Innovations in heap leaching and mine waste discussed at 2014 Elko Roundtable

by Bryan Ulrich

On March 20, 2014, the "Roundtable Discussion on Innovations in Heap Leaching and Mine Waste Management" was hosted by Knight Piésold and Co. at the Red Lion Hotel in Elko, NV.

This topic is timely, and formed something of a lead into the inaugural "Workshop on Innovations in Waste Rock, Tails and Heap Leach Management." That workshop, which grew from the 2013 Elko Roundtable, was held on the University of Nevada, Reno (UNR) campus on May 19, 2014.

The workshop was hosted by UNR and the University of British Columbia.

Knight Piésold's local representatives, Bryan Ulrich and Logan Jensen, were joined by Tom Kerr, president of Knight Piésold's, U.S. practice; Rick Frechette, senior vice president, environmental services and Jeff Coffin, geotechnical engineer, from the Denver, CO office for the roundtable event.

The event played host to about two dozen attendees from several western states.

Attendees included personnel from 12 mining properties, various corporate offices and academia.

The purpose of the roundtable was to exchange ideas and information pertaining to broad topics revolving around the subject of innovations in heap leaching and mine waste management. Compared to traditional conferences and symposia, the roundtable type of forum tends to provide a much less inhibited format for discussion. In the roundtable format lively discussions and helpful tangential departures are encouraged.

This was the eighth in the series of the Elko Roundtable events. Previous roundtables pertained to:

- Heap leach pad design, construction and operation.
- Design, construction and operation of tailings storage facilities.
- Site-wide water considerations.
- Mine closure and cover design.
- Strides toward sustainability in mining.
- High-density tailings, paste and filtered tailings.
- Acid rock drainage for engineers and environmental scientists.
- Material co-disposal/co-placement in the mining industry.

The initial subtopics for Roundtable 2014 included:

- Heap leaching.
- Drain down from waste rock and heap leach piles.
- Lining difficult slopes.
- Numerical modeling and large scale laboratory testing.
- Evaporation cells (E-cells).
- Waste rock.
- Tailings: Conventional, thickened, paste, filtered and novel facilities.
- Knight Piésold project presentations.
- Round Robin: What keeps you up at night?
- Closing comments.

The roundtable created an environment to discuss the current practices, challenges and accomplishments associated with the need for, and the advancement of, innovation. Since there is considerable overlap between the roundtable's subtopics, the conversations frequently wandered from theme to theme and back again. In keeping with the spirit of an open roundtable discussion with unbridled conversation, the authors have chosen to create sanitized minutes of the meeting, wherein specific quotes are not attributed to their author, but rather the proceedings of the discussions are presented in a rather stripped down version in order to avoid stifling the free exchange of ideas.

The following is partly a tangential discussion and partly the proceedings of the roundtable.

It has been said that necessity is the mother of invention. As the conversation pertaining to the day's topic commenced, it was clear that the mining industry has always been innovative. What was even more certain is that the mining industry will continue to need further innovation in order to sustainably operate in an ever-challenging world.

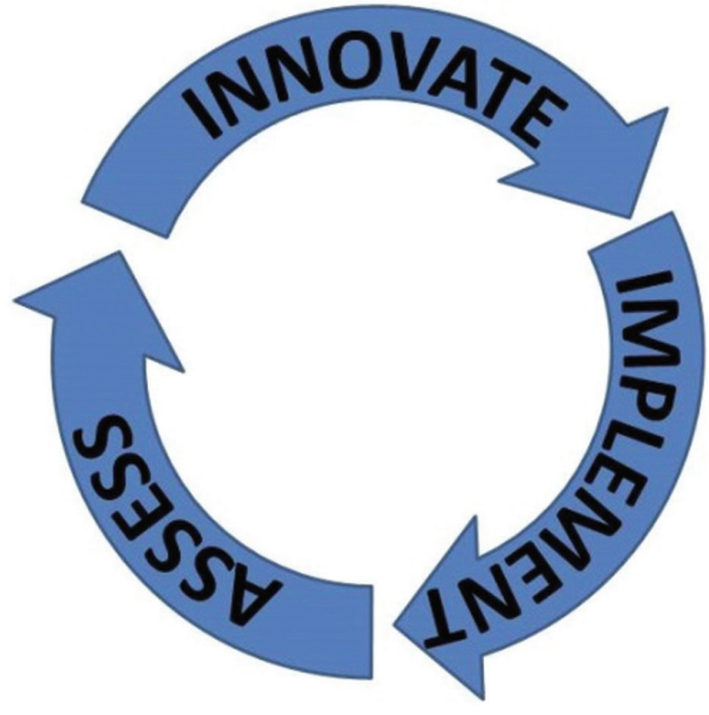
Following a safety share to begin the event, the conversation began with introductions and a round robin answering of the question, "What does today's discussion topic raise in your minds?" The responses to that question were many and varied, and included:

- By nature, all predictive models have

Bryan Ulrich, member SME, is senior vice president, Nevada Operation, Knight Piésold, email bulrich@knightpiesold.com.

