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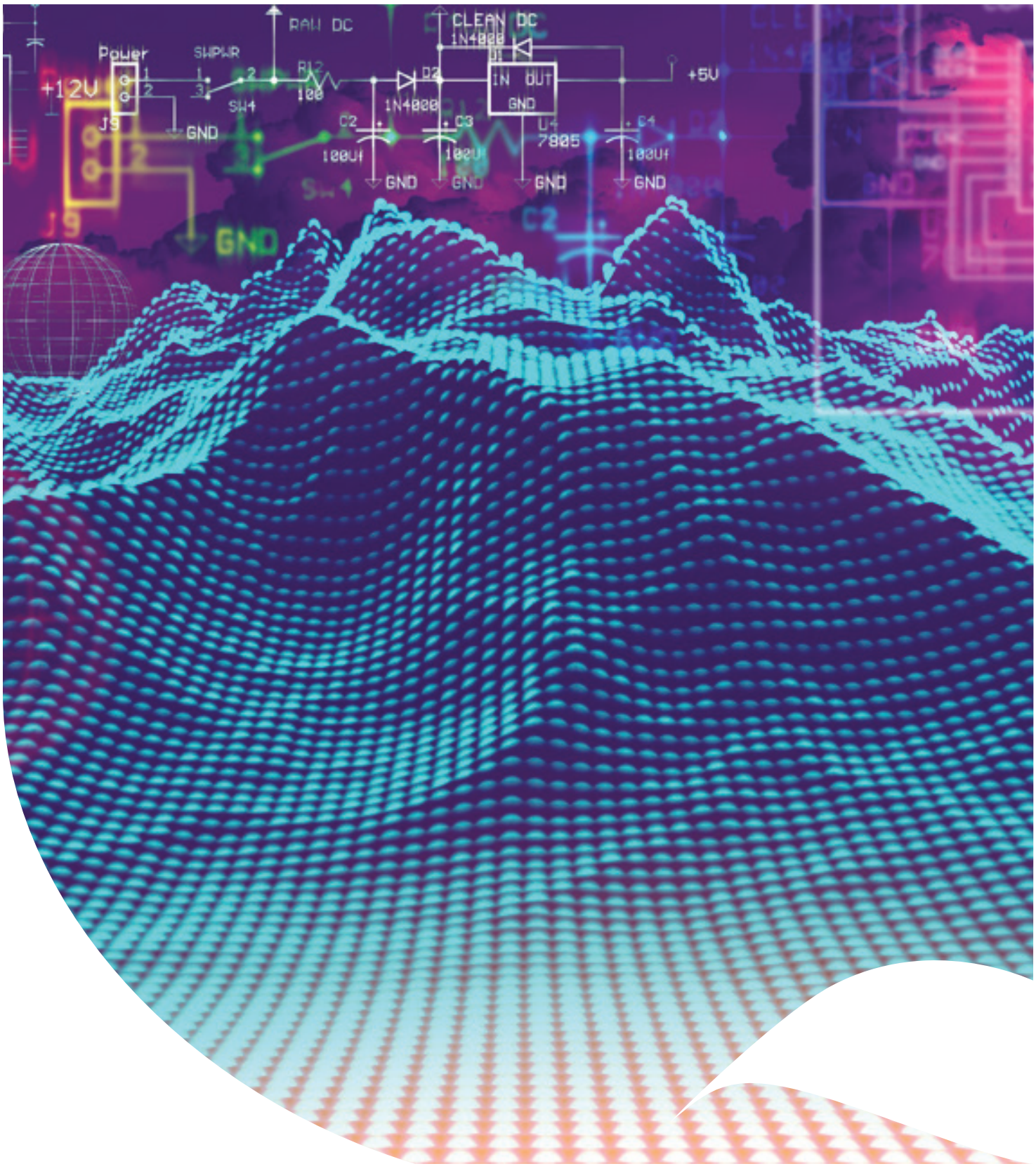
CREATE CHANGE

Sustainable Minerals Institute

Annual Report 2020



As society seeks to create a sustainable future, the global demand for minerals will continue to increase. At The University of Queensland's (UQ) Sustainable Minerals Institute (SMI) we are developing the people and the transformative approaches and technologies to ensure sustainability for the future.

The Institute's work is transdisciplinary, independent, impartial and rigorous. Our research integrates the expertise of production, environmental and social science specialists to deliver responsible resource development.

Julius Kruttschnitt Mineral Research Centre (JKMRC)

Minerals Industry Safety and Health Centre (MISCH)

The International Centre of Excellence in Chile (SMI-ICE-Chile)

W.H.Bryan Mining and Geology Research Centre (BRC)

Centre for Mined Land Rehabilitation (CMLR)

Centre for Social Responsibility in Mining (CSRM)

Centre for Water in the Minerals Industry (CWiMi)

JKTech Technology Transfer company

Strategic Progams

Unlocking Complex Orebodies

Development Minerals

Governance and Leadership

Transformational Learning

Transforming the Mine Lifecycle

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Message from the Vice-Chancellor and President

Despite disruption to both the resources and higher education sectors throughout 2020, The University of Queensland's Sustainable Minerals Institute (SMI) continued to advance the cause of sustainability through its commitment to research, industry collaboration and support for future leaders.

"The combined expertise and knowledge of its researchers ensures the international resources sector has access to impartial information across the mine life cycle..."

SMI has been a unique resource for the mining industry since its launch in 2001. The combined expertise and knowledge of its researchers ensures the international resources sector has access to impartial information across the mine life cycle, from exploration and mineral processing to environmental management, health and safety, and social responsibility. The Institute's impact has been elevated by the proactive approach it takes to engaging directly with the mining industry on these issues.

SMI's vision to train the next generation of mining leaders through postgraduate education and professional development was a major focus in 2020. Along with many other units throughout UQ, SMI showed incredible adaptability in maintaining, and even growing, its suite of professional development offerings during 2020. SMI's close working relationship with UQ's Institute for Teaching and Learning Innovation was key to that growth this year.

I congratulate the 17 HDR students who graduated from SMI in 2020, and I look forward to hearing about your future research and work within the mining industry to help create a sustainable future.

Thank you to SMI Director Professor Neville Plint and the experienced Senior Leadership Team he has built. Their flexible leadership and sincere commitment to the wellbeing of their teams has been critical to the Institute's success in 2020.

I would also like to extend my thanks to SMI's Advisory Board Chair Dr Charlie Sartain, whose ongoing support for UQ and service to the mining industry was recognised with an Honorary Doctorate in Engineering in 2019.

To the staff and students at SMI, thank you for all of your hard work and commitment. I look forward to seeing how SMI continues to build on its many successes in 2021.

Professor Deborah Terry AO

Vice-Chancellor and President
The University of Queensland

Message from the Director

In 2020 the team at the Sustainable Minerals Institute (SMI) prioritised the wellbeing of staff and students while continuing to deliver high impact work and build on our long-term strategy.

SMI is its people. Our staff and students are at the centre of everything we do – every project, every achievement, and every plan. That is why I am glad to write that, amid plenty of operational achievements, it is our caring and compassionate behaviour that made me most proud in 2020.

SMI's vision is to support the global transition towards sustainability by assisting the mining industry to advance leading practice. This can only happen if we support the next generation of industry and community leaders by providing them with a space where they are open, confident and healthy. Everyone, from our research students to our Senior Leaders, reflected that reality in 2020.

I was constantly impressed to hear about conversations between students and their supervisors, researchers and their team leaders, amongst our operational staff, and between our Senior Leaders. First and foremost, they reflected a sincere interest in their colleagues' wellbeing. This enabled us to transition quickly to alternative working arrangements when the time came.

2020 was also a stand-out year in terms of work delivered. SMI researchers were invited into prominent roles in the Australian Research Council Centre of Excellence for Enabling Eco-Efficient Beneficiation of Minerals and initiated the Collaborative Consortium for Coarse Particle Processing Research. They contributed material for the Global Industry Standard on Tailings Management, partnered in the development of the Cooperative Research Centre for Transformations in Mining Economies (CRC TiME), and were awarded ARC Linkage projects on the effectiveness of independent inquiries in mining as well as the eco-engineering of mine waste.

2020 was a record year for SMI publications - over 115 of our staff and students were involved in publishing journal articles, book chapters and research reports. Our commitment to a long-term strategy that emphasises depth of expertise within our Centres and breadth of expertise across our Strategic Programs made this possible.

In February 2020, new directors of SMI's Centre for Mined Land Rehabilitation and Centre for Water in the Minerals Industry, Associate Professor Peter Erskine and Associate Professor Claire Cote respectively, commenced. Their experience will be key to the continued growth of the Environment Centres. Experienced mining industry executive and policymaker Susan Johnston was also appointed to lead the Governance and Leadership Program

Although 2020 was challenging, our successes in supporting our people and building our Centres leave me confident that the coming years will see SMI continue to grow.

I would like to thank our staff and students for the contributions and energy they brought to the Institute and, as an extension of that, I would like to sincerely thank their family and friends for providing them with invaluable support.

The SMI Advisory Board deserves our thanks for the industry, government and civil society insights and advice they have shared throughout the year. In particular, SMI Advisory Board Chair Charlie Sartain ensured there was always an open channel to connect with the Board. I welcome the Board's new members and look forward to their contribution to SMI's future goals.

I would also like to highlight the contribution, guidance and support of UQ's Provost Professor Aidan Byrne.

Finally, I would like to thank UQ Vice-Chancellor and President Professor Deborah Terry AO for her contributions to UQ and her support and interest in SMI.

Professor Neville Plint

Director, SMI
The University of Queensland

Message from the SMI Advisory Board Chair

The Sustainable Minerals Institute (SMI) responded to the unprecedented challenges of 2020 with innovation, flexibility and compassion; putting people first while continuing to grow a strong portfolio of applied research projects.

In 2020, Senior Leadership Teams from across the resources and education sectors were given the difficult task of managing the disruptions and risks created by the COVID-19 pandemic. Resilience and thoughtfulness defined both sectors' responses, and I am glad to say that is particularly true for SMI.

