it with safety and environmental stewardship. Thus, trends like electrification and automation are gaining momentum, and mining companies are either adopting these solutions or closely monitoring their development.

Mining equipment

The mining industry has been associated with high carbon emissions because it relies on diesel-powered equipment. According to McKinsey & Company, mining accounts for approximately 4% to 7% of worldwide greenhouse gas emissions (GHG), and mining vehicles account for an estimated 30% to 50% of the total GHG. Mining "green metals" can also be done in a "greener" way, which would have multiple benefits, such as reducing energy costs by as much as 40% to 70% and improving health conditions for miners, especially in the underground segment.

However, adopting new solutions is not an easy task. During an interview with Epiroc about the long-term benefits associated with BEVs, Maryse Lyonnais, underground business manager North America, stated that the main challenges are infrastructure and the initial investment required: "It is essential to consider the bigger picture. In the long term, substantial fuel, maintenance, and ventilation cost savings can be realized. As mines extend their depth, the need for increased ventilation to operate diesel equipment becomes a significant challenge. Some operations must transition to battery electric vehicles, not just for ESG reasons but because diesel equipment becomes impractical at specific depths," she added.

Epiroc has managed to introduce BEV equipment, like the Epiroc Scooptram and Minetruck models, and a Boltec BEV is set to arrive in US by the end of 2023. "This brings the total of our electric machines in operation to three. We anticipate this will create momentum in the region and are excited to witness its positive impact," commented Lyonnais.

In the surface segment, Epiroc expanded its surface drill autonomous fleet. Several factors are pushing for more autonomous solutions: Increased productivity, safety, efficiency, and maybe, most importantly, a changing labor force. For Matthew Inge, manager for drilling solutions, automation, and digitalization at Epiroc, automation is a double-sided coin to address the labor shortage and the need to produce more: "As fewer US mines are coming online, the industry must produce more while adapting to the changing labor environment."

Companies across the Western US are collaborating with these OEMs to convert their existing fleet into autonomous. For example, in September 2023,Freeport-McMoRan and Caterpillar announced a collaboration to convert the mining company's fleet of 33 car and 793 haul trucks at its Bagdad Mine in Arizona to an autonomous haulage system (AHS) using Cat MineStar Command for hauling. "In approximately three years, we will be the first large-scale operation in the US to have a fully autonomous haulage fleet. This will drive improved efficiencies, which will help us on the ESG front. It will help us overcome the labor shortage challenges the industry is facing, and it is also a steppingstone as we think about the path to electrification for decarbonization," commented Joshua Olmsted, president and America's COO of Freeport.

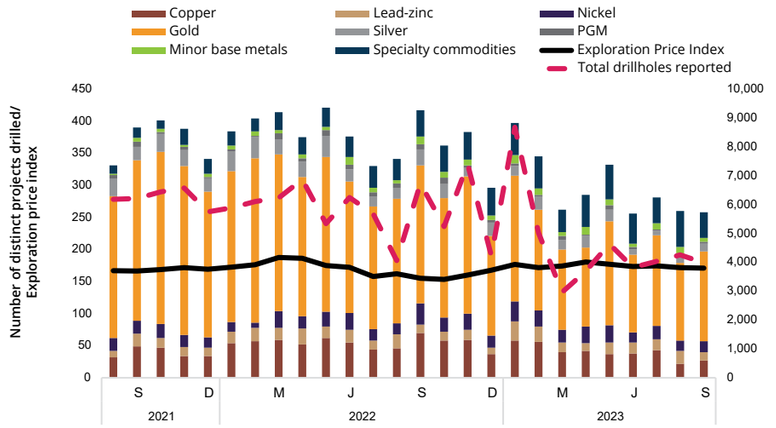
Empire Southwest is an Arizona-based dealer that has a long history working with Freeport, and that acquired Cashman Equipment Company in Nevada earlier this year. Dennis Sorensen, vice president of Empire Southwest, explained that throughout 2023 the company has been completing the branding transition to achieve complete integration: "By comparing best practices, we have identified innovative solutions, benefiting our critical clients. Our goal is to provide exceptional support for Nevada clients while maintaining our commitments to our long-standing Arizona clients."

Regarding automation, there is a prevailing notion that embracing cutting-edge technologies in new projects is akin to starting with a blank canvas. However, Sorensen sees benefits in the gradual application of automation in existing operations. "Transitioning an existing manned fleet to autonomy allows for a smoother transition with continuous production while learning and implementing the technology. Despite unique challenges in both scenarios, the goal is significant—the deployment of autonomous systems to safely maximize efficiency and productivity in the operation," he finalized.

Image courtesy of Epiroc

Drilling overview, 2020–23

Jan-Sep 2023 drilling lower year over year from gold activity slowdown



41,086
Drilled holes Jan-Sep
23% lower than in 2022

↓ 36%
Fewer gold drilled holes YOY

↑ 63%
More specialty commodity drilled holes YOY

Source: S&P Global Market Intelligence

Drilling

Despite not reaching the same levels observed in 2022, at least until October 2023, drilled projects surged to a five-month high, driven by an uptick in various electrification metals, according to S&P figures. Among the top jurisdictions reporting drilling, Australia leads with up to 102 projects, followed by Canada with 75, and the US with 33 projects.

Premier Drilling is a Nevada-based drilling provider that has observed a notable increase in demand for its services, particularly in core exploration. The company has three operational rigs but aims to expand resources and geographical access. "Our goal is to have eight teams. While our primary focus has been on Nevada and California, we are expanding our operations into Arizona, Utah and Idaho in 2024," said James Stephens, client service manager.

Many service providers benefit from highly portable equipment and rigs, which are convenient for the often-remote locations where many mining activities occur. For instance, Alaska is crowned as a prominent mining jurisdiction due to its untapped natural resources and potential for valuable deposits. However, the challenging weather conditions and vast land area make it a harsh environment for exploration. In the Alaskan mining jurisdiction, Alaska Drilling & Competitions stands out for its local expertise and utilization of the Delorean rig. "The primary goal in constructing these rigs was to ensure they were ultra-mobile and tailored explicitly for remote areas like Alaska. However, their mobility is not limited to Alaska; they can be transported virtually anywhere," shared David Ross, president and co-founder.

The company recently ventured into the mining industry with the Whistler gold-copper project from U.S. GoldMining, which came with a "learning curve," according to Ross. Still, they achieved coring rates in the range of 200-220 feet per day by the project's conclusion.

Despite the observed activity, a persistent sentiment suggests that new deposits are becoming harder to find, coupled with a decline in ore grades, inflation, and a labor shortage. These challenges have positioned drill service providers in a situation where they must reinvent how they assist their clients in achieving their goals. That is the case of Veracio.