Figure 1

The innovation circle: innovate, implement, assess and repeat.



some level of uncertainty. The higher the level of uncertainty in your predictive geochemical model, the higher your closure bond will be.

- There are examples of heap leach facilities that have had their bonds reduced by the regulatory authorities when uncertainty in their predictive models had been reduced.
- The GARD Guide indicates that, as time goes by, the viable options for closure of mine facilities are fewer and their costs increase.
- There is need to consider long-term funding for heap leach facilities versus prevention of acid rock drainage (ARD). It often does not help just to throw money at the situation.
- There are regions in the world that do not allow perpetual treatment as a design option.
- There is a need to share case history information regarding successes and failures in the closure on heap leach and mine waste facilities.

Following the round robin, participants gave several presentations to the attendees, including draindown physics, large-scale laboratory testing, considerations for installing liners on steep slopes, evaporation cell design, codisposal of mine waste materials and the use of geotubes in tailings management.

Kerr and Coffin's presentation on lining steep slopes provided the attendees with a summary of what is presently a proprietary method of lining steep slopes.

The mining industry and geotechnical community are constantly being faced with increasingly difficult challenges of lining steep slopes. Steep slopes may present slope stability concerns, many of which can be solved, but the greater challenge is associated with the tremendous down-drag forces that occur, for example when heap ore settles under the compressional pressures created by additional heap ore placement. Heap leach ore near the base of a heap leach facility may settle several meters when buried by, say 100 m (300 ft) of ore. That magnitude of deformation on a liner requires very careful design considerations. As Knight Piésold advances this proprietary lining system, it is hoped that this technique may be of broad application for projects with very challenging slopes.

That presentation was followed bypresentations by Kerr and Coffin on the Fort Knox tailings facility and the La Quinua combined heap leach/tailings storage facility.

The Fort Knox tailings facility in Alaska was developed with an embankment that was designed as a zoned-fill, water-retaining dam. Tailings were deposited along the perimeter of the facility farthest from the embankment, creating a supernatant pond at the dam. Mine expansion tied to increased ore reserves required an innovative redesign of the tailings facility. In order to significantly increase storage capacity, it was decided to convert the facility in a manner that would have tailings being deposited from the embankment, rather than toward the embankment. This would fundamentally change the way the facility would be constructed and operated. The results of a geotechnical investigation indicated that this required the placement of fill into the supernatant pond near the embankment, which would allow the founding of an embankment partially extending "upstream." This redesign also required the reorientation of the zonation within the upper regions of the embankment, and has led to a significant increase to the tailings storage capacity of the facility.

The Yanacocha Mine's La Quinua Mill has a thickened tailings storage facility that is contained within an active heap leach facility. It is an innovative, unique and unprecedented design that provides its operator with cost, land-use and closure efficiencies. This design requires that leach ore embankments retaining

Figure 2

Mixing two dissimilar granular materials (concrete sand and pea gravel) at the Paterson & Cooke facility in Golden, CO.

the tailings provide the same level of stability required of major tailings dams. As compared to conventional tailings dam construction, the leach ore in these embankments is consistent with normal heap leaching operations; that is, with thick uncompacted lifts to maintain adequate permeability for leaching. The resulting loose structure makes the proper assessment of static and dynamic liquefaction a critical issue. The key design principle for avoiding liquefaction is to maintain the phreatic surface well away from the outer faces of the embankments and within large unsaturated structural shells. The facility was successfully commissioned in early 2008 and its performance to date has met or exceeded its design objectives. Recently completed field investigations to assess pore pressure buildup within the facility have indicated that the facility is performing as designed.

At the conclusion of Kerr and Coffin's presentation, there was considerable discussion about the practice of placing amended tailings into mined-out underground workings (amendments may include materials such as cement, fly ash and diatomaceous earth). Amended paste tailings have been used as underground mine backfill at mines around the world for many years, but such an operation is fairly novel in Nevada. This is largely due to the wording in Nevada's regulations for tailings storage. Nevada's regulations for tailings storage are heavily swayed toward placement of tailings on a clay or geosynthetic liner, an installation, which would be impossible (or at least unlikely) in an underground opening. The mine operator who successfully permitted the use of amended backfill in its mine in Nevada did so by demonstrating to the satisfaction of the state that there would be no potential contaminants migrating from the paste tailings.