The Institute was proactive in embracing alternative means of working to protect the health and wellbeing of its staff and students while also maintaining its consulting, professional development and research. Because of this, I believe the Institute is well positioned to continue its multi-year growth trend and take advantage of the upturn the resources sector is now experiencing.

Examining a research institute's portfolio of new projects is one of the best ways to judge its success, and SMI certainly delivered in that regard in 2020. From projects covering the eco-engineering of mine waste and the development of water management tools to research looking at coarse particle processing solutions and the health and safety ramifications of automation, SMI's seven Centres delivered a significant range of work given the circumstances. The Advisory Board was also particularly pleased to see the substantial advances in a number of important collaborative cross-disciplined strategic research programs, notably Complex Orebodies, Development Minerals and Governance and Leadership.

At the core of this research has been deep collaboration with industry partners, both old and new. Anglo American, Rio Tinto, Newcrest Mining, Newmont, Aeries Resources, Hudbay Minerals, BHP, Mitsubishi and Whitehaven Coal are just a few of the companies SMI researchers have been working with. SMI's central role in several industry-academia consortia, such as the Collaborative Consortium for Coarse Particle Processing Research and the Social Aspects of Mine Closure Research Consortium, also reinforced its ethos of industry engagement.

A growing emphasis on the environmental, social and governance aspects of the minerals industry has also reaffirmed the key role of independent research organisations like SMI. As companies revisit policies in a range of areas, such as cultural heritage management, being able to access past learnings, share new information and conduct science-based research is vital to assist the industry in addressing society's key sustainability challenges . Equally profound are the increasingly demanding expectations from the investor community and government. SMI is very well equipped to respond to this trend through its research, consulting and professional development activities in the space.

I'd like to thank SMI Director Professor Neville Plint for his energetic and inspirational leadership, which ensured the Institute navigated 2020 safely and successfully.

I would also like to thank my distinguished colleagues on the SMI Advisory Board, whose industry insight and experience enabled them to provide invaluable advice to the Institute's leadership team, staff and students.

And finally, I would like to extend my sincere thanks, on behalf of the Advisory Board, to the Executive of The University of Queensland for its enduring support of SMI, which continues to be a crucial factor in initiating strategic research projects and maintaining momentum on key programs during difficult times.

Dr Charlie Sartain

SMI Advisory Board Chair
The University of Queensland

SMI Advisory Board Members

SMI's Advisory Board benefits from decades of mining industry experience to provide advice and guidance on the strategic direction of SMI to the Director and The University of Queensland.

In 2020, the Advisory Board welcomed Mr Michael Wright, Mr Michael Wilson, Mr Andrew Kennedy, Mr Andrew McClelland, Mr Michael Holmes, Ms Bobbie Foot and Ms Rebecca Perrett.

- Professor Aidan Byrne, Provost, The University of Queensland
- Mr Andrew Kennedy, Group Executive, Legal, Sustainability and Government Relations, Newmont Goldcorp Australia
- Mr Andrew McClelland, Group Head Processing, Anglo American plc
- Ms Bobbie Foot, Co-Chair, Minerals Industry Safety and Health Centre Advisory Board
- Dr Charlie Sartain, Chair
- Adjunct Professor Christine Charles, Chair, Centre for Social Responsibility in Mining Advisory Board
- Mr Frans Knox, Head of Production, BMA
- Mr James Purtill, Director-General, Department of Natural Resources, Mines and Energy
- Mr Michael Holmes, President and CEO, OceanaGold
- Mr Michael Wilson, General Manager Health, Safety, Environment & Security, Newcrest Mining Limited
- Mr Michael Wright, Executive Chairman, Thiess Pty Ltd
- Mr Mick Wilkes, Independent Member
- Professor Neville Plint, Director, Sustainable Minerals Institute
- Mr Paul Dowd, Independent Member
- Mr Peter Forrestal, Chair, Production Centres Board
- Mr Peter Roe, Chair, SMI-Environment Centres Advisory Board
- Ms Rebecca Perrett, Co-Chair, Minerals Industry Safety and Health Centre Advisory Board
- Adjunct Professor Roger Higgins, Independent Member
- Mr Troy Hey, Executive General Manager – Stakeholder Relations, MMG Limited

SMI Senior Leadership Team

Professor Neville Plint
Director

Melissa Glendenning
Deputy Director
(Operations)

Professor Alice Clark
Deputy Director
(Strategy)

Professor Deanna Kemp
Director, CSRM

Brett Garland
Director, MISHC

Associate Professor Claire Côte
Director, CWiMI

Associate Professor Peter Erskine
Director, CMLR

Professor Rick Valenta
Acting Director, JKMRC
Director, BRC
Program Leader
Complex Orebodies

Professor David Mulligan
Director, SMI ICE-Chile

Susan Johnston
Program Leader
Governance and
Leadership in Mining

Professor Daniel Franks
Program Leader
Development Minerals

Professor Anna Littleboy
Program Leader
Transforming the Mine
Lifecycle

Professor Robin Evans
Program Leader
Transformational
Learning

SMI Snapshot 2021

Current staff (FTE)
129 staff in total
90 academic
39 professional

Gender diversity
66 female
63 male

Leadership
50% of the 2021 Senior Leadership Team are female

Current students
84 enrolled
35 female
49 male

2020 Funding
$25m

Student diversity
50 domestic
34 international

Equity and Diversity

The diversity of our staff and student populations contributes to innovation and excellence in our research, teaching and learning endeavours, and marks UQ as an internationally leading institution.

By practising the principles of equity, diversity and inclusion at SMI, we seek to create a vibrant and inclusive environment that allows ideas to flourish, people to be empowered and our community to grow.

During 2020, SMI developed an implementation strategy for UQ's Reconciliation Action Plan (RAP).

SMI is committed to creating further opportunities with and for Aboriginal and Torres Strait Islander peoples as potential HDR students and as staff. Likewise, Aboriginal and Torres Strait Islander peoples who work for industry and those who have an interest in the sector, will be welcome as part of the SMI's broader network.

Research Highlights

$30m to help regional communities find sustainable post-mining future

A national consortium led by The University of Queensland and University of Western Australia secured $30 million from the Federal Government to help regional communities transition to a sustainable future after their local mines have closed.

The funding forms part of a total 10-year investment of $135.4 million supporting mining communities to create sustainable community and development opportunities.

The consortium has formed a Cooperative Research Centre on Transformations in Mining Economies (CRC TiME) with hubs in both Queensland and Western Australia.

Former UQ Vice-Chancellor and President Professor Peter Høj said that with several large mines reaching the end of production within the next 10 years, both states had pressing motivation to find new futures for former mining communities.

"There has been a shift in thinking about mine closures and there is growing recognition that the end of a mine's life should be the start of something new," he said.

"CRC TiME will work directly with our industry partners and communities to support sustainable development opportunities post mining."

CRC TiME brings together 75 partners including BHP, Rio Tinto, Deswik, Decipher, the State Governments of Western Australia, Queensland and the Northern Territory, as well as researchers from eight universities and the CSIRO.

UQ's Sustainable Minerals Institute and CRC TiME's Research Director Professor Anna Littleboy said the Centre is expected to provide more than $2.4 billion of benefit by approaching closures as an agent for regional development.

"Rather than discussing mine closure as the end game, this project will bring industry, communities and governments together to provide new knowledge to help balance environment, economic and social outcomes and deliver regional aspirations after mining " she said.

CRC TiME's Chief Executive Officer, Dr Guy Boggs from UWA and the Western Australian Biodiversity Science Institute, said Australia's mining boom had contributed greatly to wealth and living standards, but an increasing number of projects were approaching closure.

"We have the potential to create hundreds of new opportunities and regional jobs by implementing restoration activities and increasing the supply of closure and post-closure products and services," he said.

Breaking critical barriers in red mud rehabilitation

The Centre for Mined Land Rehabilitation (CMLR) secured over $1.2 million in government and industry funding for research on the eco-engineering of mine waste into useful soil.

Led by Professor Longbin Huang, the project *Breaking critical barriers in soil formation of bauxite residues* received $777,000 from the Australian Research Council's (ARC) Linkage Program, and industry partners Rio Tinto Aluminium's Yarwun Refinery and Queensland Alumina Limited (QAL) contributed an additional $520,000.

CMLR researchers have been working with Yarwun and QAL since 2018 to develop the technology for rehabilitating the waste also known as red mud.

Professor Longbin Huang said the new project would build on their recent breakthroughs.

"While we have made substantial progress in developing field processes to engineer red mud into useful soil at Gove and QAL red mud dams, this new funding allows us to understand the underpinning science for improving the technology's scalability and operability under different field conditions at other refineries across Australia," Professor Huang said.

"Alumina refineries in Australia and overseas are facing enormous environmental and economic challenges in rehabilitating red mud as conventional methods to develop sustainable ecosystems are very expensive.

"Currently, billions of tonnes of bauxite residues or 'red mud' are being stored in dams at alumina refineries worldwide.

"Large amounts of caustic soda and alkaline minerals remain in the red mud, making it difficult to overcome the extremely alkaline and salty conditions in the short-term.

"This new research aims to understand the fundamental processes to break barriers of persistent and reversible alkalinity and salinity in red mud within a short time frame, and improve the reliability and operability of the new technology - which has been the biggest obstacle to many decades of efforts to rehabilitate the vast areas of red mud landscapes worldwide.

"If successful this research would significantly impact the economic and ecological sustainability of the alumina industry in Australia," he said.

Australia is the world's second largest alumina producer accounting for around 20% of global production. Queensland alumina refineries generate an annual revenue in excess of $6 billion.

The ARC Linkage research team brings together expertise from across UQ including the School of Chemistry and Molecular Biosciences and the School of Agriculture and Food Science as well as CMLR.

Public lessons, private interests: Do inquiries promote industry change?

The Centre for Social Responsibility in Mining (CSRM) was awarded funding from the Australian Research Council's Linkage Program to lead research into the role and effectiveness of independent inquiries in mining.

The project brings together experts from UQ, the Australia National University (ANU), gold mining company Newmont, and leading international NGO RESOLVE.

Professor Deanna Kemp, Director of CSRM, who leads the project said there had been an increase over the past decade in the number of companies commissioning independent inquiries, as a means of responding to major issues and community grievances.

