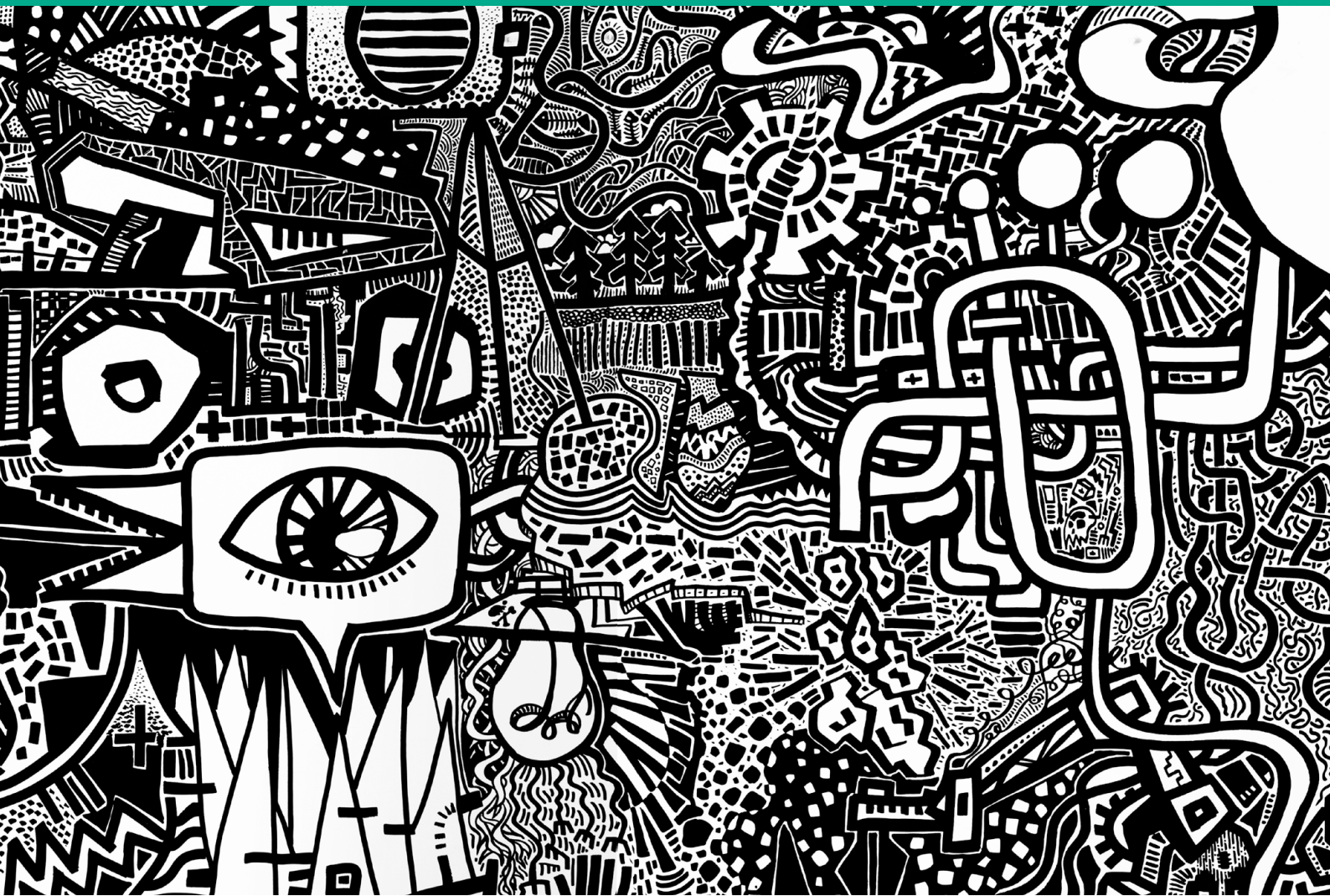


Think & Act Differently

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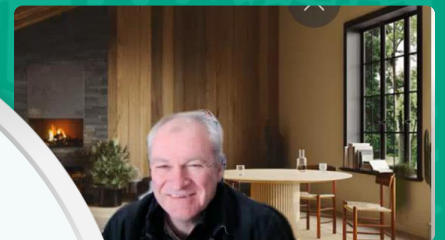
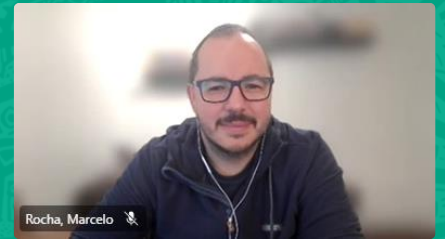
ISR Cohort