Boart Longyear, one of the leading providers of drilling services, noticed that improving the quality of orebody knowledge was critical to exploration and resource development and invested substantially in technology development around orebody knowledge through its Geological Data Services. "As these technologies became full-scale products and started to have global adoption, the company recognized that by having a technology company sit within a drilling services company, the technology was not as available to the worldwide mining market as it would be if separated" explained JT Clark, Veracio's CEO, adding that, ultimately, the company "graduated" from the Geological Data Services to operate with autonomy.

Veracio offers three primary platforms to deliver AI-centric data sets: TruScan, an expandable platform that uses XRF hyperspectral LiDAR and photography to augment knowledge of ore body; TruProbe, which captures information from the downhole environment; and TruSub, which captures data from the drill string itself, monitoring the performance of a diamond bit as it penetrates through the ore body.

In the wake of AI and its benefits in exploration, JT Clark argued that its effectiveness in mining is constrained by working with datasets designed for human consumption. Clark emphasizes the existence of an information gap that must be addressed to harness the potential of AI in the mining sector fully: "The leaders in mining understand the challenge that we need to bring not just AI capabilities into the industry but create AI-centric datasets that will unlock the potential of AI technology in mining. As ore bodies become smaller, deeper, more challenging, and lower grade, for us to produce critical minerals to support the energy transition economically, we must be more accurate and targeted in how we understand and develop ore bodies," he concluded. ■

ML

MI

Maryse Lyonnais and Matthew Inge

ML: Underground Business Manager – North America
MI: Business Line Manager for Drilling Solutions, Automation and Digitalization
EPIROC

What is Epiroc's strategy for introducing automation to medium and smaller mining operations?
MI: In the US, we have significantly expanded our surface drill autonomous fleet. Many customers are recognizing the value of surface automation for safety, productivity and efficiency, and investing accordingly. Traditionally, Epiroc focused on larger mines, but we are now extending automation to medium and smaller operations. Our automated platform, previously exclusive to the Pit Viper drill rig series for over 22 years, is now being scaled down the full product portfolio.

ML: One notable introduction in the US underground segment for 2023 is our Boltec with pumpable resin, which reduces bottlenecks in the drill and blast cycle. This system provides a faster, more reliable, and cost-effective bolting alternative for long-term rock reinforcement. In Nevada, we are deploying nine of these this year, significantly improving safety and operational efficiency. Additionally, we've received orders for our large MT65 truck in Alaska.

What progress has Epiroc made in implementing BEV and autonomous equipment in the US?
ML: In 2023, we introduced BEV equipment in the US, including Epiroc Scooptram and Minetruck models available for customer rentals. Additionally, a Boltec BEV is set to arrive in the US by the end of 2023, bringing the total of electric machines in operation to three. We anticipate this will create momentum in the region and are excited to witness its positive impact.

MI: We highlight safety through our 'live work elimination' approach. Notably, we have introduced an automatic bit changing system for our Pit Viper drills, eliminating the risk of harm to operators and technicians during bit changes. Over the last six to eight months, we successfully implemented this system with one of our major US customers. After rigorous testing and validation in late 2022 and early 2023, we are seeing high demand in the US but also globally for this system on both new and existing machines.

What is the significance of Epiroc's acquisitions to address automation and labor shortage?
MI: The labor shortage in mining is driven by declining interest in related fields like electricians, welders, and mechanics, coinciding with the growing demand for these skilled workers as mines expand to meet increased production requirements.

With so few US mines coming online, the industry must produce more while adapting to the changing labor environment. Thus, automation is vital for maximizing workforce and equipment efficiency. At Epiroc, we are transitioning from a traditional machinery focus to embracing technology and digitalization, extending our capabilities beyond our fleet to other OEMs. We provide technology and digital solutions for various surface and underground equipment to adapt to the changing landscape and labor shortage. Acquisitions like ASI Mining have positioned us prominently in the surface truck autonomous sector. RCT and Mernok Elektronik has allowed us to offer collision avoidance and automation products, a step toward full automation, especially in complex underground environments. These acquisitions bridge the gap, enabling customers to explore and test innovative technologies in their operations. Simultaneously, we provide comprehensive service and support, addressing not only equipment but also the broader digital and automated environment.

What is the main purpose of the Elko and Tucson competency centers?
MI: In Elko, we are building a facility specializing in parts rebuilds and integrating technology and digital solutions, primarily focusing on underground operations. Tucson is our surface competency center. These centers are set to offer high levels of innovation, technical expertise, and training. We have allocated substantial resources to both areas and plan to open these facilities in early 2024.

What will be Epiroc focus in the next 12 months?
MI: More companies are turning to us for service and support agreements, not only for our equipment but potentially for other OEMs' equipment. We focus on successfully implementing large-scale automation and digital projects. Epiroc aims to address these issues from a holistic perspective, enhancing not only equipment but also overall operations. ■

Dennis Sorensen

Vice President
EMPIRE SOUTHWEST

What was the strategic significance behind Empire Southwest acquiring Cashman Equipment?
We acquired Cashman Equipment Company in Nevada in December 2022, aligning with our strong mining presence in Arizona, reflecting the significance of mining in Nevada. Throughout the year, we integrated Cashman into Empire. Our collaborative effort will continue over the next 12 to 24 months and beyond, with heavy investments in Nevada, acquiring land, constructing new facilities, and upgrading existing ones.
We are optimistic about mining opportunities and overall business prospects in the region. By comparing best practices, we have identified innovative solutions, benefiting our critical clients. Our goal is to provide exceptional support for Nevada clients while maintaining our commitments to our long-standing Arizona clients.

Given the industry's move toward battery solutions, what immediate improvements is Empire focusing on to make mining operations more environmentally friendly?
Caterpillar is actively embracing green technologies, particularly battery electrics, across its product line. In the battery electric space, evolving battery technology presents both challenges and opportunities. Caterpillar is at the forefront of these advancements, and the industry is eagerly anticipating how various manufacturers will approach these technologies. Contrary to the misconception of an immediate shift from traditional engines to battery electric, there is a parallel with the automotive industry's evolution. Like gasoline engines in passenger vehicles, equipment industry technologies are progressing toward cleaner solutions. Empire actively collaborates with mining clients in Arizona, Nevada and California, helping evaluate existing fleets for greenhouse gas reduction and enhancing fleet efficiency. While the industry is moving towards battery solutions, Empire focuses on immediate improvements to make mining operations more environmentally friendly, ensuring profitability and functionality. ■

JT Clark

CEO
VERACIO

Can you introduce Veracio?
Veracio started within Boart Longyear, which eventually decided to graduate its Geological Data Services division into a separate entity. As we explore ore bodies, we capture information and seek to understand it early in the development stage. However, historically, we have used methods that produce data for human consumption, and we relied on human intelligence to extrapolate from those data points to better understand what the ore body might contain. Recently, we have sought to add artificial intelligence (AI) capabilities. Veracio is fundamentally building AI-centric datasets that will add to the human capability to understand ore bodies. Fundamentally, we are solving a problem around the information gap: the lack of AI-centric information that we need to enable mining to make the next step-change in productivity, which is required for us to access and develop ore bodies that are increasingly smaller, deeper, and in more challenging environments.