"Mining companies are facing increased public scrutiny over the social and environmental impacts of resource extraction and as a result a number of companies have initiated inquiries and ceded control over the process and the outcome. But little is known about their governance arrangements or whether they drive change," she said.

"Large-scale mining developments are complex: they straddle national boundaries, economies and cultures, and intersect with the rights, interests and worldviews of different groups, in unique and often problematic ways.

"These circumstances are bound to raise issues that are difficult to resolve, and these inquiries may offer a potential pathway forward.

"The award from the ARC allows us to investigate the utility of these inquiries for different stakeholder groups and also draw on lessons learned in conventional government led commissions of inquiry.

"It will define a set of principles, guidelines and pre-conditions for conducting inquiries that achieve meaningful change."

Newmont Senior Vice President of External Relations Nick Cotts said public inquiries have been very helpful for Newmont to gain an independent perspective of some challenging situations and provide useful guidance and direction.

"We are excited to partner with SMI and RESOLVE to better understand inquiry processes and how they can be designed to deliver better outcomes," he said.

RESOLVE's President and CEO, Stephen D'Esposito said the project was an opportunity to take a fresh look at the inquiry process.

"We've participated in, designed, and led independent inquires. In that role we've seen public benefits as well as challenges and shortcomings," he said.

"SMI can help us pull back, take a wide lens view, and ask, what's working, for all stakeholders."

Collaborations and Partnerships

Industry and academia partner on new sustainable mineral processing technologies

The Julius Kruttschnitt Mineral Research Centre (JKMRC) championed the push towards more sustainable minerals processing with prominent roles in two new initiatives, the Australian Research Council (ARC) Centre of Excellence for Enabling Eco-Efficient Beneficiation of Minerals and the Collaborative Consortium for Coarse Particle Processing Research (CPR).

The federally-backed $35 million ARC Centre of Excellence aims to achieve a step-change in mineral processing by doubling energy and water productivity and reducing the amount of high value metals lost during processing by up to 90 per cent.

Under the CPR Consortium, JKMRC researchers are collaborating with representatives from Anglo American, Aeris Resources, Eriez Flotation Division, Glencore, Hudbay Minerals, Newcrest Mining and Newmont. They will tackle multidisciplinary aspects of coarse particle processing such as flotation, comminution, classification, and equipment design and process chemistry.

JKMRC Senior Research Fellow Dr Liza Forbes, who holds leading roles in the initiatives alongside Dr Susana Brito e Abreu and Associate Professor Kym Runge, said the mining industry needs to develop innovative and sustainable solutions.

"Research will focus on the core of minerals processing - particles size - and how coarser particles can increase robustness, efficiency, and speed of separation and, therefore, energy efficiency," Dr Forbes said.

"New methods of reducing tailings and maximising water recovery will also be developed, which will not only save energy and reduce the loss of high-value minerals but also significantly reduce the industry's environmental footprint."

SMI Director Professor Neville Plint said the initiatives were invaluable opportunities for Australia's mining sector to collaborate on building sustainable and leading capability in mineral processing technologies.

"Collaboration with industry, government and universities across disciplines is core to SMI because of its demonstrated success in developing innovative solutions," Professor Plint said.

"One of the most exciting aspects of the Centre of Excellence is it brings together experts from the country's leading universities, companies, and international research partners to advance sustainable mineral processing.

"The CPR Consortium also brings together depth and breadth of expertise and significant technical skill, and it shows the willingness of industry to work closely with university researchers to tackle complex problems and have an impact.

"In both of these areas the JKMRC is uniquely equipped to contribute through applied industry impact."

Newmont Director of Processing Dr Ronel Kappes said the company had identified Coarse Particle Recovery (CPR) as a key enabling technology to focus on, in order to improve future processing efficiencies.

"The UQ CPR Consortium project is an important step in technology development in order to leverage future CPR applications," Dr Kappes said.

Eriez Flotation Division's Dr Eric Wasmund said the company was pleased to be a founding sponsor of the Consortium.

"This consortium fits EFD's vision to enable sustainable technology solutions through strong customer partnerships," he said.

"As demonstrated by our leading-edge HydroFloat® technology, coarse particle flotation is a key disruptive technology for improving mineral recoveries, reducing power and water consumption and producing safer tailings."

Unlocking Queensland's rare earth elements

University of Queensland researchers are investigating more sustainable methods of extracting rare earth elements (REE) from Queensland's extensive deposits as part of a 4.5 year, $920,000 government-supported project.

Under the project a multi-disciplinary team from the Sustainable Minerals Institute (SMI), Faculty of Engineering Architecture and IT (EAIT), and School of Environmental and Earth Sciences (SEES) began working to bolster the capabilities of Queensland's increasingly important REE sector.

The project is part of SMI's Complex Orebodies strategic program and is supported by the Queensland Department of Natural Resources, Mines and Energy (DNRME) as part of its New Economy Minerals Initiative.

Complex Orebodies Program Leader Professor Rick Valenta said accessing critical mineral supply is vitally important for sustainable development.

"Our modern lifestyle and any hope we have for a low-emissions future are tied to the future supply of tongue-twisting rare earth elements like dysprosium, neodymium, and praseodymium", Professor Valenta said.

"Demand for REE has doubled since 2000 and is set to double again in the next ten years, but the current supply is alarmingly concentrated in areas vulnerable to being restricted.

"If this demand is to be met governments and industry will need to put resources into discovering new orebodies, improving the efficiency of mining and processing, emphasise the role of recycling, and re-examine social aspects of mining.

"SMI, in conjunction with its UQ and external partners, is uniquely placed to assist with this challenge due its multidisciplinary expertise and experience with applied research."

Dr Emma Gagen, Research Fellow at the UQ School of Earth and Environmental Sciences, said the project would help ensure future methods used to access REEs in Queensland are informed by research.

"The pathways from discovery to mining, extraction and sale are much more poorly understood for REEs than they are for more commonly-sought elements like gold or copper", Dr Gagen said.

"This project aims to give explorers a toolkit of extraction approaches for REE commodities which will allow them to better understand what they should be looking for in terms of ore grades, mineralogy and other important factors.

"The project will first look at the range of different known REE mineral styles in Queensland as they are currently known, in a component led by the SMI's W.H. Bryan Mining and Geology Research Centre.

"It will then use this knowledge as a basis to consider a range of extraction approaches, including innovative comminution and separation, hydrometallurgical extraction, geomicrobiological technologies and phytomining."

UQ School of Chemical Engineering Associate Professor James Vaughan said a multidisciplinary approach to the project is key.

"This project aims to give explorers a toolkit of extraction approaches for REE commodities which will allow them to better understand what they should be looking for in terms of ore grades, mineralogy and other important factors," he said.

"Rare earth elements are actually present in a wide range of ores and residues, and the challenge is to identify the feed materials that can be most efficiently processed into saleable products. This requires both geologists and metallurgical engineers to work together and to be seeking improved approaches."

SMI researchers contribute to the Global Industry Standard on Tailings Management

The Global Industry Standard on Tailings strengthened tailings management practices by integrating social, environmental, local economic and technical considerations across a facility's entire life cycle, wherever they are and whoever operates them.

The Standard was launched by the United Nations Environment Programme, the International Council on Mining and Metals, and the Principles for Responsible Investment in August 2020.

It was the result of a Global Tailings Review chaired by Dr Bruno Oberle and supported by an expert panel that included Centre for Social Responsibility in Mining Director Professor Deanna Kemp as a community and human rights specialist.

Professor Kemp was also one of six SMI researchers who contributed to chapters in the Standard's accompanying compendium.

"I was honoured to be part of the Global Tailings Review's expert panel, and to work with the Independent Chair, the multi-stakeholder Advisory Group, and industry, to formulate the Standard.

"The Global Tailings Review was a very urgent and rapid process that still focused on dialogue and achieving consensus between the co-conveners – in this sense no one party 'owned' the process.

"The chapters written by SMI researchers in the accompanying volume, Towards Zero Harm: A compendium of papers, demonstrate our commitment to bringing knowledge to bear on the most contemporary industry challenges.

"Professor Rick Valenta, Professor Daniel Franks, Professor Anna Littleboy, Robin Evans, Emeritus Professor David Brereton and I explore important environmental, social, governance and technical aspects of tailings management.

"Professor David Williams from UQ's School of Civil Engineering also contributed a chapter on the role of technology and innovation in improving tailings management.

"The compendium isn't there to simply explain the Standard but offers a broader examination of key issues that were beyond the scope of the Standard.

Global Tailings Review Independent Chair Dr Bruno Oberle said the Standard was an important step towards the goal of achieving zero harm from tailings.

"The catastrophic dam collapse at Vale's Córrego de Feijão mine in Brumadinho was a human and environmental tragedy that demanded decisive and appropriate action to enhance the safety and strengthen the governance of tailings facilities across the globe.

"I am particularly pleased to deliver a document which reflects and addresses the complexity and multi-disciplinary nature of sound tailings management.

"It is my hope that the Standard will be supported by an independent body that can maintain the quality and further refine and strengthen the Standard over time."

UQ and Curtin collaborate with industry on new online mining course

The University of Queensland (UQ) and Curtin University developed a new Professional Certificate Program that is increasing understanding of the modern mining industry in Australia and opening pathways to postgraduate study for people currently working within the industry.

The Foundations of Modern Mining Program is sponsored by the Minerals Council of Australia (MCA) and consists of six courses available globally via the edX platform.

Senior staff from UQ's Sustainable Minerals Institute and School of Business as well as Curtin University's Western Australian School of Mines (WASM) will teach the courses.

SMI Director Professor Neville Plint said he was delighted the Institute was partnering with Curtin University and leveraging the expertise across the two institutions.

"The education landscape is changing rapidly, and this new Professional Certificate is an excellent example of a more flexible approach," Professor Plint said.

"It provides pathways to allow people to upskill to meet new demands for the mining workforce in a rapidly changing context."

Associate Professor Chris Rawson, Dean of Learning and Teaching for Curtin's Faculty of Science and Engineering, said the new Program would help learners up-skill within their current role and improve their understanding of the sector.

"The mining industry within Australia is constantly evolving and it is important to keep track of emerging technologies and modern techniques that are being used by mining companies and affiliated professions," Associate Professor Rawson said.