RioTinto **BHP**



BOLIDEN



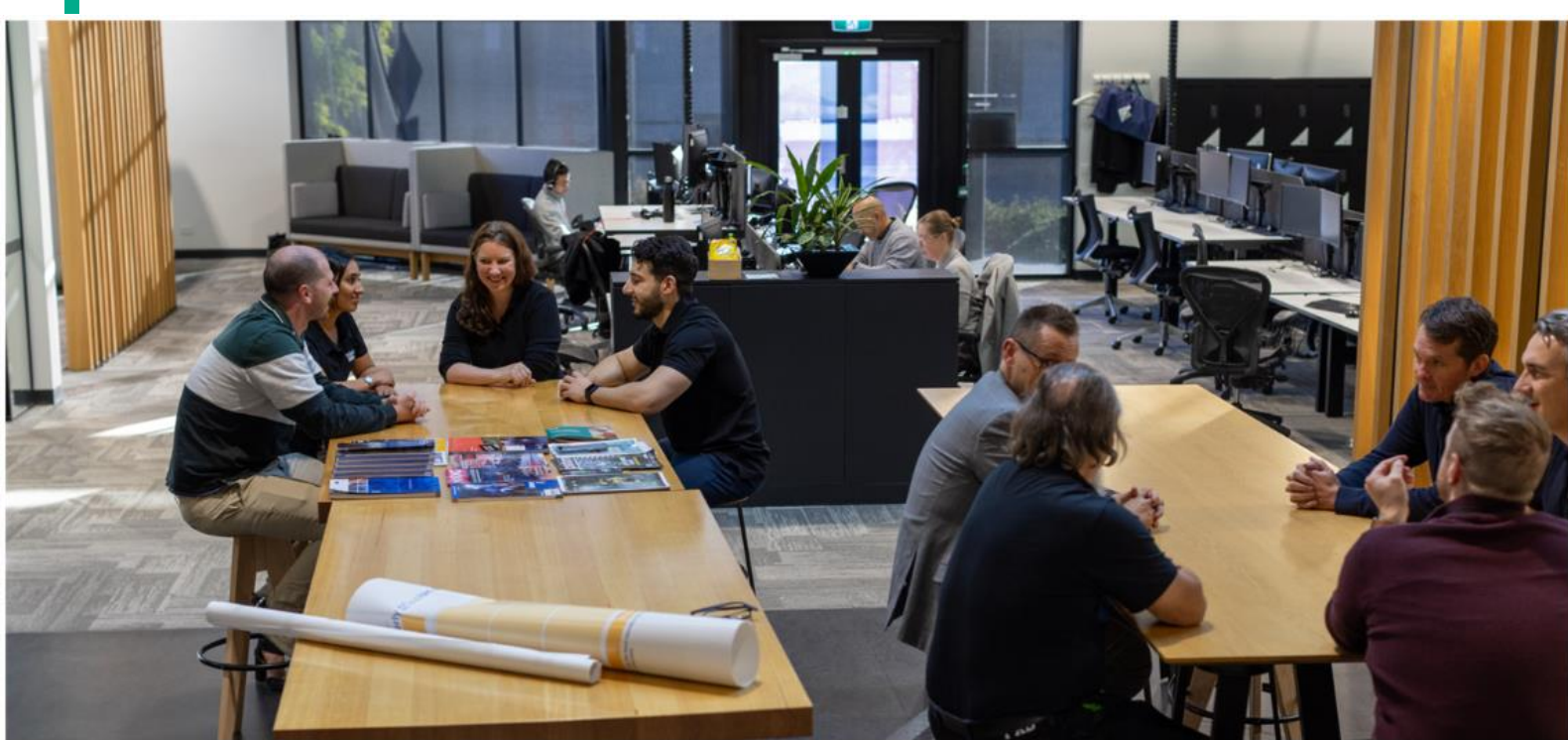
Cohort Summary





Think and Act Differently

Think and Act Differently, powered by BHP, (TAD) find and accelerate the best technology solutions to support BHP's ambitions to deliver resources the world needs in new ways. TAD uses a systems approach to foster a continuous flow of new technologies and capabilities that empower BHP to meet today's needs and build a roadmap for future value. Using the TAD and partner innovation ecosystems, collaboration is fostered with a range of individuals and organisations to accelerate technologies at scale, fostering optionality, speed, and diversity.





In-Situ Recovery Cohort

The Challenge

The ISR cohort was built by approaching innovators from the TAD Ecosystem to collaborate and explore some of mining's most challenging opportunities.

