ALTA 2019 FIT-FOR-PURPOSE LEACHING SYSTEMS PANEL DISCUSSION

May 2019

The panel discussion was held on Thursday 23 May 2019, immediately following the Gold-PM sessions at ALTA 2019 in Perth, Australia.

Panel Chair: Prof Jacques Eksteen (JE), WASM, Curtin University (Australia)

Panel Participants (left to right): Elsayed Oraby (EO), WASM, Curtin University (Australia); Tim Newton (TN), Mining and Process Solutions (Australia); Damian Connelly (DC), METS Engineering Group Pty Ltd (Australia), Yeonuk Choi (YC), President, YaKum Consulting Inc. (Canada); Paul Breuer (PB), CSIRO (Australia); Brigitte Seaman (BS), Newcrest Mining Limited (Australia); Joe Zhou (JZ), Joe Zhou Mineralogy Ltd (Canada)

***Editor's Note**: The contributions of the panel members and delegates are not presented verbatim, but rather have been paraphrased and condensed for clarity and brevity. They are not necessarily recorded in order but are grouped into major topics. Also, it is not feasible to include all contributions made during the discussions, and they are limited to some that are representative of the key points raised and debated.*

What is Preventing Gold Companies from Pursuing Alternative Gold Leaching Lixiviants?

JE (chair) opened the discussion by asking the panel what is actually preventing gold companies to pursue alternative gold leaching lixiviants.

Bryn Harris (BH), NMR360 Inc (Canada), floor said that companies do not want to be the first one to try a new technology and do not want to take the risk, particularly in mining industry. For example, around 2010, his version of chloride processing was piloted for a mid-level company in Canada who already had a conventional operation producing around 100,000 oz/yr. They had another orebody that was highly refractory with a lot of arsenic and carbon. The pilot plant ran for 6 months and validated the technical and economic feasibility. The Albion Process and POX had been found to be unsuitable. They had a perfect feasibility study, the capex and opex were favourable, and they were all set to go. However, the CEO had changed, and a board meeting was held where the board decided not to proceed because of adverse market perception, and that it wouldn't create value for shareholders. That company does not exist anymore.

DC (panel) said he found that the introduction of any new technology takes about 30 years. For example, looking at the early CIP plants, they were terrible compared with the current ones. There was a huge learning period over which improvements were made through the efforts of the operators. Another problem is that a lot of boards are ruled by financial people and shareholders who want return on investment, and banks are

extremely difficult to convince despite advice from consultants that the technology looks good and the pilot plant results are positive. They tend to cite previous problems and failures in the industry.

JZ (panel) agreed with Damian Connelly that any new technology will take some time to be recognized and implemented, and cyanide has been used for over 100 years and it is very effective. But he believed that non-cyanide lixiviants will be the trend in the future, but it may take time and more effort to be recognized. When he was working in Zijin Mining's research centre in China, he found that as with cyanide, all the alternative regents have advantages and disadvantages. He suggested that chemical companies spend money and effort on fundamental studies and that a systematic program should be developed which may last for 10 to 20 years. Also, he pointed out that if the gold is not exposed, neither cyanide or nor non-cyanide lixiviants will not work.

Mark Benz (MB), MRB International Consulting (Canada), floor pointed out that besides the perception of the new technology, there is an inertia amongst decision makers from the perspective of sticking to what they are actually doing at the time and which appears to work satisfactorily. Once public traded companies have cut a certain image, they tend to become more and more risk adverse to change, and it has been this way for many decades. The response of financial analysts is also another issue; for example when Barrick looked at investing into copper (copper-gold), he was flabbergasted at the response of the market and financial analysts who find it difficult to look at two products at the same time.

On the other hand, Sherritt Gordon was a little-known small player in copper-zinc concentrates in the 1950s. When they decided to go ahead with their major nickel mining and refining project they were completely defined in the market, make or break, by that project. Fortunately, they found Newmont as a sponsor who were a diversified company at that time.

How Do We Obtain a Greater Uptake of Alternative Lixiviants in Gold Processing?

JE (chair) asked Yeonuk Choi to comment in view of his experience of persuading Barrick to choose an alternative gold lixiviant.

YC (panel) said that it is difficult to persuade a CEO who was not a technical person to adopt an alternative lixiviant. Financial people are focussed on cost and are not interested in new technology. Typically, if cyanide can achieve 85% recovery the potential gain with an alternative lixiviant is likely to be regarded as too marginal. In the case of Barrick Goldstrike, however, gold recovery for the particular feed material increased from close to zero to 60-70%, utilising a big portion of existing infrastructure (e.g. autoclaves) which is was huge leap.

JE (chair) asked Brigitte Seaman's opinion given that her CEO is a chemical engineer.

BS (panel) said the CEO did support the use the new technology. In Newcrest's experience cyanide can result in very good extraction and can operate over a broad operating range of pH and Eh compared to alternatives such as halides and thiosulphate. The key drivers for seeking an alternative for the Telfer operation, which is featured in her presentation, were cost and legislation. The cost for using cyanide was prohibitively high due to the presence of soluble copper, and they decided to investigate a glycine-based leach approach.