"This new program gives participants a better understanding of key aspects of modern mining including the business of mining, mining operations, the digital transformation of mining, sustainability, leadership and diversity, and health, safety and wellness."

MCA's Chief Executive Officer, Tania Constable, said providing flexible, high quality education and training was crucial to building the minerals workforce of the future.

"Support for this certificate course is part of a long-term substantial investment by MCA member companies to ensure the quality supply of Australian graduates for the mining industry," Ms Constable said.

"Effective, collaborative partnerships across industry, universities, government and the community are essential to reinvigorate learning pathways, student experiences and outcomes to attract and engage diverse talent."

Completion of the Professional Certificate will provide an entry pathway into Postgraduate Certificate courses at both universities.

Driving innovation in mining and mineral processing

The Julius Kruttschnitt Mineral Research Centre (JKMRC) and UQ Holding company JKTech integrated their activities under one management structure to enhance the consulting and research functions of both organisations.

JKTech Board Chair Dr Barry Kelly said the unified management structure would strengthen the ability to develop solutions across the mining value chain.

"The link between research and consulting is very important and this integration will ensure our clients are receiving the benefits of new research, expertise in technology based consulting, laboratory services, software, specialist equipment, and professional development," he said.

SMI's Director Professor Neville Plint has been appointed Managing Director of JKTech in addition to his SMI role.

He said the move would benefit the researching, testing and product delivery to clients.

"SMI's goal is to provide solutions to the challenges facing our research and industry partners in the resources sector," he said.

"Bringing together the teams in JKTech and JKMRC helps us drive innovation and continue to provide mining and metallurgy research and consulting services worldwide."

JKMRC was established at The University of Queensland in 1970 and is an internationally recognised minerals and mining research centre with strong industry partners and a successful PhD student program. In 2000 it became part of UQ's newly established Sustainable Minerals Institute.

JKTech opened in 1986 as the commercial division of JKMRC. It became an incorporated company in 2001, wholly owned by UQ Holdings Pty Ltd.

The teams in both organisations maintained a close working relationship over the years, but this announcement sees a return to a single management structure whilst preserving JKTech's corporate and technical identity.

Industry research funding to investigate the human aspects of mining automation

The Minerals Industry Safety and Health Centre (MISHC) secured industry funding to ensure improvements to safety and health accompany increased system automation.

The funding is supporting several projects as part of MISHC's Human Aspects of Mining Automation research program, led by Professor Robin Burgess-Limerick, and involves researchers from across The University of Queensland.

BHP Mitsubishi Alliance (BMA) is contributing $300,000 and Whitehaven Coal, as part of an enforceable undertaking, is contributing $225,000 to a multi-year collaborative research consortium initially focussed on four priority human aspects of automation topics: risk analysis; human-centred design; training; and health.

Professor Robin Burgess-Limerick said the funding would ensure automation improves safety as well as productivity.

"Australia is at the forefront in the automation of mining equipment, with approximately 40% of all automated fleet installations globally," Professor Burgess-Limerick said.

"It's likely that automation will be a net benefit for safety and health because people are being removed from hazardous areas, however, to ensure that is the case, systems need to be designed with people's capabilities and limitations in mind."

BMA Head of Production Frans Knox said the research would help BMA further build upon their current health and safety processes.

"Our workforce is fundamental to mine automation and their safety remains our number one priority. This includes their health – both mental and physical – so it is critical that we invest in understanding how our workforce can interact with these new systems in the safest and healthiest way," he said.

Autonomous haulage is in use at BMA's Goonyella Riverside mine and will soon be introduced at Daunia.

"We are seeing some early positive signs from our Goonyella Riverside operation who are at the beginning of their automation journey. Their performance to date continues to build further confidence in the safety case for autonomous haulage."

SMI partners with industry to tackle water supply concerns in Chile

The Sustainable Minerals Institute's International Centre of Excellence in Chile (SMI ICE-Chile) announced it is partnering with Mitsubishi Corporation subsidiary M.C. Invesiones Limitada (MCI) to provide Chile with sustainable water supply system planning tools.

The 'smart' tools will assist in designing optimised water supply systems that minimise economic costs and environmental impacts by taking into account local contexts and conditions.

Water consumption across most sectors in Chile is increasing and availability is declining, causing concerns for continued industrial productivity, ecosystem health and society in general.

SMI ICE-Chile researchers will lead the three-year project in close collaboration with MCI, colleagues across SMI and local partners in Chile.

SMI ICE-Chile Sustainability Leader Dr Doug Aitken said the tools would be key to ensuring the sustainability of water management.

"Both the Sustainable Minerals Institute and M.C. Inversiones see water scarcity and sustainable water resource management as an enormous challenge for the future of Chilean industry and society.

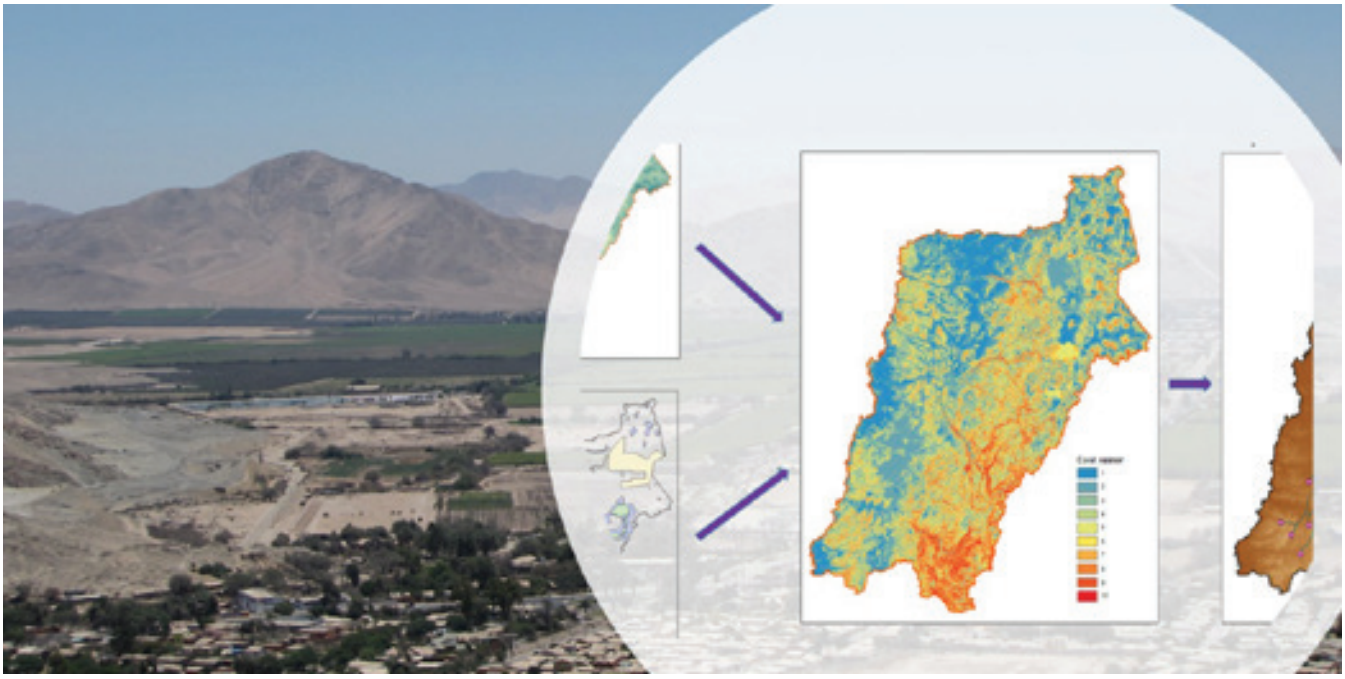
"New smart tools that identify opportunities and support decision making have a huge amount of potential to unlock optimizations across many important sectors."

SMI ICE-Chile Executive Director Professor David Mulligan said he was looking forward to working with the team at Mitsubishi

"Our partnership with the Mitsubishi Corporation is a very exciting step towards helping address Chile's water resource management challenges and we are looking forward to working with their team in Chile to develop solutions and open up new opportunities."

M.C. Inversiones Chief Executive Officer Mr. Tadashi Mizuno welcomed the opportunities of the research partnership.

"We are delighted to begin collaborating with UQ's SMI ICE-Chile on this project which we believe will support the development of important solutions to address the challenge of water scarcity in Chile, and also contribute to the sustainability agenda of the mining industry, a sector in which we have been actively participating," he said.



Planning for post-mining land use in regional Queensland

A multidisciplinary research team from SMI has partnered with the mining industry to support post-mining land use planning in the Bowen Basin's Moranbah region ahead of a wave of forecasted mine closures.

After completing both a technical assessment of the region's environment and a socio-economic baseline assessment, researchers mapped the suitability of the region for post-closure alternatives – ranging from agriculture to tourism - and the potential for collaboration between stakeholders.

The project was funded by Anglo American, BHP and the International Council on Mining and Metals (ICMM), with in-kind support from Peabody. It is a pilot for a larger, state-wide mine rehabilitation and closure collaboration project commissioned and funded by the Queensland Resources Council and ICMM.

Centre for Water in the Minerals Industry (CWiMI) Director and Project Lead Associate Professor Claire Côte said the pilot project illustrates a systematic pathway to explore potential land use alternatives after the mines close.

"The viability of mining regions is not only shaped by population size and annual economic outputs, but also by a resilient mix of industries, which means economic alternatives for mining communities need to be explored," Associate Professor Côte said.

"Many of Queensland's major mining regions, particularly those associated with coal, may face serious ramifications from cumulative mine closures unless there is early established, collaborative and forward-thinking post-mine planning.

"Moranbah demonstrates the vulnerability of mining regions; the resources sector is of vital importance in the region employing just short of 40% of the population and yet we expect over twenty mining operations will reach the end of their life in the next few decades.

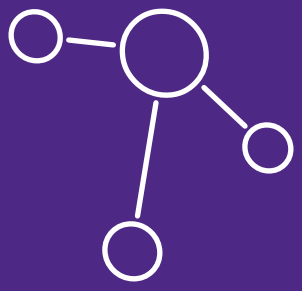
"Our study combined multidisciplinary talent from across SMI, industry data and deep research to produce a report that will provide companies with clearer understanding of technical and social suitability of the region for multiple post-mining alternatives."