Can you speak to Veracio's portfolio for the mining industry?
Veracio has three primary platforms to deliver AI-centric data sets. Our TruScan technology can accelerate an understanding of an ore body using XRF hyperspectral LiDAR and photography. TruProbe captures information from the downhole environment. TruProbe's primary IP is an expandable driller deployable platform that allows us to stack sensors on top of each other. TruSub, captures information from the drill string itself, monitoring the performance of a diamond bit as it penetrates through the ore body.

On top of these three data capture platforms, we have built a data management platform. Veracio recently acquired Minalyze, which developed a best-in-class data management platform to capture the information gathered by Veracio's three sensory platforms and bring that together into one data platform to enable clients to interact with that data, as well as for us to make that data accessible to AI solutions and applications. ■

Material Handling and Mining Components

Tailored approaches and eco-friendly innovations

Thomas Carmichael
VP – Mining Technology
CAID INDUSTRIES

> “With the broader acceptance of automation, we see significant potential in removing operators from exposure to potential hazards and enabling employees to engage in more value-added tasks.”

Companies are increasingly prioritizing customized solutions that address the specific needs of clients and the unique environmental conditions of mine sites, moving away from standardized approaches. The benefits are evident on both sides: for mining customers, tailored solutions result in a better rate of improvement, addressing their specific challenges more effectively. On the service provider side, offering customized solutions fosters long-term relationships, increasing the likelihood of clients returning to rely on their services repeatedly.

This trend has also shifted to the material handling segment. Steffen Gjorvard, president of TAKRAF USA, commented that the company's client-focused philosophy and direct collaboration with them provide TAKRAF with a smoother and more personalized engagement: "This client-focused philosophy is especially noticeable in our work with Kennecott, where we operated as an integrated team, including the client and other engineering and construction companies, to create the best possible solutions. A comparable strategy defined our engineering contribution to Nevada Gold Mines, emphasizing our commitment to close cooperation to meet their specific needs," he commented.

On the topic of customized equipment, Gjorvard provided an example of how they can also deliver eco-friendly and sustainable solutions that are cost-effective, as seen in Kennecott: "In the case of downhill conveyors, like in Kennecott, we can generate energy, making our systems efficient and cost-effective in terms of energy consumption. At Chuquicamata in Chile, for instance, the use of gearless drive conveyor technology in the conveyor systems not only allowed us to save a lot of space in terms of drive footprint but also, more importantly, these highly efficient electric drive motors replaced diesel truck engines, cutting CO2 emissions produced when transporting the material by more than two thirds for the same copper volume," he elaborated.

Gjorvad sees promising opportunities on the horizon for TAKRAF in the Western USA, particularly in the copper and gold segment: "As demand grows, we aim to foster organic growth and are keen to expand our involvement in projects across mining states like Nevada and Arizona," he concluded.

Another company that plans to tap into growth opportunities in the Western USA mining sector, but in emerging areas like lithium, is Bosch Rexroth, the German Hydraulic specialist: "Our focus is expanding to include high-pressure grinding applications, addressing challenges in conveyors with variable speed and load. Over the past 30 years, we have diversified into drum drives for rotating equipment and adapted components for broader applications, showcasing our solutions' versatility and meeting evolving industry needs," said Ashok Amin, mining segment manager – Americas.

Unlike TAKRAF, although there is a notable difference in terms of the suite of products, Bosch Rexroth asserts that providing a single-concept and one-platform approach delivers a consistent and effective solution globally, setting them apart in the market. This has likely contributed to the company experiencing improved activity and enhanced results in 2023 compared to 2022, mainly driven by growth in copper and gold mines. Bosch Rexroth has worked with key players across the mining spectrum, such as Komatsu,Freeport-McMoRan, BHP, Barrick and Newmont.

Regarding growth, Bosch Rexroth anticipates an expansion of its business in the upcoming years: “In the coming years, Bosch Rexroth aims to double its business. While no specific acquisitions are announced, we are open to opportunities aligning with our growth plan. We are strengthening our market presence by expanding teams and training service personnel to meet robust market demand. The USA is a crucial market for us, offering opportunities to extend services to existing customers and enhance our position,” commented Amin.

Cathodes for the green revolution

On the topic of lower-carbon products, according to Thomas Charmichael, VP-mining technology at Caid Industries, commented that the green energy movement has put increasing demand on necessary resources like copper to be produced more sustainably. "Mining operations not only need to produce more copper but there is a recognition that energy consumption during copper plating must be reduced," he explained.

Caid's flagship product is the stainless-steel cathode, which, according to Carmichael, is the longest-lasting cathode in the market and are called "permanent cathodes" because, with reasonable maintenance, they last at least 20 years.

Like many other industry players, Caid has taken notice of the looming copper shortage. As a result, they have been assisting customers in preparing for growth and modernization: “With demand expected to surpass copper availability in the next few years, Caid is well positioned to service copper-related mineral processing and mining projects. We are part of the large, diverse company, Samuel Son & Co, which distributes everything from metals to robotic systems to complex parts that go into satellites, ” concluded Carmichael. ■

Ashok Amin
Mining Segment Manager – Americas
BOSCH REXROTH

> “Our hydraulic-labeled drives primarily operate on electric energy, employing a modular system for flexibility. We prevent unnecessary energy consumption by deactivating components when capacity needs decrease.”

Image courtesy of Takraf

> While many mining companies continue to depend on trucking solutions, we can innovate and develop environmentally friendly conveying system alternatives.

Steffen Gjorvad

President
TAKRAF USA

What is the history of TAKRAF Group in the USA, and what are some key mining projects the company has been involved in?
TAKRAF has been operating directly out of Denver since 1994, primarily focusing on projects in the USA and Mexico, while occasionally also taking on projects in South America and collaborating with our colleagues in Canada. Our core area of expertise encompasses crushing stations and material handling, ranging from conveying to loading and unloading stations, stockyard equipment and port logistics.

One noteworthy project we worked on was the relocation of crushers for Kennecott in Salt Lake City, Utah. Our most recent work with them was in 2020, when we relocated a crusher out of the pit and built a large capacity downhill conveyor for copper ore. Besides Kennecott, with Rio Tinto, we have also worked at the Boron mine in California. Additionally, we have engaged in engineering work with Nevada Gold Mines.

What are the benefits of your Dry Stack Tailings solution?
We take immense pride in being one of the few global suppliers capable of offering a comprehensive suite of services with our Dry Stack Tailings (DST) solution. From thickening to filtering, conveying, and stacking, we encompass the entire DST management spectrum.

What factors do you take into consideration for conveyor solutions?
To provide the best solution, we consider factors such as the expected lifespan of the equipment and the material characteristics, which can vary significantly. For example, in the cases where materials are highly abrasive and wear out the belt, the design of chutes becomes crucial to minimize belt damage and prolong their longevity.