JE (chair) asked Paul Breuer about his experience in working with New Fortune Gold to agree to use the Menzies site for testing the new CSIRO thiosulphate leaching system.

PB (panel) said that they were able to overcome the barrier to considering an alternative to cyanide by identifying a potential leach process with a lower CAPEX and OPEX cost compared to cyanidation. The base cost and project delays with regard to documentation, legislation requirements, dangerous goods handling requirements, and to set up a cyanidation leach plant is large for a junior mining company.

YC (panel) pointed out that from his own experience, with thiosulfate, that the process is reversible. Therefore, it is very hard to design and develop the process. For example, comparing carbon and resin, carbon is not reversible, but resin is. Thus, it may take a long time to understand the process, and the level of understanding is very important. He pointed out that the plant needs to be controlled like a chemical factory rather than a conventional cyanide-based processing plant which tend to be very forgiving and robust.

TN (panel) added that glycine leaching will hopefully take less than 30 years to be implemented. MPS try to get the message across that they are not talking about a wholly different process with strange equipment and exotic materials. They are introducing a relatively minor retrofit to an existing or conventional process by taking smaller steps rather than trying to revolutionize the whole process. So they think there should be less of a barrier to get it implemented.

JE (chair) mentioned that he knew that China is moving away from cyanide and are looking at a number of green options, and he asked Joe Zhou, from his experience in China, what is their view of looking at alternative lixiviants.

JZ (panel) said that China is actively looking at greener alternatives, but have particular challenges with refractory gold deposits which currently mostly utilise roasting with a gradual transition to BIOX and POX pretreatment processes.

JE (chair) asked Elsayed Oraby about his experience in testing Glyleach™ and Glycat™ lixiviant systems on numerous ore types supplied by companies.

EO (panel) said that problem solving is the key to attracting the mining companies to alternative lixiviants. Mining companies are like patients and researchers are like doctors. If the mining companies have no problem, they will not come to the doctor, and they will not give up cyanide as cyanide is a tough competitor. Most of his work has been with gold-copper ores and concentrates which are usually problematic, which is why the companies were looking for solutions. He has found that if solutions with robust technologies and dollar value can be developed, mining companies can be convinced. Regarding Jacques's question, he has tested glycine with many problematic materials from mining companies - for example, gold-copper oxide containing carbonaceous materials; gold-copper ores, and gold ores with high silver. Glycine does not give an improvement in gold recovery over cyanide for ores with preg-robbing material, ores with a high reactive sulphide content although decision to use glycine may not only be recovery based.

JE (chair) Added that the time for uptake of an invention is typically beyond the life of the patent, resulting in little incentive for universities or any other institutions.

How Do We Get a Higher Use of IX in Gold Processing?

JE (chair) raised the question as to why the application of resins is not common in the western world, even though it has been used in Russia for decades.

YC (panel) said that it is usually adopted when there is no other choice but to use resin, otherwise mining companies will not change from carbon.

DC (panel) said that some of the early implementations of resin were problematic in terms of screening because of particle size and swelling issues, and a number of projects failed, and that some mining companies are still concerned about this. However, resins have improved over time and are working very well in pilot plants, and also the prices have come down a lot. Resin-in-Pulp is potentially very attractive and has been tested, but he has not seen anyone using it commercially in Australia, and it may take a long time before it is implemented. He believes that in time resins will offer a great opportunity.

Malcolm Paterson (MP), PT Green Gold Engineering (Indonesia), floor commented that Penjom, Malaysia, adopted resin by necessity because of the preg-robbing materials, so there was no alternative. He referred to an excellent book called "Crossing the Chasm" about the acceptance of technology, and said that it is extremely difficult to get acceptance of new technology in industry, and is even more difficult for the mining industry. He considers himself lucky as he was the CEO on two projects and was able to make the decision to use resin on both. A third application is being implemented at Martabe because of the two previous operations. They have a resin in pulp operation running for six years but it is still regarded as new technology because it is the only one. IX technology has existed for 50 years and is only now gradually being accepted, but it remains a battle.

BS (Panel) asked Malcolm Paterson what was the main driver for Green Gold to adopt resin instead of carbon.

MP (floor) said they did a feasibility study using carbon and the project was marginal. With the introduction of resin, the project became economic. The reason was that the ores contained high silver, and the ability to recycle cyanide allowed them to have high cyanide level to achieve a high silver recovery.

PB (panel) commented that it IX was likely to be applied initially for cyanide recovery, but as a company gains experience with it there is no reason why it could not be also used for the recovery of gold.

Can Hybrid Lixiviant Systems be Used to Extend the Range of Applicability?

JE (chair) asked the panel for their view on whether they see an opportunity to use a mixture of lixiviants such as in the GlyCat™ Process to extend the overall range of applicability i.e. pH-Eh-T-Ionic strength?

PB (panel) agreed it is really an opportunity. If the process can be simplified to a single step by using a mixture lixiviants, why go for two-stage leaching using the lixiviants separately?

EO (panel) said that using a mixture of thiourea and glycine is another example.