Centre for Social Responsibility in Mining (CSRM) Research Fellow Dr Kamila Svobodova led the team studying the social aspects of post-mining land use in Moranbah and said understanding the composition and balance of regional assets and constraints is key for resilient, long-term planning.

"Besides the region's development goals, regulatory frameworks and multi-stakeholder priorities, we mapped collaborative potential and collaborative opportunities and suggested criteria for recognising promising collaborative initiatives across the Moranbah region," Dr Svobodova said.

"Even though collaborative projects have the advantage of fitting well with mining's social performance strategies and government budget approaches, there are no short-cuts to building the essential cross-sector collaborations. It requires creating stable and long-term relationships characterized by common goals, open and frequent communication, shared risk, resources and power.

"This project represents an innovative step towards collaborative closure planning and post-mining regional development in Australia in general, and Queensland in particular, acknowledging the importance of being strategic, inclusive and collaborative in undertaking long term planning at the regional level."



Centre Reports

Julius Kruttschnitt Mineral Research Centre

In 2020, the JKMRC enhanced its capabilities by integrating with JKTech and welcoming the High Temperature Processing (HTP) Program. The team also continued to secure a strong core of collaborative projects with industry and university partners.

The Centre's integration with JKTech in June of 2020 strengthened consulting, research and product commercialisation and delivery. JKTech assists mine sites to achieve future production targets through advisory services and training and has historically worked closely with JKMRC, but their integration will take that cooperation to the next level.

JKMRC also expanded the breadth of its in-house research expertise with the addition of a new program - the HTP Program. The Program's five staff and nine students, who were originally embedded in UQ Chemical Engineering, moved their award-winning research on the processing of ferrous and non-ferrous metal productions to the JKMRC to reinforce the Centre's value-chain-spanning mineral processing expertise.

The strength of the JKMRC's industry relationships and expertise were demonstrated with the success of the Collaborative Consortium for Coarse Particle Processing Research, which launched with the aim of tackling multidisciplinary aspects of coarse particle processing.

JKMRC researchers hold key positions in the five-year Consortium, alongside representatives from Anglo American, Aeris Resources, Eriez Flotation Division, Glencore, Hudbay Minerals, Newcrest Mining and Newmont.

JKMRC's new Mill Filling Prediction Tool, a soft sensor that provides information about the mill's contents and enables it to be controlled closer to its maximum capacity, was installed at a number of sites throughout the year, reflecting growing interest from industry.

A new project to improve efficiency and productivity through the use of Semi-inverted hydrocyclones after a JKMRC study demonstrated the technology's improved classification efficiency compared to conventional hydrocyclone designs.

As part of the five-year partnership agreement with Newcrest Mining, Bellson Awatey was appointed as JKMRC's Newcrest Research Fellow, with responsibility for coordinating the collaborative projects between the two organisations.

The Julius Kruttschnitt Mineral Research Centre (JKMRC) is a world-class provider of postgraduate education and innovative applied research in mineral processing and geometallurgy.

Centre Director

Professor Rick Valenta

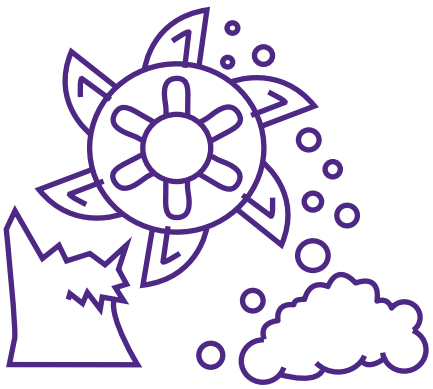
Research Groups

Avanced Process Prediction and Control Program (APPCo), lead by Associate Professor Mohsen Yahyaei

High Temperature Processing Program (HTP), lead by Dr Xiaodong Maa

Mine Energy Transformation and Intergration, lead by Associate Professor Marcin Ziemski

Seperation Program, lead by Associate Professor Kym Runge



W.H. Bryan Mining and Geology Research Centre

In 2020, the BRC substantially expanded its portfolio of long-term research projects, developed its expertise with the addition of new researchers and grew its industry presence through a number of knowledge-sharing initiatives.

The Centre's collaborations with government continued to grow in 2020. In Queensland, projects under the Department of Resources' New Economy Minerals Initiative and Strategic Resources Exploration Program received particular focus. Contributions to the North-West Mineral Province Deposit Atlas and North-East Queensland Mineral Deposit Atlas, both valuable resources for regional explorers, continued to demonstrate the unique benefits of work in this space, simultaneously increasing industry knowledge and capability, and promoting the abilities of BRC researchers. The Centre also launched the first of three projects with the Northern Territory Geology Survey.

The BRC expanded its research and consultation work with major, mid-tier and junior companies. Over 20 new projects were confirmed with over 10 industry partners, including Anglo Exploration, Nexa Resources, OceanaGold, Grande Resources, Anglo American, Aeon Resources, Hammer Metals, Centrex Metals, Paladin Energy and Newcrest Mining.

The Total Deposit Knowledge Group worked across a range of fields in 2020, with partners from the mining industry and the state geological surveys, and other groups within the SMI and UQ. The outputs ranged from regional geological framework and exploration targeting studies to geometallurgical characterisation projects to improve ore sorting and process outcomes in both new economy and base metal operations.

Increased industry and government interest in mine waste characterisation led to the growth of the mine waste characterisation team and, ultimately, the launch of the Mine Waste Transformation through Characterisation group (MIWATCH) under Dr Anita Parbhakar-Fox in early 2021.

Momentum throughout the year was maintained by the addition of six experts in the areas of mine waste, hyperspectral imaging, geophysical modelling and data analysing.

Combined with several highly visible projects and an incredibly successful series of webinars, this expanded team enabled a new level of industry engagement. Researchers had 70 meetings with 42 separate industry representatives, 35 meetings with 20 separate government and not-for-profit groups; 16 meetings with 14 separate METS groups; and 4 meetings with investment funds.

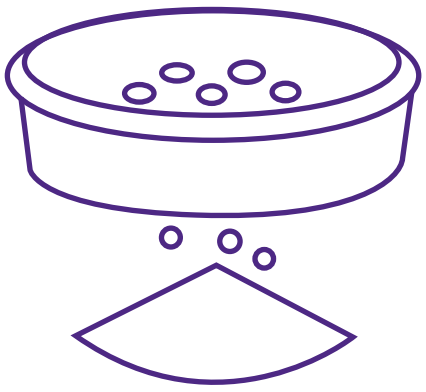
The W.H. Bryan Mining & Geology Research Centre (BRC) has a reputation for practical innovation and is focused on delivering industrial research solutions for active and future mines.

Centre Director
Professor Rick Valenta

Research Groups

Total Deposit Knowledge, lead by Associate Professor Paul Gow

Mine Waste Transformation through Characterisation, lead by Dr Anita Parbhakar-Fox



JKTech

A key outcome for 2020 was the integration of the activities JKTech and JKMRC under a single management structure to build a world leading mining and metallurgy research centre.

While JKTech continues to preserve its corporate and technical identity, the unified management serves to consolidate and strengthen both JKTech and JKMRC, and ensure clients receive the benefits of innovative research, expertise in technology-based consulting, laboratory services, software, specialist equipment, and professional development.

2020 was a challenging year for many businesses and at JKTech the consulting team worked hard to develop ways to provide expertise remotely.

Testing and laboratory services delivered on client projects throughout the year by implementing strict hygiene and physical distancing controls and the demand for JKTech tools and products remained solid.

JKTech continued with the ongoing development of the JK Value Based Ore Control ("JKVBOC") tool as well as the deployment of the platform into various mine site operations globally. JKVBOC is the company's most recent engineering tool to simulate and predict blast movement in open pit mining to make proactive decisions.

JKTech established an innovation fund to contribute cash funding toward JKMRC IP development and commercialisation activities.

They also set in place plans to establish a 'Corporate Sponsorship Program" for JKMRC students. These funds will be used to support PhD and/or other appropriate student experiences and initiatives. It is believed such a program will further enrich the student experience.

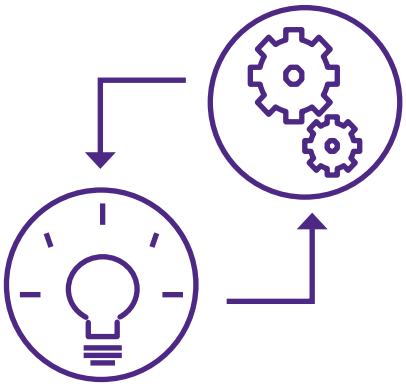
JKTech offers consultancy and laboratory services, specialist software and equipment, and professional development courses to help mining companies achieve positive and sustainable outcomes.

Managing Director
Professor Neville Plint

Chairman
Dr Barry Kelly AM

Non-Executive Director
Robert Hubbard

Operations Manager
Bevin Wong



SMI ICE-Chile

SMI ICE-Chile had a strong 2020 despite challenging circumstances within Chile, building collaborative relationships through internal and external engagement, securing new projects, and delivering value-adding outcomes for existing projects.

Staff responded to COVID-19 restrictions by refocusing on research able to be planned and executed remotely.

This workload included project-building in water and tailings management but also in the areas of cobalt recovery, safety culture, community dialogue, participatory monitoring, circular economy, clean technologies, and addressing climate change impacts.

A series of workshops on future scenarios and strategies for water and tailings management were delivered to CODELCO's División El Teniente in the first half of the year and then presented the final report to the broader CODELCO community in July. A second major project with CODELCO División Salvador, and involving CMLR, focusing on the impacts and opportunities of irrigating land for non-food crop production using tailings water commenced later in the year.

The Centre led the Solar Tailings Transformation project proposal submitted to the BHP Expande Tailings Challenge and was one of 10 teams (from over 150 globally) selected to participate in the Proof-of-Concept stage. The Centre was also a partner with a German consortium in the successful Recomine proposal.