What technology disruptions is TAKRAF leveraging?
We collaborate with companies like Siemens, ABB and others to develop digital twins and employ advanced monitoring devices, and all our machines and processes can be fully automated. For example, we can use scanning systems for stockpile management, providing precise inventory data, and optimize both stacking and reclaiming. The use of technology not only enhances safety, but also allows for continuous equipment monitoring and predictive maintenance.

Lastly, the suitability of our TAKRAF X-TREME class sizer to hard-rock applications has been a significant disruptor to the industry's traditional way of crushing hard rock.

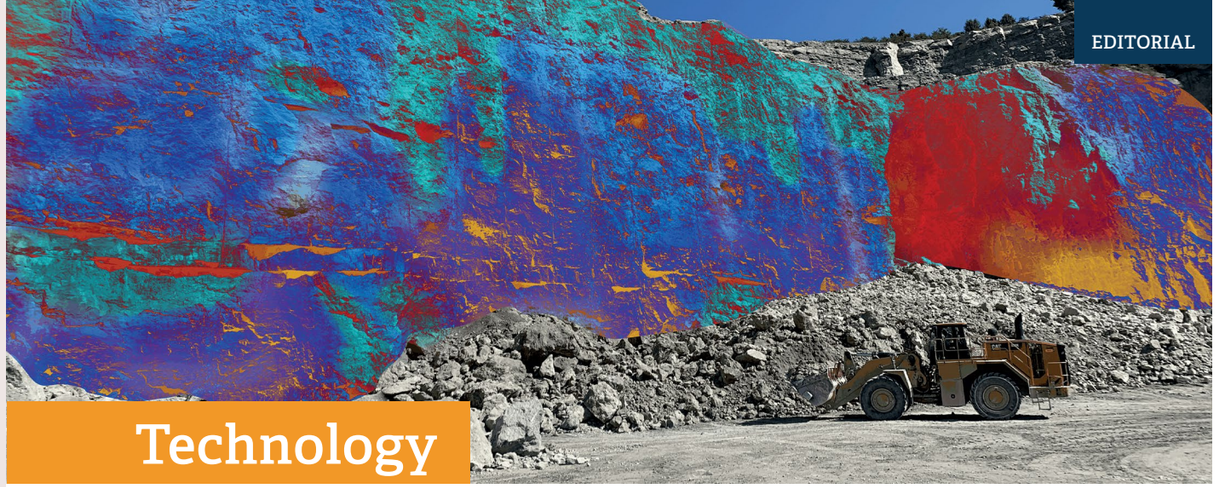
What is TAKRAF's approach to sustainability?
TAKRAF has consistently led the way by employing electrically driven equipment, avoiding using diesel or gas-powered machinery. While many mining companies continue to depend on trucking solutions, we can innovate and develop environmentally friendly conveying system alternatives. In the case of downhill conveyors, like in Kennecott, we can generate energy, making our systems efficient and cost-effective in terms of energy consumption. At Chuquicamata in Chile, for instance, the use of gearless drive conveyor technology in the conveyor systems not only allowed us to save a lot of space in terms of drive footprint, but more importantly, these highly efficient electric drive motors replaced diesel truck engines, cutting CO_2 emissions produced when transporting the material by more than two thirds for the same copper volume. This brings with it the advantage of reduced water consumption for haul road dust suppression and maintenance and reduces the airborne silica dust created by truck traffic significantly. Moreover, our solutions encompass a range of dust suppression systems, including dry fog systems and dust collectors. These approaches are tailored to specific project requirements, and we see a growing demand for their implementation.

On the other hand, we are also dedicated to sourcing components from manufacturers who share our commitment to environmental responsibility, ensuring that our systems or equipment are safe, efficient and environmentally friendly throughout their lifecycle.

In which segment do you see more opportunities for growth for TAKRAF?
Promising opportunities are on the horizon for TAKRAF, particularly in the copper and gold sector, as demand grows. We aim to foster organic growth and are keen to expand our involvement in projects across mining states like Nevada and Arizona.

Every time an operation requires a massive movement of material, we are the right partner with the right solutions, whether that is on the product or on the waste handling side.

In the precious metals segment, we predominantly get involved on the DELKOR liquid/solid separation side. Nonetheless, as TAKRAF, we remain open to opportunities in this sector, especially if large or complex expansion initiatives take hold. ■



Technology

The digital revolution in the Western USA

Today's mining industry bears little resemblance to what it was a decade ago. Terms and concepts like machine learning and Artificial Intelligence (AI) have taken center stage in the Western USA mining industry, shaping its present and future. While some players in the mining value chain are tasked with developing these new technologies, others, such as junior exploration companies, producers, or OEMs, are leveraging these technological disruptions to meet the increasing demand for greener solutions.

The mining industry is no longer as reluctant to changes as before. "They are shifting towards a more open approach of conducting pilot and experimentation projects to test technologies," said Ravi Sahu, CEO of Strayos.

In the Western USA, Strayos works directly with blasting contractors, drilling companies and copper producers providing automation and AI solutions. Recently, Strayos has been incorporating greater intelligence into the ore extraction process with its Ore Dilution Control solution. "One area where significant costs are incurred is in drilling and blasting, and many mining operations believe that they can optimize their resource through better dilution control. We introduced our Ore Dilution Control solution as a generative digital twin to address this challenge," explained Sahu. "This virtual replica mimics the behavior of the process, considers various blasting parameters, and accurately predicts the distribution of waste and ore, reducing waste and maximizing recovery, mitigating the common issue of dilution."

However, according to Sahu, in the Western USA adopting AI is not easy since it requires a structured amount of data to build an adequate model, which many companies lack.

Another challenge in implementing new technological disruptions or software is unfamiliarity with new tools. Guido Pérez, general manager of Americas of Micromine, commented that miners need guidance with these. "We have enhanced our onboarding process for new clients, providing dedicated support to improve the user experience when transitioning to Micromine products," explained Pérez.

Micromine has a strong relationship with Nevada Gold Mines. According to Pérez, they have standardized the mine solutions across all Nevada Gold Mines' underground projects, including Gold Rush and Turquoise Ridge: "Micromine Pitram has been the most successful and proven solution we supply to them. This mine control system manages day-to-day operations in underground assets and requires no in-site development, allowing for a record implementation time," Pérez concluded.

Retrofitting equipment
Freeport-McMoRan is kicking off an effort to implement autonomous haulage at its Bagdad mine in Arizona, and many operators are jumping on board this trend. For instance, Nevada Gold Mines (NGM) has been actively exploring and implementing these solutions over the years: "Our initiatives have included testing autonomous trucks and underground

Image courtesy of Strayos

battery-driven equipment. Currently, we have several open-pit drills at Carlin operating autonomously, with the capability of remote control. In our underground operations, we utilize remote mucking, where operators control loaders from the surface using joysticks and cameras," commented Peter Richardson, executive managing director from NGM.