JE (chair) added that the glycine-thiourea leaching, an acidic system, has been tested. However, glycine-thiourea is actually a compound that can be crystallized as a single compound. It significantly reduces the amount of thiourea needed and extends the pH range. But being a new compound rather than a hybrid mixture may affect the likelihood of its acceptance as simplicity is a key issue in gaining acceptance.

BS (panel) said that in the Telfer case, the leaching system is cyanide and glycine, and the presence of cyanide makes the company feel more comfortable together with the recovery being similar to using cyanide alone.

Danielle Hewitt (DH), CSIRO (Australia), floor agreed, and said that introducing something a little different and getting people used to the concept of adding different lixiviants provides a good opportunity to increase the uptake of alternative lixiviants down the track. The concept is similar to introducing additives in flotation and catalysts to improve leaching performance. Similarly, the use of resins to replace carbon in cyanide systems could be another step towards the acceptance of alternative lixiviants which require resins. However, based on her experience in the commissioning of the Goldstrike circuit, operators need to be educated about the differences between resins and carbon. Likewise, educating operators who are used to cyanide about the different chemistry and operating characteristics of an alternative system will lead to better performance, which will improve acceptance and uptake.

What can replace CIP/CIL or RIP/RIL to Eliminate Inter-Stage Screens?

JE (chair) asked for comments on the feasibility of replacing CIP/CIL or RIP/RIL to eliminate inter-stage screens which can be problematic due to maintenance issues and pegging, especially in cyanide systems.

PB (panel) said that eliminating inter-stage screens becomes a real option when considering dry stacking of tailings using filters because recycled solution can be used for to washing to reduce losses in the filter cake.

JE (chair) added that US company Gold Corp have made a major drive towards dry stacking of tailings and a growing number of other gold companies are also moving in that direction, particularly in the USA, though not yet in Australia.

YC (panel) added that wholly dry processing may be an option especially when water availability is an issue. The Goldstrike whole ore roasting process is wholly dry up to cyanidation (which includes dry grinding).

Can Thiosulfate Leaching be Extended to Heap and In-Situ Leaching?

PB (panel) said that thiosulphate is leaching similar to cyanidation in that oxygen is needed and the oxidant will expire at some point if the heap is too deep. It also has similar problems to other leaching systems in terms of the impact of mineralogy on the leach system and control of pH to achieve stability long enough. For in-situ leaching, CSIRO has looked at the thiosulfate and iodine systems. In early work with iodine on one of the ores precipitation of gold iodide occurred through the column which will be an issue depending on the mineralogy. Summing up the approach has to be fit-for-purpose for each application.

YC (panel) said that Barrick research indicated the application of thiosulphate to heap leaching was ore specific it worked well on some ores but not on others. Also, compared to cyanide, you have to add high concentration of chemicals which has to be washed after leaching and the solution has to be reconcentrated it for reuse which requires understanding the chemistry of the system.

Can Cyanide-Free Glycine Leaching be Effective at Room Temperature in Agitated Tank CIP/CIL Circuits with a Maximum of 48 hr Residence Time?

JE (chair) advised that glycine leaching without catalytic amounts of cyanide needs heat and takes a long time, and asked EO to comment research using additives, which has been patented allows leaching at room temperature with a 48-hour leach time.

EO (panel) said that they tried to modify the rate of using glycine alone. They have tested the effects of with and without oxygen, and they found that oxygen is necessary. They also tested different strong oxidants in the absence of cyanide, and proved that a similar leaching rate can be obtained by using the strong oxidants. But it is also subject to the ore type. Until now, it is only feasible for gold oxide ores; for gold sulphide, the oxidant can be easily consumed. Compared to the normal cyanidation, the results were promising.

Summary of Key Points

- Uptake of new processing technology remains very difficult in mining companies with a poor knowledge of process metallurgy at executive level. Due to the slow uptake, often after patents have expired, is discouraging new innovation due to a risk-reward or pain-to-gain ratio that is unacceptable for most inventors (compared to other industries).
- Uptake of new technologies is easier with an incremental approach or where there is no other alternative. Having a board with some risk apatite and chemical process understanding is also helpful.
- All alternatives to cyanide have detracting factors, and because of their lower stability than the cyanide-gold complex, requires more lixiviant to maintain gold in solution.
- Activated carbon remains the default method for gold recovery from solution and upgrading, and resins are only used when carbon has been shown not to be economic.
- As ore grades decline, there will be a bigger focus on non-cyanide heap and in situ leaching approaches, which would necessitate lixiviant systems that can withstand fairly large pH, Eh and dissolved oxygen gradients.

The Editors acknowledges the work of the student volunteer from WASM, Curtin University, Zixian Deng, for proving detailed notes on the discussion.

Cyanide Alleviation & Alternative Lixiviants is the featured topic for the ALTA 2020 Gold-PM Forum and Panel, which will be held 28 May in Perth, Australia.

Editors:
Prof. Jacques Eksteen, Director, Gold Technology Group and Chair, Extractive Metallurgy, Curtin University, Australia
Alan Taylor, Metallurgical Consultant and Managing Director ALTA Metallurgical Services, Australia
ALTA Panel Notes