The team collaborated on a successful proposal led by EBP Chile for a three-year study to develop climate-change resilient infrastructure for indigenous communities in Tarapacá that is supported by the BHP Climate Change Resilience Fund and Fundación Chile's Global Ventures.

In collaboration with CWiMI, the Centre commenced a major three-year project with M.C. Inversiones, a subsidiary of Mitsubishi Corporation, to provide Chilean industries and society with sustainable water supply system planning tools.

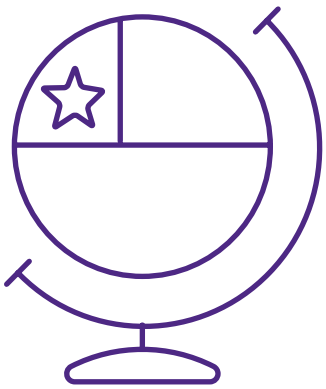
In addition to the above projects, SMI ICE-Chile helped evaluate company-communities agreements in northern Chile's lithium mining precincts; completed a series of climate-change impact maps for the mining industry with CWiMI and local partners; commenced a project with BRC on smelter waste reuse options with Nexa Resources in Peru; completed the first stage of a project with Anglo American on the impacts of recycled water on process plant performance with CWiMI and JKMRC; completed the initial stage of a project with CSRM related to the social aspects of mine closure with BHP Minerals America; and commenced site assessments with MISHC for a significant project with Antofagasta Minerals on safety culture.

The Sustainable Minerals Institute International Centre of Excellence in Chile (SMI ICE-Chile) aims to improve productivity and environmental and social performance of mining operations in Chile through a partnership model of innovative research, and technology development and transfer.

Executive Director
Professor David Mulligan

Research Leader
Dr Douglas Aitken

Senior Controller
Rodrigo Rivas



Minerals Industry Safety and Health Centre

2020 was a year of growth for MISHC, with an expanded team set to ensure the Centre has increased capacity to address industry needs while delivering high quality research and consultancy.

Three new early career researchers joined MISHC in 2020 – Dr Ben Seligman, Philippa Dodshon and Nikky LaBranche – expanding the team's expertise in risk management and hazard identification, incident investigation and analysis, and dust particulates. The team also welcomed Sibanye Stillwater's Professor Kobus De Jager, Downer's Dr Matt Hancock and SIMTARS' Dr Gareth Kennedy as adjunct staff.

A new Advisory Board was launched under experienced industry Co-Chairs Bobbie Foot and Rebecca Perrett.

The Board members represent a range of commodities and perspectives and bring a wealth of insight and direction to MISHC.

The Centre also launched a research advisory group led by MISHC founder and respected operational risk management professional Professor Jim Joy.

Professor Robin Burgess-Limerick, Dr Danellie Lynas and Dr Andrew Hill, in collaboration with Professor Mark Horswill from the UQ School of Psychology, completed a pilot program to assess the hazard perception of contract workers for BMA. Additionally, Professor Burgess-Limerick's expertise in human aspects of automation resulted in the launch of related projects with BMA, Whitehaven Coal, and the US National Institute for Occupational Safety and Health, in conjunction with Prof Joel Haight at the University of Pittsburgh.

Research into whole body vibration led by Dr Danielle Lynas continues in collaboration with Dr Konstanty Bialkowski from the UQ School of ITEE through the installation of measurement equipment in earth-moving equipment at a Peabody mine in Central Queensland.

Professor David Cliff, a leading expert in mine fires and spontaneous combustion in coal, assisted major incident investigations at Anglo American's Grosvenor Coal Mine and Peabody's North Goonyella Mine

MISHC's education team of Associate Professor Carmel Bofinger and Sharyn Cobbin responded quickly to changing circumstances to ensure the Centre's courses could be delivered online. The team also designed and released the Risk and Critical Control Management and Incident Investigation and Analysis courses and reviewed and advised on improvements to the application of risk management on mine sites.

The year was capped with a highly successful hybrid event focused on knowledge sharing around mine dust and particulates, organised by Nikky LaBranche. Over 80 people attended in-person and over 100 online, including operational, executive and academic delegates.

The Minerals Industry Safety and Health Centre (MISHC) delivers risk management education, consultancy, and research to improve health and safety performance in the mining industry.

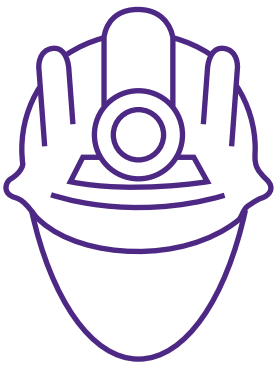
Centre Director
Brett Garland

Research Groups

The Human Aspects of Mining Automation, lead by Professor Robin Burgess-Limerick

Gaps in the Understanding and Management of Particulates, lead by Professor David Cliff

Health Safety and Risk Professional Development Managers
Associate Professor Carmel Bofinger and Sharyn Cobbin



Centre for Social Responsibility in Mining

In 2020, CSRM continued to develop its disciplinary expertise in the social sciences through high impact publications and industry collaboration, while expanding its multidisciplinary connections across SMI, UQ and global institutions.

Deepening and expanding the Centre's international network of stakeholders and partners was a priority throughout 2020.

New research partnerships were developed with the University of the Free State in South Africa and the University of Lincoln in the United Kingdom, while existing relationships with key stakeholders, such as RESOLVE and the Institute for Human Rights and Business, were strengthened.

These relationships were reinforced by the Centre's involvement in several established and emerging multi-party initiatives, such as the Global Tailings Review, commodity stewardship bodies, and the Social Aspects of Mine Closure and Resettlement Consortia. These initiatives continue to support cutting edge social research and provide a ready platform for communicating and ground-truthing the value of our research with diverse industry stakeholders. The Institutional investor community also showed more interest in the Centre's research.

Researchers applied for five ARC grant applications in 2020. These included one large linkage grant on the role and effectiveness of independent inquiries in mining led by Professor Deanna Kemp, and supported by Newmont and international NGO, RESOLVE. This grant was successful early in the year. CSRM also submitted two early career category discovery applications (DECRAs) led by Dr Eleonore Lebre and Dr Ruilian Zhang, and two future fellow applications lead by Associate Professor Nick Bainton and Professor John Owen.

2020 was an unprecedented year for CSRM's scholarly outputs, both in terms of quality, quantity and impact. Researchers hit new highs in journal metrics and received more attention and recognition in policy briefs and government reports.

Two senior appointments were made in 2020. Dr Vigya Sharma was appointed as Senior Research Fellow, with a focus on energy transitions and resource extraction, and mine closure. Dr John Burton was appointed as Principal Research Fellow, with a focus on developing online training offerings in social impact assessment and social mapping in extractive contexts.

The Centre retained a steady number of new Research Higher Degree (RHD) commencements (4 candidates) and completions in 2020, despite the impact of border closures on international enrolments and fieldwork.

The Centre for Social Responsibility in Mining (CSRM) is a leading research centre committed to improving the social performance of the global resource industry.

Centre Director
Professor Deanna Kemp

Leadership Team

Professor John Owen
Professorial Research Fellow

Associate Professor Nick Bainton
Principal Research Fellow

Dr Kathryn Sturman
Senior Research Fellow & Postgraduate Coordinator

Centre for Water in the Minerals Industry

In 2020 CWiMI committed to developing a strong future research strategy to guide the team's long-term activities while also engaging widely with industry representatives and funding bodies and delivering on existing projects. The broader approach of engaging industry to secure a pipeline of projects was successful.

Constant communication and planning ensured projects were not severely impacted by the COVID-19 pandemic, though organising field work in New South Wales, Australia proved difficult.

CWiMI researchers worked on three projects funded by ACARP and were successful in securing another beginning in 2022, and they will be leading three CRC TiME foundational projects and participating in an additional two.

CWiMI led a multidisciplinary team in a project to assess all potential options for post-mining land uses and proposing collaborative frameworks to achieve implementation of positive post-mining outcomes, funded by Anglo American, BHP, Peabody and ICMM. In 2021, this work will be extended to the whole of Queensland. The Centre's reputation within industry was also reinforced by a range of consulting studies for industry partners, including Idemitsu, Rio Tinto, and the BHP Mitsubishi Alliance.

In another demonstration of multidisciplinary strength, CWiMI joined CMLR, CSRM and SMI ICE-Chile for a project to design future scenarios for the management of dams, tailings and water resources in Chile, funded by CODELCO. CWiMI and SMI ICE-Chile also obtained funding for a project developing smart water supply systems in arid regions, sponsored by M.C. Inversiones, and for their contribution to the Climate Risk Atlas of Chile

CWiMI researchers began coordinating an international research team to assess water management approaches in Nickel mines in New Caledonia, identify potential for improvement and develop modelling procedures for the design of water management structures.

Within UQ, CWiMI continued to build on an already strong relationship with the Centre for Natural Gas (CNG). The two Centres secured additional funding from the Office of Groundwater Impact Assessment for the Groundwater Use Metering project in the Surat Basin project for the next three years and collaborated on The Great Artesian Basin project to produce the Special Issue Advances in hydrogeologic understanding of Australia's Great Artesian Basin in Hydrogeology Journal.

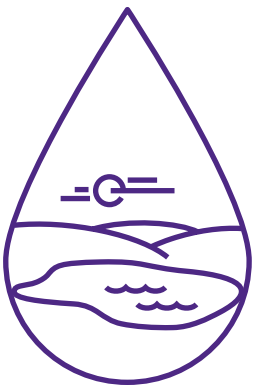
The Centre for Water in the Minerals Industry (CWiMI) is a leading research centre for supporting sustainable management of water in the minerals and energy industries.

Centre Director
Associate Professor Claire Côte

Professor Neil McIntyre
Regional Water & Land Resources Group Leader

Dr Robynne Chrystal
Operational Water Management

Shona Stevens
Environmental Leadership and Performance Manager



Centre for Mined Land Rehabilitation

In 2020 CMLR demonstrated the value of its expertise in environmental management to the mining industry through a stream of new projects and results. Careful planning ensured COVID-19 did not significantly affect critical lab work.