Mining companies expect that automation will allow operators to work from remote control centers miles away from the mining sites, attracting a new generation of talent that might not be interested in working at mine sites. However, not every existing mining equipment and machinery is autonomous. To solve this problem, Teleo is a company that builds technology to retrofit large construction mining equipment and is OEM agnostic: "We can retrofit any make and model of machine. We are introducing an incremental path to autonomy for mining equipment that allows for remote operation where a single operator can simultaneously control multiple pieces of equipment from a central command center," commented Vinay Shet, co-founder and CEO of Teleo.

The company's primary customers are contractors who operate heavy equipment in the construction and mining industries.

ASI Mining is another company specializing in retrofitting old equipment that collaborated with NGM to deploy autonomous haul conversions for five Komatsu 930E-2 trucks at Goldstrike. Operating as a JV with Epiroc since 2018, its director of business development, Drew Larsen, also highlighted the importance of being OEM agnostic. This approach maximizes flexibility and avoids restrictions, fostering competitive tension among suppliers: "An OEM-agnostic solution offers distinct advantages, aligning well with the evolving landscape of energy solutions and the need for flexibility in decarbonization efforts," he commented.

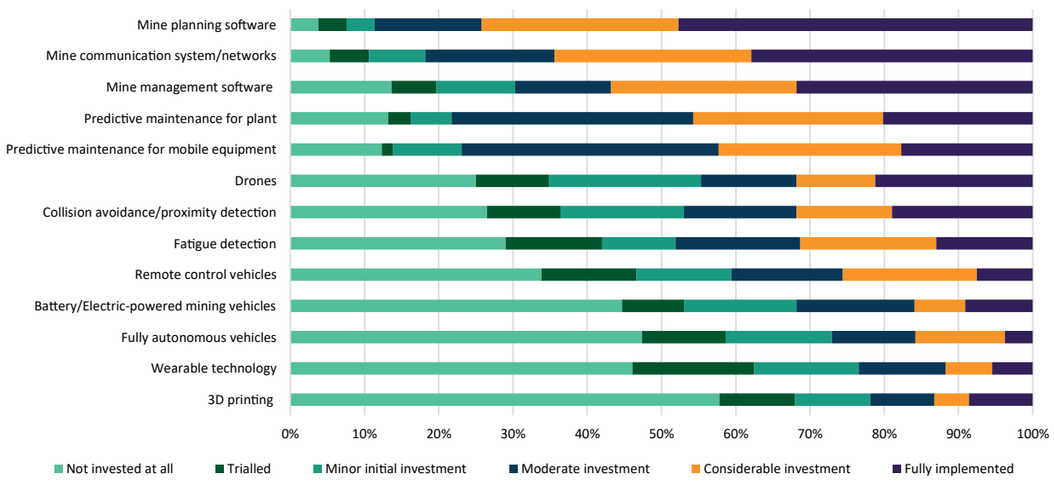
The connectivity problem

The effectiveness of new technologies, such as automation and AI, depends significantly on connectivity. Thus, telecommunications and network resellers are pivotal in addressing limited bandwidth challenges. 3D-P's operation revolves around three key areas: As a network reseller specializing in infrastructure design, manufacturing intelligent endpoints for mobile fleets to meet growing ESG-driven data demands, and offering professional services for network support and compatibility across diverse technologies.

Given the potential weaponization of critical minerals, it is imperative to recognize mines as vulnerable assets susceptible to various cyberattacks. For example, in December 2022, part-owned by the Mitsubishi Materials Corporation, the Canadian Copper Mountain Mining Corporation in BC shut down its mill after suffering a ransomware attack. More recently, in August 2023,Freeport-McMoRan was subject to a cybersecurity incident that affected its information system. According to Ron White, the director of sales and marketing at 3D-P, the vulnerability in network security often lies in human behavior, especially in physical security aspects such as opening suspicious emails or inadvertently allowing access to cyber-attacks by opening doors to potential threats: "Educating customers on protecting against threats is essential, highlighting that even advanced technologies are ineffective if we unintentionally enable unauthorized access," he concluded. ■

Mine Planning, Communications and Predictive Maintenance

Over half of mines globally have made considerable investments into, or fully implemented mine planning and management software and mine communication systems



Source: The Energy Transitions Commission (ETC) 2023

> "The operational focus revolves around two key themes: Geotechnical analysis and improving ore dilution and fragmentation."

Ravi Sahu

CEO
STRAYOS

What is one of Strayos' latest technological solutions?

Our focus has shifted towards incorporating greater intelligence into the ore extraction process. Many mining operations believe that they can optimize their resource through better dilution control. To address this challenge, we introduced our Ore Dilution Control solution, in the form of a generative digital twin.

This solution utilizes existing data to model and analyze each 5 cm block, considering various blasting parameters. Accurately predicting the distribution of waste and ore empowers mining professionals to determine the optimal blasting parameters for reducing waste and maximizing ore recovery. This mitigates the common issue of dilution, frequently encountered in copper-gold mines, a prevalent concern in the Western region of the USA.

How is the mining industry embracing new technologies?

The industry is undergoing a significant transformation both in terms of evaluating new technologies and embracing them wholeheartedly. Technologies such as AI, autonomy and advanced sensor systems are being adopted, marking a departure from the previous resistance and hesitancy towards innovative solutions and companies have developed a culture of practice that did not exist a few years ago, shifting towards a more open approach of conducing pilot and experimentation projects to test these technologies.

The primary focus remains on achieving a quick return on investment. Companies are eager to see tangible results within a relatively short timeframe, typically ranging from six months to a year. Strayos' success lies in demonstrating that the implementation process is streamlined, and we have observed positive outcomes in the companies we engage with and where our technology is implemented.

What are some common challenges that companies face when adopting AI models?

Many companies lack structured data storage practices and diligent data collection efforts necessary for building effective AI models. Another customer profile involves those who have been collecting data but without an intelligent layer surrounding it. In such cases, the data needs to be structured before it can be utilized in AI models. Finally, computation poses a challenge. The sheer volume of data often requires substantial computing power to run complex AI models and transitioning from the customer's existing servers to a centralized or cloud-based environment can be a complex process that many mines are hesitant to undertake.

Strayos recently partnered with Quantum Systems and Delta Drone. Could you delve into the company's expanding strategy and how AI combined with drones prove to be powerful?

As data collection becomes more commonplace, combining drones and AI proves to be incredibly powerful. Drones excel at collecting vast amounts of data, but the key lies in automating the analysis process. With the abundance of imagery, videos and surveying data, automation becomes critical in efficient processing and extracting intelligence from this information.

How are Strayos' AI solutions utilized in the Western USA mining industry?

In the Western US, we work directly with blasting contractors, drilling companies and copper mining companies. Our platform is utilized in various areas, including drilling, and blasting optimization, fragmentation optimization, and geotechnical operations. The operational focus revolves around two key themes: geotechnical analysis and improving ore dilution and fragmentation.