The conversation next turned to the subject of filtered tailings. Large-scale filtering operations are being designed in the United States and elsewhere. It was said that properly designed, constructed and operated filtered tailings facilities may offer the closest application the industry has in attaining a truly walkaway tailings facility. The filtered tailings facility at Kinross's La Coipa Mine in Chile is often cited as being an excellent example for the use of this technology. La Coipa is located in an arid environment that tends to further decrease the filter cake moisture content as it is delivered to, and dozed into place on the tailings facility.

It was noted that there are no one-size-fits-all technologies that are suitable for all applications. This is true for filtered tailings. Each project should be approached individually and technologies chosen or discarded based on their merits for a particular site. Note that the term "dry stack" has not been used herein. Most frequently filtered tailings are created at a moisture content that is near its optimum moisture content in terms of compaction. Once compacted and subjected to self-weight settlement, the filtered tailings can be at or nearly at full saturation. Therefore, on most occasions, the term "dry stack" is a misleading misnomer.

An elusive goal, but one that has been written about numerous times, is the essentially perfectly blended mixture of tailings and waste rock. Such a mixture would have the following traits:

- Tailings and mine waste are mixed relatively homogeneously.
- Tailings essentially fill all the voids between waste rock particles.
- Waste rock has predominantly rock-to-rock contact.

Ideally, thickened tailings and waste rock

would be mixed and compacted (if necessary) to result in a mixture that is essentially saturated, but without any free water (i.e., it would exist in a condition near the zero air void curve on a compaction test report). Benefits/goals of achieving the essentially perfectly blended mixture of tailings and waste rock are:

- Reduced facility footprint area.
- Waste mass exhibits a shear strength similar to waste rock.
- Waste mass has a low permeability akin to tailings.
- The combined waste exhibits a low oxygen diffusion rate.
- The waste mass may be able to greatly reduce ARD production.
- Because the waste mass should be very stable throughout its operating life, improved closure opportunities should exist.

Due to their high shear strength and low permeability, a successful co-disposed tailings and waste rock facility would have several admirable traits. This would include a low oxygen diffusion rate, which may preclude the production of ARD.

There have been numerous articles written about this co-disposing application. However, this has been an elusive goal at anything that approaches a full-scale operating mine level.

For a recently completed project, Knight Piésold developed a design for a co-disposed waste rock and thickened tailings facility. The goals were to design a facility with the following physical attributes:

- Accommodate waste rock and tailings at an approximate ratio of four parts waste rock to one part tailings (reflecting the approximate ratio of air void space typically found in waste rock piles).
- Result in an essentially homogeneous mixture using thickened tailings and with waste rock particles up to 0.3 m (1 ft) in diameter.

Due in part to the absence of adequate equipment to achieve the project's mixing goals, a bench-scale laboratory static mixing device was developed and tested, and testing results thus far have been favorable. The device has been used to satisfactorily demonstrate the mixing of two dissimilar granular materials (concrete sand and pea gravel) and a granular materials (pea gravel) and tailings slurry. In this particular test series, the slurry tailings had a relatively low solids content, but that would not be the intention of a full-scale operation.

Knight Piésold has just begun an initiative with the Department of Civil Engineering at Colorado State University that may further the understanding and operation of the static mixing device, including the use of tailings at various solids contents.

Depictions of the device are provided in Fig. 2.

After some additional discussion, the day ended as it had started, with a round robin discussion. The question was posed to the roundtable's attendees, "What keeps you up at night?"

The following are a few of their responses:

- Given the general cyclic state of mining, it can be difficult to attract top minds to our industry. As such, one may wonder, where will the next generation of mine waste experts come from?
- There are several problems for engineering consulting firms that are caused by the cyclic nature of mining. For example, during boom cycles, great ideas can be initiated, only to be de-funded during down-cycles.
- It can be difficult to keep our young and talented staff engaged, satisfied and moving along in their careers during down-cycles.
- People often complain about the lack of mentoring in their group. It was suggested that capable senior staff embrace the act of mentoring, rather than asking, "Who will mentor this staff?"

There were also technical challenges brought up, such as:

- The need for the development of corporate standards for tailings and mine waste management (note that some mining companies have such standards).
- There can be short-term decisions made that can have long-term impacts on facilities. It was suggested that short-term objectives be given the appropriate amount of consideration before they are enacted.

By all accounts, this year's roundtable was seen as being highly successful. Next year, Knight Piésold plans to once again host a roundtable discussion in Elko. ■