The Ecological Engineering of Mine Waste group launched several new projects in 2020. Particularly noteworthy is their successful bid for an ARC Linkage Project, Breaking critical barriers in soil formation of bauxite residues, which will run until 2024. The group also launched the 'Returning Ecosystem Resilience' project under CRC TiME and a project with Kirkland Lake Gold to develop cost-effective chemical engineering technology. Group member Dr Fang You received an Advance Queensland Industrial Research Fellowship 2020-2023, supported by the Queensland Government, Rio Tinto and Queensland Alumina Ltd.

The Environmental Geochemistry Group commenced a project with Stanwell Corporation Limited on the beneficial reuse options for coal combustion products, Under it, they began investigating the potential economic value and beneficial uses of using coal combustion by-products at Tarong power station to reduce the costs of ash dam rehabilitation. The March 2020 AMD Workshop and 2021 ICARD Conference were postponed due to COVID-19, but Group Leader Associate Professor Mansour Edraki, through his role as AMD Conference Chair, ensured the former was replaced by a AMD Short Course.

Phill McKenna's Testing the Resilience of Mine Site Rehabilitation with Fire project monitored four post-fire rehabilitated sites in Queensland and a controlled burn of over 60 hectares at a Central Queensland Mine.

Researchers collaborated with industry, government and academia under the CRC TiME project 'Transforming disparate approaches to remote sensing and monitoring to industry best practice'.

The project builds on CMLR's expertise in remote sensing by reviewing the best technology and practice available and articulating future approaches to environmental monitoring.

Ahead of Ranger uranium mine's closure in early 2021, CMLR was involved in the Commonwealth of Australia Ecosystem establishment and landform project 2020-2021, which aims to enhance the mine's sustainability criteria.

A new multidisciplinary research project, Project Ark, utilised expertise from CMLR, UQ's Science Faculty, the University of the Sunshine Coast and Southern Cross University to map the revegetation program on former phosphate mine Lady Elliot Island.

The Centre for Mined Land Rehabilitation (CMLR) addresses the environmental challenges of the minerals industry by translating scientific results into practices that improve mine rehabilitation and closure outcomes.

Centre Director:
Associate Professor Peter Erskine

Research Groups:

Ecological Engineering of Mine Wastes, lead by Professor Longbin Huang

Ecosystem Assessment, Restoration & Resilience, lead by Associate Professor Peter Erskine

Industrial Ecology & Circular Economy, lead by Associate Professor Glen Corder

Environmental Geochemistry, lead by Associate Professor Mansour Edraki

Strategic Program Reports

Complex Orebodies

The Complex Orebodies Strategic Program was established in 2018 and is led by Professor Rick Valenta.

The Program supports collaborative projects across SMI and the University and aims to understand and address the challenges associated with the unlocking of future mineral supplies. The challenges associated with this span environmental, social, governance and technical themes, and require interdependence and understanding between researchers from different discipline backgrounds.

Researchers within the Complex Orebodies Program have published 34 journal articles, including 3 papers in Nature Communications, and 6 conference papers. To date, 89 researchers from 15 UQ Schools and Centres have participated in the Program. As a result, it is of significant academic and industry interest.

During 2020, seed-funded projects continued to lead to the initiation of much larger solely industry-funded projects, including two projects aiming to develop new technologies to achieve better and more energy efficient processing of ore bodies.

A multi-year, multi-party collaborative research project into High Voltage Pulse technology has continued in conjunction with Newmont USA, Newcrest Mining and HUST University in China.

Work commenced on a multi-party Coarse Particle Processing technology collaborative research program with seven industry partners, seed funded through Complex Orebodies strategic funding.

Multidisciplinary research projects also continued to progress strongly in 2020, for example researchers from five UQ organisational units are working together to improve understanding of the mix of challenges relating to undeveloped ore bodies. The Complex Orebodies database considers multiple complexities in the resources sector - including legal, social, environmental, economic, geological, and waste considerations. This body of research has now attracted industry funding from two partners for 2021.

The Complex Orebodies program is in year three of its five-year, $5 million allocation of UQ funding, and is on track to exceed the external funding and cross-disciplinary participation targets envisaged at its outset.

Funding has been received from 26 external partners – with $7.8m committed by the end of 2020.

Governance and Leadership

The Governance & Leadership Strategic Program was established in 2018. In 2020, Susan Johnston was appointed Program Leader after Professor Daniel Franks was assigned to the new Development Minerals Strategic Program.

The Governance and Leadership Program supports the resources industry to operate in a manner that maximises mining's benefits to society and minimises its negative impacts, through advisory services, executive development, and research. The Program reinforces the importance of effective and substantive industry responses to environmental, health and safety, and social issues.

SMI and the Governance and Leadership team are uniquely positioned to progress research and practice in these areas due to strong connections with experts from across industry and academia. As well as drawing on talent from within SMI's seven Centres, the Program collaborates with thought-leaders at The University of Queensland's Schools of Psychology, Business and Law, other research institutions, and from the mining industry.

The Program's current focus is on the organisational hallmarks of high reliability; enhancing mining industry governance; and new approaches to diagnosis and measurement of organisational effectiveness in such areas as safety and health.

The Governance and Leadership team hosted a High Reliability Organisations (HRO) Forum early in 2021 with the support of Queensland's Commissioner for Resources Safety and Health, BHP and Anglo American. The Forum explored key practical issues including: the role of leadership in entrenching a culture of high reliability; implications for regulators; and measuring reliability.

Future focus areas for the Program include: governance of regional transitions in mining areas; identification and trialling of leading indicators, particularly of safety leadership, organisational effectiveness, and safety culture; and legislative and policy assessments and advice.

Development Minerals

The Development Minerals Strategic Program was established in 2020 and is led by Professor Daniel Franks.

The Program aims to improve sustainability and human development outcomes, and help realise the UN Sustainable Development Goals.

Development Minerals refer to minerals and materials that are mined, processed, and used domestically. They are crucial inputs for infrastructure, housing, road building, manufacturing and agriculture and support the livelihoods of millions of people working in domestic artisanal, small and medium sized businesses.

The Development Minerals research team undertake research, education and technical assistance projects. They collaborate across SMI and the University and are working with a wide range of international development partners to build capabilities and expertise in the local materials most important for local development.

Current partners include the United Nations Environment Programme, the United Nations Development Programme, the World Bank, Association of Women in Mining in Africa, the University of Geneva and Vale.

Example partner projects include: a scope of the feasibility of the adoption of low-carbon Limestone Calcined Clay Cement in the Pacific Region; development of the 'Stone for Development Work-Integrated Learning Program,' that provides placements for students to advance practical knowledge of sustainable development; and developing the DELVE Exchange, a global virtual network of artisanal and small-scale mining and quarrying associations.

Transformational Learning

The Transformational Learning Strategic Program was established and led by Robin Evans in 2018. It concluded in 2020, with Dr Elaine Wightman continuing its activities under SMI's Transformational Learning Group.

The COVID-19 pandemic resulted in a rapid switch to online delivery of professional development activities across the SMI. The principal focus of the Transformational Learning team was supporting Centres and Programs to develop and deliver material through UQ's online systems including the edX Edge platform and live Zoom sessions.

SMI has continued to actively engage with UQ's Working Group on Alternative Credentials, with the new Shorter Form Credential policy rolled out in 2020.

Significant progress was made on the Foundations of Modern Mining course, a joint project with Curtin University funded by the Minerals Council of Australia. UQ delivered two of the Massive Open Online Courses (MOOCs) on time, with the third scheduled as planned in 2021. Over a thousand participants enrolled in the first two courses, including a group of pilot testers from industry sponsors of the project.

New learning design approaches continued to be supported and deployed, particularly in blended learning programs being developed by CSRM but also in an online version of Professor Tim Napier-Munn's popular Comparative Statistics and Experimental Design course.

Work with international groups on various topics under the broad theme of mining governance and leadership was curtailed by travel restrictions, with five project proposals active at the beginning of the year put on hold.

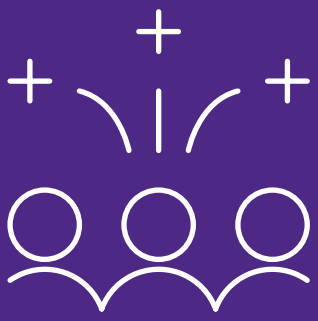
Transforming the Mine Lifecycle

Across its three-year life (2018 – 2020) the Transforming the Mine Lifecycle Strategic Program aimed to catalyse change and accelerate sustainability outcomes in resource rich regions by integrating interests and activities along the mine life cycle. The Program was led by Professor Anna Littleboy.

2020 focused on locking-in new research initiatives generated by the Program's integrated agenda. From a relatively small investment, significant new vehicles for integrated research have emerged with SMI positioned to take a central role in all of them.

The Program invested successfully in the development of a bid for a new Cooperative Research Centre on Transformations in Mining Economies (CRC TiME) through UQ funding. Launched in March 2020, CRC TiME is a public/private partnership led by UQ and the University of Western Australia that is investing $130 million over ten years into uniting stakeholders in the transition of mining regions through mine closure and into sustainable post-mining prosperity. It brings together more than 70 partners from industry, communities, research, suppliers and governments. This unique integrated research vehicle is now in its first year, with research direction provided by SMI's Professor Anna Littleboy.

Significant international consultation into the development of principles for a global consortium on research into mine tailings was undertaken and discussions held with AMIRA due to their experience running multiparty global initiatives. In 2020, AMIRA International started developing a major initiative around tailings, held a tailings muster and called for expressions of interest in being involved in a new major tailing's initiative. SMI researchers will continue taking this initiative forward.



Professional Development

Professional Development

SMI delivers a range of professional development options for the resources sector to increase specialist knowledge and skills. The Institute offers courses and masterclasses led by experts that connect participants with the latest research and best practice in health, safety and risk; social performance; mine site environmental management; and geology, mining and metallurgy. SMI also works with organisations to tailor programs that meet their specific needs.

In 2020, SMI strengthened its commitment to providing professional development with the delivery of over ten new courses.

This growth was accompanied by a simultaneous shift towards online learning that was driven by travel restrictions and government health advice during the COVID-19 pandemic.

This had the added benefit of introducing SMI's courses to an international audience, with certain courses receiving registrations from countries like Mongolia, Tanzania, Germany and Chile.