On the geotechnical side, mining companies are eager to leverage our tools to better understand their operations. They seek ways to optimize geotechnical processes and minimize ore dilution. By utilizing our platform, they can capture data before and after blasting, enabling them to generate a dilution factor through algorithms. This valuable information can then be fed back into the model, facilitating continuous improvement and decision-making.

What are Strayos' goals for the upcoming months?

In 2023 and 2024, we aim to expand the implementation of our new Ore Dilution Control solution globally, with a particular focus on copper and gold mines, as they stand to gain substantial benefits from its utilization.

On the other hand, we have developed a cutting-edge machine vision solution, a 3D AI camera that offers full autonomy, effortlessly collecting data and correlating it to specific material blocks.

On the product front, we are also dedicated to expanding our solutions in hyperspectral sensing. We focus on leveraging imagery data and other sensor inputs to generate significant value. Hyperspectral imaging solutions are posed to play a vital role in the future of metal mines, enhancing their capabilities and extracting valuable insights. ■

> Our commitment to being OEM and technology agnostic sets us apart, enabling collaboration with diverse technologies.

Ron White

Director - Sales and Marketing
3D-P

How would you describe 3D-P's activities in 2023?
We expanded our presence in Wyoming, Montana, Arizona and New Mexico. Additionally, we successfully executed new implementations, adapting to changes within the Epiroc organization.

What are the key value propositions of 3D-P?
Firstly, as a network reseller for various technology companies, we specialize in designing and deploying networks for clients needing new infrastructure. Our second focus entails manufacturing intelligent endpoints designed for mobile fleets—rugged devices capable of data collection and logging, serving as an onboard computing platform. This caters to the growing demand for comprehensive fleet data, primarily driven by ESG initiatives in the mining industry. Lastly, our professional services group monitors and supports customer networks, providing network support, audits, and recommendations to ensure compatibility between required applications and technologies such as LTE, Wi-Fi, or meshing solutions. Our commitment to being OEM and technology agnostic sets us apart, enabling collaboration with diverse technologies.

How important is LTE for mining operations in the Western USA?
To-date, LTE has held a minor role in the Western US, especially in open-pit settings. This is primarily due to lack of available RF spectrum in the region. We continue to work with those Telco's so that LTE and 5G become a valid solution in this region.

How does the unique environment of remote mining locations impact the deployment of communication technologies?
Recognizing the unique challenges of remote locations, limited infrastructure, and constant device mobility is paramount. While the absence of outside RF signal interference is advantageous, wide-open spaces can result in self-interference challenges, particularly in open-pit mining applications. An in-depth understanding of specialized mining applications significantly differs from everyday uses. Once we comprehend the environment and applications, we strategically choose the right technology and deployment methods. Our role is to determine the most effective methodologies for deploying these technologies in mining, ensuring seamless functionality and proactively addressing potential issues.

Can you share insights into the evolving cybersecurity landscape in the mining industry?
While most networking technologies used in mining have robust security features, the main challenge still lies in human behavior, particularly in physical security, actions can compromise system integrity, like individuals opening suspicious emails and clicking on harmful links in industrial settings, we may unknowingly open doors to cyber-attacks. Educating customers on protecting against threats is essential, highlighting that even advanced technologies are ineffective if we unintentionally enable unauthorized access.

What is the Network-as-a-Service and how did you employ it at the Spring Creek mine?
We recently completed a network upgrade for a mine in Montana, encompassing fleet and infrastructure through a comprehensive site-wide network upgrade. Our delivery model—Network-as-a-Service (NaaS)-sets this project apart. NaaS offers a unique advantage by alleviating the burden on the customer. In the dynamic mining industry, frequent mine advances, application changes, and other environmental challenges require network redesigns as often as every six months. With NaaS, we monitor, manage and maintain the network to align with the customer's specified service level. We work with the customer to determine the level of service the network must provide and deliver that. The customer simply uses the network without worrying about it, similar to how we all work with our cellular provider for access on our phones.

Our services team delivers the on-site network and ongoing support, reducing workforce costs and the complexities of network management for the customer. This Montana mine's success with this approach is evident, allowing them to make monthly payments based on their required service level without upfront capital investment. Notably, most mining customers seek a network not for its own sake but for enhanced productivity, safety systems, or support for ESG initiatives. NaaS simplifies this process, acting as the 'fourth utility' that facilitates the integration of valued applications and technologies, providing a streamlined and efficient solution.

What are 3D-P's goals for 2024?
In 2024, we are focused on deepening integration with Epiroc to enhance efficiency and tap into their global presence and customer relationships. ■

Drew Larsen

Director of Business Development - Mining
ASI MINING

What is the genesis of ASI Mining?
ASI Mining operates as a privately held company, with Autonomous Solutions Inc. (ASI) being the majority shareholder and Epiroc, which acquired a 34% stake in the company in 2018, holding a minority stake, but also serving as our collaborative distribution partner. Since 2006, ASI Mining has been at the forefront of autonomy in surface mining, starting with the automation of a Caterpillar 777 haul truck for Phelps Dodge in Arizona.

We have observed a strong desire in the mining industry for flexibility in fleet and equipment selection. Our agnostic approach separates technology decisions from truck procurement, enabling mine operators to choose different makes and models tailored to their needs. OEM agnostic autonomous technology enables miners to pivot to the machine fleet that best meets their needs, by maintaining a dynamic and adaptable approach to vehicle automation.

Can you delve into ASI Mining's portfolio of solutions?
Our primary focus revolves around haul truck automation, specifically our Autonomous Haulage System (AHS). Our robotics expertise has led us to automate various applications. Partnering with Epiroc, we have connected drilling solutions to our autonomous traffic management system, which is called Mobius. Additionally, since 2016, we have delved into semi-autonomous blasting solutions with two blasting companies, foreseeing integration with drilling capabilities in the future. Beyond drilling and blasting, we have extended our automation efforts to include dozers, wheel loaders and excavators.

Could you highlight some projects where ASI provided its solutions?
Notable projects include working in 2018 with Barrick Gold and later Nevada Gold Mines to deploy autonomous haul truck conversions of Komatsu 930E-2 haul trucks in their Goldstrike project, showcasing early AHS adoption in the US. ■

Guido Pérez

General Manager – Americas
MICROMINE

Could you introduce us to Micromine?
Micromine is a software company with comprehensive solutions addressing the entire mining life cycle, from geological modeling and resource estimation during the exploration phase to mining design, planning, and asset optimization solutions. Our relationship with Newmont, now Nevada Gold Mines, led us to establish our first office in Elko and we have been operating in the US for the last decade.

Could you highlight what solution Micromine offers to Nevada Gold Mines?
One of the most successful and proven solutions we supply to them is Micromine Pitram, which manages day-to-day operations and requires no in-site development, only configuration, allowing for a record implementation time.

