Unearthing the snake oil for gold extraction

by Jaeheon Lee, Associate Professor, Department of Mining and Geological Engineering, University of Arizona

Gold is one of the most sought-after metals in human history. The first reference to gold dates back to around 5,000 BC. This yellow metal is the symbol of wealth, power and of course beauty. About 180 kt (5.8 billion ounces) of gold have been produced so far and more than 90 percent have been produced since the California Gold Rush of 1848. If we collected all the gold produced in one place, can you guess how big the chunk of yellow metal could be? Could it be the size of the Capitol Building in Washington, DC? Or could it be the size of a football field? In reality, it would be much smaller than those two examples — it would be a cube with each side measuring 21 meters and could easily fit into a basketball court with a height of 22 m (72 ft).

From U.S. Geological Survey data, the global production of gold in 2018 and 2019 was about 3 kt (3,300 st). China produced the most, followed by Australia and Russia. The production of gold in the United States was around 181 t (200 st) in 2019. The majority of gold production is by hydrometallurgical processes that use a water-based solution system to extract and treat the metal. Almost 90 percent of U.S. production comes from these processes, which can extract gold effectively and economically from various ores, concentrates and recycled materials. Cyanidation using potassium or sodium cyanide as a complexing agent of gold has been used for more than a century to extract the precious metal into an aqueous solution. In heap leaching and tank leaching, such as carbon in leach (CIL), cyanide is widely used for gold extraction. Due to environmental concerns and the complexity of ores, cyanidation shows some limitations for efficient gold extraction. Many metallurgists and chemists have tried to find alternative lixiviant systems that could replace the use of cyanide. The first successful commercial application is the thiosulfate leach system that Barrick Gold (now, Nevada Gold Mine Inc.) had developed and used at the Goldstrike operation in Nevada. Thiosulfate systems had been investigated by many researchers around the world and eventually applied at the Goldstrike site. Other than thiosulfate, there have been several candidates, such as thiocyanate, thiourea and, most recently, amino acids like glycine. Thiocyanate can be a great option for gold extraction after biooxidation of sulfidic gold ores or bioleaching of gold-bearing copper sulfide ores. The very low concentration of thiocyanate proved to be effective for significantly decreasing the microbial activities. It could potentially control acid mine drainage if properly utilized. Thiourea has been studied widely as an additive to the thiocyanate system and has also proved to be an effective lixiviant for gold extraction by itself with proper oxidants. It has been on and off the list of carcinogens and is now considered to be harmless to humans.

The gold industry and academia have been investigating many different lixiviant systems to replace cyanide.

I have been involved in the development of the thiourea technology with Ken Jewell and David Drye at TCB international in Phoenix, AZ. The proprietary and patent-pending technology has shown very high precious-metal extraction from pyritic sulfide concentrates, black sands, gold-bearing magnetite and e-waste. The key advantage of the process is to eliminate the oxidation of sulfide prior to the gold extraction. Conventionally, sulfide oxidation must be carried out using roasting, pressure oxidation or biooxidation to destruct the sulfide matrix and expose the precious metals for chemical leaching. Those pretreatment processes have high capital and operational costs that could negatively affect the economics of the overall process. Using an engineered recipe of lixiviant solution, a precious-metal recovery of higher than 90 percent was achieved from various sulfidic refractory gold concentrates around the world. Additionally, gold could be extracted from a primary copper sulfide often bearing gold in the sulfide matrix. This process enables the extraction of precious metals prior to shipping the copper concentrate to a smelting plant.

This technology utilizes thiourea solution as a basic complexing agent with proprietary additives. Thiourea is a very efficient and environmentally friendly reagent with fast leaching kinetics. The recovery of the gold from the pregnant leach solution can be achieved by using an ion-exchange resin, and the solution can be recycled. This technology was licensed to ATG (Auxilium Technology Group, auxtechnologies.com, Abraham Jalbout, chief

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Total Worker Health

Mining industry stands to benefit from NIOSH's initiative

by David Lauriski, EMCIS Program, Colorado School of Mines

In 2006, the U.S. National Institute for Occupational Safety and Health (NIOSH) established an initiative to address "worker health and well-being in a more comprehensive way." This more-inclusive approach looked at the work environment, both the areas where workers perform their tasks as well as the organizational factors that may affect them. In addition, factors of individual behavior were considered. Within six years, the initiative gained traction among health and safety (H&S) practitioners and researchers because of the attention given to the general health and overall well-being of employees. The initiative became known as the Total Worker Health (TWH) program. Since its inception, TWH has expanded its influence with a growing profile of research, publications, partnerships and more. Essentially, TWH works to advance the notion that "integrating occupational safety and health protection program activities with other workplace policies, programs and practices is more effective for worker well-being than either of these activities on their own."

NIOSH currently funds six TWH "centers of excellence" to serve the need for comprehensive and innovative approaches to advancing worker well-being. Spread across the country, the six centers examine a wide variety of subjects, including work environments in the construction industry, the health of nursing-home and patient-care workers, the health of workers from Native American communities, opioid abuse, food-service worker health and many more.

The TWH program seeks to improve the ability of workplaces to promote their workers' well-being, recognizing that certain factors related to worker well-being may not be considered in H&S policies or procedures. Such individual factors pertain to health status, lifestyle choices and behaviors. But safety professionals in mining who look to TWH for guidance may come up empty, as TWH research efforts to date have given little attention to the unique environments and tasks common in the extraction industries. There is a need to educate mine safety professionals about how TWH interventions can help address the numerous organizational and behavioral factors that can influence workers' health and their safety performance.

Health and safety practitioners in the mining industry have complex jobs. The numbers of tools, bodies of knowledge, policies, regulations and safety philosophies are staggering, and many of them may contrast with each other. This adds to the complexity of their work. While safety professionals may have a variety of safety interventions to consider, the comprehensive approach of NIOSH's TWH program makes sense to standardize H&S efforts, as well as apply best practices based on research and evidence. Given the prevalence of illnesses and injuries in mining, the industry stands to benefit from the thorough and detailed research methods that define TWH.

Although TWH research efforts have yet to fully reach the mining industry, they soon will. Institutions including the Colorado School of Mines have identified a need for TWH in mining and the extractive industries and are spearheading efforts to advance its ability to help mines and other industry employers keep their workers safe above and beyond what may have been possible before. Learn more about the NIOSH Total Worker Health Program at https://www.cdc.gov/niosh/twh/ ■

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executive officer) by Tech Launch Arizona at the University of Arizona and will be used globally on different projects to improve the efficiency of gold extraction with lower cost. The advanced technology of the thiourea system could be a game changer for many sulfide gold deposits that are in the project stage around the world.

The gold industry and academia have been investigating many different lixiviant systems to replace cyanide. Efforts will not stop here to find the real solution – rather than snake oil — that has a better extraction performance with less toxicity and lower cost. I can tell you from experience that it will not be easy, as cyanide has been the gold standard for more than 100 years. Those of us who are extractive metallurgical engineers will find good solutions in the future, so our industry will thrive and achieve sustainability in a circular economy. ■

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