Through this challenge, we looked to identify technology opportunities that could significantly accelerate low-footprint recovery in the field of **in-situ recovery (ISR)**, **in-mine recovery (IMR)** and **heap and stockpile leach extraction**. Exploring collaboration with organisations to accelerate technology development.

The Cohort

In collaboration with our partner, Uearthed, the TAD Cohort was curated through a technology scouting and review process and included members of TAD's ecosystem.

*This cohort was supported and funded through the JV by BHP, Boliden, Rio Tinto, South32 and IGO as part of our collaboration to unlock new technologies and reimagine lower impact mining and processing to find value in overlooked resources. **

The cohort brought together nine diverse innovators, start-ups, researchers, OEMs and others to solve problems relating to ISR, IMR and heap and stockpile leach extraction.

The cohort worked with mentors and technical subject matter experts who provided coaching and support during the program. Fortnightly roundtables were conducted to provide a place to connect and share successes, and challenges. The cohort participated in a final showcase to communicate their technology to a broader BHP audience and the JV partners in a supportive environment, receiving ongoing feedback. **Please refer to pg 8 for more information on the JV.*

What is Insitu-recovery?

In-Situ Recovery (ISR) is a mining technique used to extract valuable minerals from underground deposits without the need for traditional mining. Instead of digging out the ore, ISR involves drilling wells into the deposit and injecting a specially formulated solution that dissolves the minerals. This solution, now carrying the minerals, is then pumped back to the surface where the minerals are extracted from the liquid. ISR is considered a more environmentally friendly and less disruptive way to access underground resources, as it minimises surface disturbance and the need for large-scale excavation.





In-Situ Recovery Cohort

Highlights

In-Situ Recovery (ISR) represents a transformative approach to mining, emphasising the need for low-impact, environmentally sustainable operations. The ISR cohort brought together a diverse range of innovators addressing key challenges—such as rock fragmentation, operational monitoring and characterisation, leaching, and solution purification—all of which are crucial to unlocking a viable ISR solution.

The innovators within the Cohort developed and tested a wide array of technologies and took away valuable learnings that will help accelerate their ideas. Some highlights included:



Eden's Electric Rock Fragmentation Technology demonstrated an increase in permeability, a critical advancement for ensuring solution flow in deep, hard rock environments.

Eden Geopower's rock fragmentation technology presented an opportunity to improve permeability in ISR resources. By using repetitive high-voltage discharges, this technology creates targeted fractures in hard or low-permeability rock formations, enhancing the flow of leaching solutions and enabling more efficient mineral extraction. This technology is working to expose fracturing preferentially along sulfide grain boundaries leading to increased leaching kinetics, and therefore, faster leaching.

Ekion

Ekion's EK Leaching Technology showed potential for ISR applications in low permeability media by using electromigration and electro-osmosis to extract metals.

Ekion are developing electrokinetic in-situ recovery (EK-ISR), a novel method to enhance mineral extraction from challenging ore bodies and tailings waste. By applying an electric field to the resource, this technology mobilises minerals from low-permeability formations where traditional ISR would struggle. The technology drives leaching solutions directly to the target minerals through electromigration and/or electro-osmosis. In this cohort, Ekion looked to test two hypotheses, firstly, if the technology could be successfully up-scaled and, secondly, if the technology could be applied to a wider range of metals and media. For most of the experiments conducted, EK-ISR could effectively migrate the lixiviant across the tested media of tailings and intact ore. However, the effectiveness of metal recovery was reliant on the ability of the applied lixiviant to extract the targeted metal.



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Unearthed



In-Situ Recovery Cohort



Loop Hydromet showcased its chloride-based leaching technology, offering a potentially more cost-effective approach to resource recovery.

Loop is looking to help solve the predicted global copper supply shortage with faster, better, stronger processing of available copper feedstocks. It is also aiming to access other rare earth elements that are very difficult to extract. Loop uses Halide Hydrometallurgy to leach a wide range of mineral concentrates. In this cohort, Loop focused on the extraction in multi-element and high arsenic ore bodies.



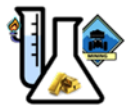
MuonVision identified use cases for its muon sensing technology to monitor saturation levels, providing critical real-time data for operational safety and efficiency.

To understand what is happening inside a leaching heap or tailings dam, Muon Vision seeks to use naturally occurring cosmic rays for sustainable mining through the mapping and distribution of the fluid content within mining assets to foster efficient leaching of low-grade ores. This technology has the potential to be extended to monitor an ISR resource.



Clean and Recover demonstrated ElectroClear recovery of water from acid mine drainage, finding that metals removal was near 100% for most metals.