What are the advantages of Micromine Alastri?
In 2021 Micromine acquired Precision Mining and Alastri, two Australian companies. The latter has been disrupting Australia's market in hard-rock open-pit projects, specifically in short-term planning or scheduling. Unlike other planning systems that require on-site implementation and extensive customization. Micromine Alastri is powerful in calculating cycle times and conducting haulage forecasting. In many projects where multiple variables come into play, existing systems often lack the flexibility to adjust these variables, resulting in overly conservative forecasts. Moreover, they can overlook key variables such as ramps' inclination, weather conditions, and other statistical factors.

Because Micromine Alastri allows for multiple variables to be considered as part of it's calculations, it can deliver highly accurate mine schedules and forecasts. Plans created using Micromine Alastri have consistently demonstrated a narrow error range of +2% to +3%, while other systems produce significantly higher error rates of around 20% with the same data. ■

Blasting and Chemicals

Alleviating supply chain complexities in modern mining

Inflation has been a significant concern for the mining industry, and mining companies have had to take measures to mitigate its impact while feeling pressure to upgrade processes to reduce environmental harm. This has pushed the industry, especially service providers, to delve deeper into R&D, seeking technological advancements to both enhance production efficiency and reduce environmental impact. Meanwhile, supply chain disruptions of cyanide, flocculant, antiscalants and ammonia, all necessary to process minerals or fabricate explosives to extract minerals, have added an extra layer of complexity. According to Brady Greifzu, Solenis' global corporate sales executive, these factors have not been compensated for by corresponding surges in mineral commodity costs. "The recent global supply chain crisis and inflation have not been matched by similar increases in mineral commodity prices, creating a gap for mine operators to fill. Thus, to enhance profitability, many operators have turned to Solenis to help reduce reagent costs and boost throughput and recovery," he explained.

To help its clients prevent disruptions and determine the exact dosage of a product, Solenis has developed Solenis Cloud, an online performance monitoring automation and data analytics platform paired with a set of sensors that can be customized based on the application and customer needs: "We have automation programs that use parameters like pH, flow rate, and ore body chemistry in real-time algorithms to determine the dosage of a product. When paired together with our online inventory, the demand can help in projecting usage. This allows us to forecast when a tank needs to be refilled and coordinate with the supply chain for timely and optimal delivery service," stated Nick Morrison, mining applications manager at Solenis.

Cyanco is another company that has witnessed an increase in the cost of essential raw materials, particularly ammonia and natural gas, which are vital for sodium cyanide production. Like Solenis, Cyanco offers its vendor-managed inventory (VMI) to control cyanide dosing precisely, set specific targets, and receive continuous feedback to tackle rising costs and assist its customers. "Having an online analyzer with real-time feedback is especially relevant in milling operations where cyanide is added at the front end of the circuit to extract raw materials. By closely monitoring and controlling cyanide dosing at the beginning of the milling process, customers can reduce the need for detox reagents at the end, leading to additional, significant cost savings," explained Steve Cochrane, US sales manager at Cyanco.

Looking for a greener blasting

The choice and usage of chemicals are intricately linked to the efficiency of explosives. "Chemical crushing achieved through explosives has long been recognized as more efficient than mechanical crushing involving steel, such as crushers and grinders. By optimizing chemical crushing through blasting, mill operations, which are significant cost

Image by Dimitri Melkin at Adobe Stock

> Once the expected outcome is clear, we fine-tune our blasts, considering both cost and performance factors, to provide the mine with precisely what it requires.

Braden Lusk

President Americas
DYNO NOBEL

What were some of the milestones achieved by Dyno Nobel over the last months?

2022 was a remarkable year for Dyno Nobel Americas, with record earnings primarily driven by the strong performance of ammonia sales from our Waggaman facility in Louisiana. As we entered 2023, high ammonia prices continued, positively and negatively impacting our business. Thus, to mitigate risks, we focused on manufacturing ammonia to produce ammonium nitrate, a strategic move considering the volatility of the ammonium nitrate and ammonia market in recent years. While the explosives business experienced some cost-related challenges, overall volumes remained robust.

We have been progressively introducing innovations to improve technologies in the explosives segment and increase market penetration for electronic detonators. Our specialized emulsion technology also continues to gain momentum among customers. On the other hand, in 2023, we conducted trials and testing for new wireless detonator systems, which show promising potential for enhancing underground mining operations and addressing various mining challenges. Finally, we have gained market share in the construction space, particularly among smaller single-mine accounts.

What are the keys to optimizing blast performance?

Optimization involves understanding the expected outcome, which often involves achieving a specific fragmentation. The final product and its subsequent processing should dictate the approach to blast optimization. In the past, the challenge was measuring the advantages of blasting in the later stages of the process (like milling, crushing, or hauling). However, this has become feasible with the integration of newer measurement technologies. Once the expected outcome is clear, we can effectively fine-tune our blasts, considering both cost and performance factors, to ultimately provide the mine with precisely what it requires.

Recently, we successfully documented a project that drove an additional value of over US$58 million for a mining operation. By optimizing the blasting process and leveraging available technology and resources, we achieved a 15% increase in mill throughput. This achievement was primarily attributed to generating 5% to 10% more materials of the desired size, facilitating easier processing through the milling system.

How can blasting impact a company's financial performance?

After mineral exploration is completed, explosives become the primary means to extract almost all mining materials. Chemical crushing achieved through explosives has long been recognized as more efficient than mechanical crushing involving steel, such as crushers and grinders. By optimizing chemical crushing through blasting, mill operations, which are significant cost drivers for the mine, can function more efficiently.

What work is Dyno Nobel doing to improve safety and environmental standards?

Safety has been at Dyno Nobel's core since its inception, and all our development projects revolve around enhancing safety and productivity for blasters. One example is the development of wireless detonators, which were initially designed for underground mining where accessing certain areas was hazardous due to potential rockfalls. However, we extended its applications to surface mining. In locations with risks such as sinkholes or other concerns, using wireless detonators significantly improves the safety of the operations.

On the environmental front, initiatives such as carbon dioxide sequestration at ammonia plants and nitrogen abatement projects across various facilities aim to provide customers with lower-carbon products. We recognize the need to offer lower-carbon solutions in the long run. Many of our technology products have proven effective in reducing NOx emissions and minimizing nitrates in water during mining operations, contributing to improved environmental footprints.

Can you explain the variances between different detonators, and when is the optimal application for each?

There are four primary types of detonators used in the industry. Electric detonators use an electric current and have declined over the years. Non-electric detonators, particularly shock tube types, have been prevalent in the market and have held a significant market share for a long time. Electronic detonators, utilizing internal circuitry and chips for timing control, are gaining ground and taking market share from non-electric systems. Lastly, wireless detonators have emerged as cutting-edge technology.