For MISHC facilitators Associate Professor Carmel Bofinger and Sharyn Cobbin, who already deliver a strong line-up of courses to mine sites, re-designing courses so they could be delivered online was the priority.

CSRM's Dr Sarah Holcombe developed the Indigenous Cultural Heritage Management: Australian resources sector online course as it became evident the industry, and wider society, were increasingly interested in seeing companies follow best practice.

The Institute's multidisciplinary expertise was demonstrated in March, when BRC researcher Dr Anita Parbhakar-Fox organised and facilitated the one-day SMI Tailings Masterclass. The Masterclass shared the latest research, practices and innovations in the tailings space by bringing together leading experts in its technical, environmental, social and governance-related aspects.

SMI Professional Development Staff

Transformational Learning Program Leader and Geology, Mining and Metallurgy Course Coordinator:
Dr Elaine Wightmann

Health, Safety and Risk Course Coordinator:
Sharyn Cobbin

Social Performance in the Resources Sector Course Coordinator:
Dr Lynda Lawson

Mine Site Environmental Management Course Coordinator:
Shona Stevens

SMI Public Courses 2020

The following professional development courses were delivered by SMI in 2020 (this does not include tailored training programs for industry):

Community Relations at Exploration

This Masterclass is designed to deepen geoscientists, community relations staff, consultants and early-stage regulators' conceptual understanding of the social issues and potential impacts of exploration activities on local communities. Developed and facilitated by Sarah Mackenzie.

Indigenous Cultural Heritage Management: Australian resources sector

This course addresses the foundational processes, practices and requirements for ensuring cultural heritage is managed effectively and respectfully throughout an operation's life. It draws upon a diverse range of Australian good practice; including practical approaches, practical examples and international standards. Developed and facilitated by Dr Sarah Holcombe.

Flotation Chemistry

This workshop focuses on the crucial role of flotation reagents in mineral resource recovery, providing an accessible overview of theory and plant practice through presentations and real world flotation examples. Developed and facilitated by Dr Liza Forbes and Dr Susana Brito e Abreu.

Geomet/Mine to Mill

This online course introduces participants to the concepts of geometallurgy and mine to mill methodologies, highlighting the value of orebody knowledge in viewing mining operations as integrated systems. Developed and facilitated by Dr Cathy Evans.

G-MIRM G3 Managers Education Program

G-MIRM G3 Managers Education is a four-day course that develops managers' understanding, appreciation and application of risk management policy and procedures. Facilitated by Associate Professor Carmel Bofinger and Sharyn Cobbin

Leadership and Diversity in Mining

This course helps participants take the first self-reflective steps of moving beyond managing and towards being an effective leader that understands the diverse work environment in which they operate. Developed as part of the Foundations of Modern Mining program.

Minerals and Mining in a Sustainable World

This course provides learners with an overview of the role of minerals in society, the history of the sustainable development agenda, and the emerging focus on the relationship between mineral development and the Sustainable Development Goals. Developed as part of the Foundations of Modern Mining program.

Process Control and Analytics

This course is designed for junior and senior metallurgists, as well as engineering students, and uses a practical approach to covering basic through to advanced process control. Developed and facilitated by Associate Professor Mohsen Yahyaei.

Process Mineralogy

The Process Minerology online course introduces metallurgists, mining and process engineers and operators to useful process mineralogy tools and techniques. Developed and facilitated by Dr Elaine Wightman and Dr Cathy Evans.

Tailings Masterclass

This online Masterclass brings together some of the world's leading experts in tailings covering technical, environmental, social and governance-related disciplines. Attendees receive a first-hand overview of the challenges and likely future developments in this vitally important area. Developed and facilitated by Dr Anita Parbhakar-Fox.

Risk and Critical Control Management Online

The Risk and Critical Control Management Online course uses the latest applied research to review participants' understanding and application of risk management systems and the development and integration of critical control systems. Developed and facilitated by Associate Professor Carmel Bofinger and Sharyn Cobbin.

Students

Student Experience

SMI Centres offer Master of Philosophy (MPhil) and Doctor of Philosophy (PhD) degrees in their discipline area.

Postgraduate research is multidisciplinary and diverse, and actively contributes towards SMI's vision for a more sustainable future. Our Higher Degree by Research (HDR) candidates become familiar with conducting research in industrial environments and in the challenges of transferring research outcomes to industry.

Daniel Lay, HDR student in JKMRC

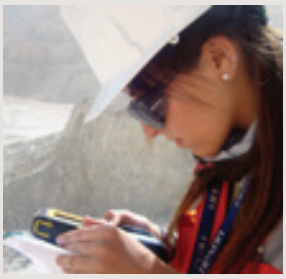
Daniel enjoyed the theoretical aspects of his undergraduate studies but never really felt like there was enough time to properly get into it thanks to being flat out with practical projects instead.

Before starting his PhD Daniel thought it would involve reading papers, thinking about the gaps between them and coming up with experiments to fill those gaps.

"I was pretty spot on, with one sidenote – the 'running into a few challenges and overcoming them' bit of the process has been a much larger part of the experience." he said

"...It's certainly helped develop my problem solving skills and filled me with a lot more patience."

Rocío Vargas Soto, HDR student in BRC



"In my PhD I am attempting to use the information we generate in geology to learn the characteristics of deposits and predict how that will affect performance in the processing stages."

"SMI is a great place to be doing this research - my supervisors are great and always there when I need them," She said.

"As geologists, we are in very good positions to bring about change. If at some point I am the leader of a project, many of the decisions I make can affect the management of water, communities and even climate change."

Jandira Morais, HDR student in CMLR

Jandira has embraced transdisciplinary research throughout her studies and it is now a key feature of her thesis.

"My PhD is on urban mining and the circular economy transition in Angola with a focus on the people behind it, who are often called scavengers though I prefer the title waste-pickers."

"By collecting different materials like aluminium, copper and bronze and delivering them to the recycling industry, waste-pickers are not only providing economic and social benefits but also environmental benefits through waste management."

SMI HDR Graduates 2020

Alidu Babatu Adam
Qualifications: PhD
Supervisor: Deanna Kemp
Centre: CSRM
Thesis Title: Conceptualizing household livelihood needs in mining-induced displacement and resettlement: A case study from Ghana

Erica Cristina Avelar
Qualifications: PhD
Supervisor: Catherine Evans
Centre: JKMRC
Thesis Title: The Measurement of Variability in Ore Competence and its Impact on Process Performance

Farhad Faramarzi
Qualifications: PhD
Supervisor: Sarma Kanchibotla
Centre: JKMRC
Thesis Title: The Measurement of Variability in Ore Competence and its Impact on Process Performance

German Dario Figueroa Salguero
Qualifications: PhD
Supervisor: Kym Runge
Centre: JKMRC
Thesis Title: Investigation of the Effects of Turbulence in Flotation

Gary Flomenhoft
Qualifications: PhD
Supervisor: Kathryn Sturman
Centre: CSRM
Thesis Title: An Inquiry into the Economic Commonwealth of Mineral Resources

Juan Jose Frausto Gonzalez
Qualifications: PhD
Supervisor: Grant Ballantyne
Centre: JKMRC
Thesis Title: The impact of classification efficiency on comminution performance and flotation recovery

Melinda Elizabeth Jayne Hilton
Qualifications: PhD
Supervisor: Mansour Edraki
Centre: CWiMI
Thesis Title: Predicting salt generation from coal mine spoil heaps in a semi-arid climate, Central Queensland, Australia

Jean-Pierre Imbrogiano
Qualifications: PhD
Supervisor: Kathryn Sturman
Centre: CSRM
Thesis Title: Sustainability Performance in Businesses and its Implications for the Sustainability Service Industry

Lynda Merilyn Lawson
Qualifications: PhD
Supervisor: Kathryn Sturman
Centre: CSRM
Thesis Title: Opportunities and challenges for women's empowerment in the gemstone value chain in Madagascar and Thailand

Yunjia Liu
Qualifications: PhD
Supervisor: Longbin Huang
Centre: CMLR
Thesis Title: Characteristics of hardpans capping sulfidic Cu-Pb-Zn tailings and potential roles of mineral bio-weathering

Pia Constanza Lois Morales
Qualifications: PhD
Supervisor: Catherine Evans
Centre: JKMRC
Thesis Title: Development of a geometallurgical approach for comminution using primary breakage properties of ores

Humaira Malik
Qualifications: PhD
Supervisor: Jo-Anne Everingham
Centre: CSRM
Thesis Title: Benefitting from the Boom? Experiences of Female Business Operators in Resource Towns of Southern Queensland

Constanza Ivonne Paredes Bujes
Qualifications: PhD
Supervisor: Vladimir Jokovic
Centre: JKMRC
Thesis Title: Measure-While-Drilling for Ore Characterisation: Links between drilling and comminution properties of rocks

Bernard Selasie Agbenuvor
Qualifications: MPhil
Supervisor: Vladimir Jokovic
Centre: JKMRC
Thesis Title: Investigation into Multistage Impact Breakage

Raoni Antunes Ferreira Lage
Qualifications: MPhil
Supervisor: Vladimir Jokovic
Centre: JKMRC
Thesis Title: Enhancing Grade Engineering through multiple and high-speed collisions

Roseanne Baxter
Qualifications: MPhil
Supervisor: Robin Burgess-Limerick
Centre: MISHC
Thesis Title: Whole-body vibration associated with dozer operation at a surface coal mine

Peter William Legge
Qualifications: MPhil
Supervisor: Frank Shi
Centre: JKMRC
Thesis Title: Rheological properties of Lihir ore

Publications

Publications 2020

Book Chapter

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Franks, D., Littleboy, A. & Williams, D. (2020) Global research consortium on tailings. In (Eds.), Towards Zero Harm: A Compendium of Papers Prepared for the Global Tailings Review (pp. 231-237). London, United Kingdom: Global Tailings Review.

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Journal Article

Abubakari, F.*, Mesjasz-Przybylowicz, J., Przybylowicz, W. & van der Ent, A.* (2020) Convergent patterns of tissue-level distribution of elements in different tropical woody nickel hyperaccumulator species from Borneo Island. AoB PLANTS, 12(6)

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