Clean & Recover demonstrated that electrochemical treatment of acid mine drainage can achieve more than chemical treatment including superior recovery, reduced costs, capturing additional value and returning water from the drainage, and avoiding carbon emissions generated by using lime or sodium hydroxide.



Auric BioRecovery, LLC

Auric BioRecovery demonstrated bio recovery processes to release metals from tailings.

Auric conducted a desktop review to explore the potential of their bio-leaching solution to extract additional nickel from a concentrator circuit. The focus was on leaching nickel from sulfide at high pH, aiming to reduce the co-leaching of iron, which would otherwise require additional precipitation steps. Auric identified two promising solutions: using bacteria to activate the pentlandite surface to enhance flotation, and applying a bacterial leach to the sample tails.



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In-Situ Recovery Cohort

P_p Precision Periodic

Precision Periodic has developed nanotechnology based chemical, filtration media, Nano Beads™, for the recovery, separation, and refinement of elements in mining, refining, recycling, and wastewater treatment. For in-situ recovery, Nano Beads, improves the extraction process by reducing power, water, and waste while delivering higher yields and improved purity. Their streamlined extraction process and small footprint enables deployment at the wellhead, eliminating the need for large centralized plants. Their current ISR deployment is in the recovery of uranium and this cohort expanded their media potential to other elements and introduced collaboration opportunities with other cohort members.

Draslovka

Draslovka demonstrated its glycine leaching technologies to extract lead and silver.

Draslovka sought to utilise its glycine leaching technologies to extract economic value from lead concentrate, zinc concentrate and tailings. The aim was to clean the concentrate samples, extracting zinc from lead concentrate and lead from zinc concentrate, extract zinc, lead and silver from the tailings and finally, to extract silver from the concentrate samples. Draslovka had success extracting lead from zinc and silver extraction from the tailings sample. These findings on zinc and lead can be potentially applied to other similar elements.



EnviroGold are developing a process for metal recovery from sulphide mine tailings and smelter residues.

EnviroGold achieved strong metal extraction rates on targeted metals as well as significant sulphide reduction rates. When looking at lower-grade tailings, pre-concentration steps are essential to achieving feasible project economics. Iron removal is also critical to the process, as such EnviroGold are continuing to develop their Iron Beneficiation Process Technology.



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In-Situ Recovery Cohort

The TAD Joint Venture (JV) Collaboration

The TAD JV supports innovators, researchers, and established vendors by providing samples, funding, technical guidance, and opportunities for field trials at mining operations. By facilitating quick testing and learning, it offers innovators the feedback they need to accelerate their ideas. Current JV partners include Rio Tinto, Boliden, South 32, IGO with Eramet and Agnico Eagle recently joining the JV.

The cohort applied their technologies to various operations and challenges presented by the different JV members, allowing each member to take the resulting insights and be able to apply them directly to their own operations. This collaborative approach enabled a cross-pollination of ideas and solutions, providing tangible value across multiple contexts.

Several JV members have expressed interest in continuing further development work with some of these innovators to understand how these technologies can be leveraged to address multiple challenges.



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Accelerating innovation through collaboration

The cohort program fostered collaboration and highlighted potential synergies among several innovators with complementary technologies that continue to work together. While ISR is a long-term, transformational technology, many solutions identified within this cohort have the potential to add value to existing operations. For example, Ekion's technology could be used to extract value from tailings, MuonVision's technology could be adapted to monitor heap leaching and tailings dam performance, and Eden's fragmentation technology could be integrated into existing comminution processes to enhance operational efficiency.

Running a challenge through a joint venture is mutually beneficial for partners and innovators as it spreads the risk for the partners and provides opportunities for innovators to work on a wide range of problems, thereby accelerating the de-risking of their technology. Receiving support from technical experts at different organizations provides innovators with insights stemming from diverse backgrounds and operations.

Working with multiple partners helps find solutions for big-picture problems. The breadth and depth of their capabilities and experiences mean that novel ways of thinking can be applied to these challenges. The cohort demonstrated that through the development of novel technologies and, more importantly, the integration of these innovations together, will help to accelerate the development of ISR as an extraction method for mining. The value created through this program has not only advanced our understanding of ISR but also identified near-term opportunities for innovation and improvement within existing operations.

Think & Act Differently (TAD) is the welcoming face of BHP Innovation, finding people with the best technology solutions to support BHP's ambitions in delivering resources the world needs in innovative ways. We help innovators develop their technology and ideas, accelerating the creation of new options. TAD collaborates with partners across different ecosystems and looks to unlock value for BHP and our partners, with an innovation and technology portfolio that aims to deliver value today, tomorrow, and into the future. For more information go to www.thinkactdifferently.com

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