The choice of detonator type often comes down to cost implications and the evaluation of features like safety and productivity. On the other hand, convincing customers traditionally using non-electric detonators to adopt better technology remains a challenge. Still, efforts are ongoing to transition them to more advanced solutions for improved results. In the future, electronic and wireless detonators will likely offer even more enhanced blasting solutions. ■

drivers for the mine, can function more efficiently," explained Braden Lusk, America's president at Dyno Nobel.

But how can a mining company optimize blasting? Investing time in understanding the expected outcomes through the integration of new technology enables companies to achieve a targeted fragmentation. "Once the expected outcome is clear, we can effectively fine-tune our blasts, considering both cost and performance factors to ultimately provide the mine with precisely what it requires," elaborated Lusk.

Dyno Nobel is focusing on manufacturing ammonia to produce ammonium nitrate. "A strategic move considering the volatility of the ammonium nitrate and ammonia market in recent years," Lusk stated.

ESG compliance is prompting mining companies to ask their service providers for more eco-friendly products and services. As such, Dyno Nobel is also working on carbon dioxide sequestration at ammonia plants and nitrogen abatement projects across various facilities to provide customers with lower-carbon products.

While the market share of the blasting segment may be controlled by a few major global companies, the Western United States presents opportunities for other companies looking to enter the market. Such is the case of the South African BME. The blasting company, currently focused on Canada as it works on establishing a manufacturing and distribution facility in Sudbury, Ontario, has a modest footprint in the US but aims to expand its presence. "The US remains a strategic market for the company, and we plan to evolve our offering in this region as we have in other international markets," commented Scott Scovira, global manager blasting science at BME.

Like Dyno Nobel, BME has been actively developing "greener" explosives and emulsions through partnerships. One such collaboration is with the Swedish company Hypex Bio, which commercializes hydrogen peroxide explosives. According to Scovira, these products demonstrate a 90% lower carbon footprint during manufacturing compared to standard nitrate products: "Hydrogen peroxide explosives stand out due to their inherent lack of nitrates, a key contaminant in mine water known to impact aquatic ecosystems and wildlife," explained Scovira.

The primary focus for BME has been directed toward Canada, where they have established substantial manufacturing and distribution facilities in the Sudbury area of Ontario. They have been actively involved in the Côté Gold project with IAMGOLD. While BME has maintained a modest presence in the US, they emphasize its strategic importance: "The US remains a strategic market for the company and we plan to evolve our offering in this region as we have in other international markets. BME is strategically positioning itself for future opportunities in the country," concluded Scovira. ■

Steve Cochrane

US Sales Manager
CYANCO

Do you think Cyanide will be replaced in the upcoming years?
Cyanide is a proven technology in the extraction of gold and silver, and it will continue to play a critical role in the mining of precious metals into the future.

From an environmental standpoint, it undergoes a natural breakdown process when exposed to heat, sunlight and oxygen, without leaving harmful long-term impacts like mercury and other chemicals used in mining historically. While new chemicals and technologies have been proposed and experimented with, sodium cyanide remains the primary lixiviation technology in precious metal mining due to its proven effectiveness and efficiency. Looking ahead, we believe there will be continued relevance and importance for cyanide in specific mining applications.

Will cyanide be more necessary as ore grades decrease?
As ore grades decrease, evidence suggests that higher cyanidation levels may be necessary. This can prove challenging for mine sites as they seek to extract minerals from lower-quality ore, potentially increasing their production costs. Striking the right balance between these elements is crucial for achieving economic viability and efficiency in the extraction process, which is why partnering with the right supplier is crucial. Cyanco can help customers achieve the lowest cost of operation for each individual mine site from initial assessment to optimal materials use to disposal and detoxification of their tailings.

What is Cyanco's focus for the upcoming months?

Our focus for the remainder of 2023 and 2024 is to continually optimize our facilities and operations to ensure the most efficient delivery of cyanide to our customers, thereby maintaining costs, despite external factors such as a turbulent global supply chain. We remain committed to improving transportation and overall processes to ensure security of supply, while prioritizing the safe handling and use of our products. ■

Kyle Green

District Manager
BRENNTAG PACIFIC

Can you provide an overview of Brenntag's performance in 2023, particularly regarding new clients in the mining industry and any notable trends or demands?
In 2023, Brenntag has observed heightened demand across the mining sector, particularly in lithium and rare earths in North America. The emphasis on reducing dependence on foreign minerals is notable.

With the increasing emphasis on sustainability and ESG factors, how is Brenntag working towards making its chemicals more sustainable and aiding customers in achieving sustainable operations?
We have an extensive sustainability plan. We are committed to being good stewards, ensuring responsible handling of chemicals, and aligning with customers who share a similar approach to sustainability. We continuously explore innovative ways to enhance sustainability in our operations and our services, such as providing product carbon footprint data on products and showcasing lower emissions options where available.

Can you highlight any notable projects in the Western US that Brenntag has been involved in?
Brenntag is actively engaged with major mining customers in the Western US. Our role involves providing expertise in chemical handling to ensure the success of greenfield projects and support the growth of our customers. We contribute to the success of these projects by providing tailored solutions that align with each customer's unique challenges and goals.

What are Brenntag's goals for the mining industry in the next 12 months, and where do you see growth opportunities?
We foresee significant opportunities in lithium, rare earths, precious metals and other commodity mining applications. Our strategic goals include prioritizing these opportunities, scaling appropriately, expanding our footprint, and closely aligning with the growth and goals of our customers in the mining industry in order to stay true to our goal of becoming the easiest to do business with in the chemical distribution industry. ■

Brady Greifzu and Nick Morrison

BG: Global Corporate Sales Executive
NM: Mining Applications Manager
SOLENIS

What is Solenis' product portfolio for the mining industry?
BG: Solenis offers products and services specifically designed for the mineral processing side of mining. Recently, we have seen a surge in demand for our innovative solutions, particularly our antiscalants, flocculants, and automation systems.

NM: We offer a range of products, primarily antiscalants, water treatment chemicals, and wastewater treatment plant chemicals such as flocculants and coagulants that aid solid removal and dewatering.

Are you noticing more demand for your services in critical mineral projects?
BG: We have been actively involved with critical minerals and are working on an R&D project to assist the copper industry in achieving its objectives with new products. We are also engaged in lithium projects both domestically and internationally, and to support these specific segments, we have hired staff in key locations where these critical minerals are mined and processed, such as Nevada and Arizona.

What technology disruptions are Solenis leveraging?
NM: We are seeing a growing interest in monitoring and data analytics; thus, we collect data from the applications we service for our customers and present it to them in an informative manner. Solenis Cloud is an online performance monitoring, automation, and data analytics platform paired with our chemistry and a set of sensors that can be customized based on the application and customer needs.

We have automation programs that use parameters like pH, flow rate, and ore body chemistry in real-time algorithms to determine the dosage of a product. When paired together with our online inventory, the demand can help in projecting usage. This allows us, forecast when a tank needs to be refilled and coordinate with the supply chain for timely and optimal delivery service. ■

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