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Sustainable Minerals Institute

Critical Minerals Research Snapshot

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

Sustainable Minerals Institute (SMI)

Develop knowledge based solutions to the complex problems facing the resource industry, society and the environment on the path to sustainability.

Complex Orebodies Program at-a-glance

Commenced Q1 2018 - $5m strategic funding over 5 years

89 UQ Researchers participating

$4.3m external funding to end 2020 (above target) ; $8.0m secured or contracting to end 2022 (above target)

21 Projects involving 15 UQ Schools and Centres

Project collaboration
- 91% cross-cutting within SMI
- 57% cross-cutting across UQ
- 85% with external collaboration

26 External funding partners from industry and government

13 Journal Publications; numerous in review; 15 Conference Publications

Funding provided to 11 HDR students and 17 Postdoctoral research fellows

One international conference and one presentation day organised

Two patent applications filed

Complex Orebodies – project themes

Recovering metals without mining at all

Transforming community and social performance

Holistic assessment of mine projects including ESG Factors

Mapping the technical, environmental, social and governance challenges to future mineral supply

Flexible mining and processing to replace "large tonnage megaprojects"

Understanding mine closure as a key to social performance

Novel technologies to extract critical metals

Addressing water supply challenges

Removing contamination from the mining value chain

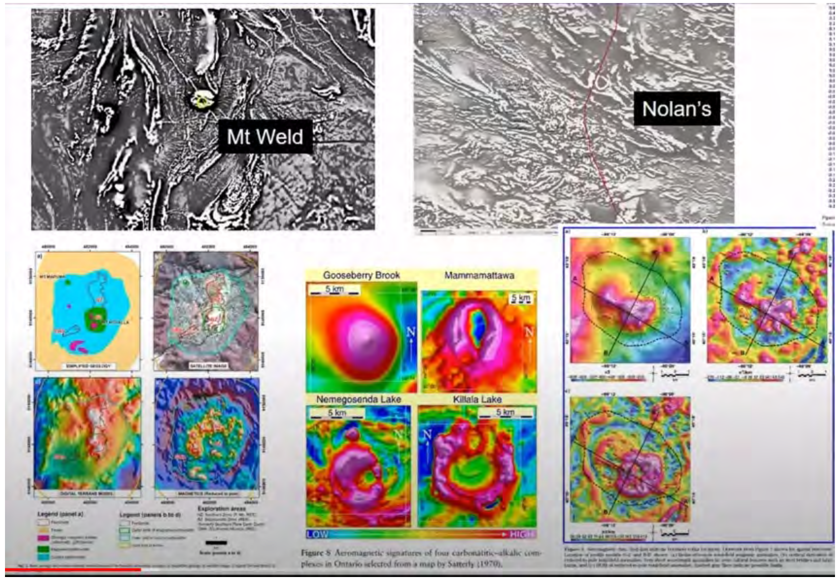
Producing metals using less energy and leaving safer tailings

SMI/UQ Critical Minerals Research at a Glance

- Large portfolio of projects covering a broad range of the mining value chain
  -  Discovery (4 projects)
  -  Upstream Processing (2 Projects)
  -  Critical metals from mine waste (4 projects)
  -  Downstream Processing (2 projects – UQ Chemical Engineering)
  -  Social and Environmental Aspects (2 Projects)
- Current SMI external project funding (2020-2024) - $3.1 million
  - *(UQ Chemical Engineering receives additional substantial funding)*
- Collaborative arrangements with 15 external organisations
- Large UQ team involved with staff from
  - SMI
  - SEES
  - EAIT (Civil and Chemical)
  - ISSR

Project Descriptions

Queensland New Economy Minerals Compilation



Summary

It is now well established that modern economies will increasingly depend on the supply of a broad and in some cases poorly understood and underexplored group of commodities termed the "New Economy Minerals" (NEM).

This project will focus on producing a suite of non-competitive geoscience products which will aid exploration for NEM Commodities.

This project is proposed to run concurrently with other projects from of researchers focusing on the development and refinement of process models for various types of REE deposits. The aim of this project is not to duplicate efforts in this area. The focus of this project is much more to replicate the work that would be expected to take place in an industry-led regional targeting exercise

Background & aims

Non-competitive datasets play a vital role in exploration success, and the Geological Survey of Queensland has produced a range of non-competitive data products that are focused on exploration for more traditional commodities such as copper, gold, coal, silver, lead and zinc (eg NWQMEP NW Mineral Province Study, 2011). Products such as these often include compilations of geology, geochemistry and geophysics relevant to the commodities of interest as well as areas of interest which have been defined on the basis of criteria gleaned from mineral process models. With the increased focus on NEM Commodities, there is a need to produce a similar suite of products to aid explorers in their area selection and discovery objectives. This project aims to provide prospective explorers with a geoscience compilation of a selected group of NEM commodities which comprises compilations for two commodity examples, one of which can occur as a primary ore commodity and the other of which is secondary. These compilations will derive spatial datasets from accepted process models and use these to map areas of potential for the commodity in question

Collaboration & Details

The project is being carried out by researchers from the SMI's WH Bryan Mining and Geology Research Centre, supported by the Geological Survey of Queensland

Project Leaders:	Paul Gow, Rick Valenta (UQ)
Timing	2020 - 2021
Participants:	Paul Gow, Rick Valenta, Karen Connors, Jenna McGovern (SMI)

Outcomes

- Literature review and classification of NEM mineralisation styles and process models for the commodities in question, drawing on Queensland examples (eg Hutton – A regional appraisal of Queensland's critical elements resources, 2019) and outputs from other jurisdictions in Australia and worldwide
- Determine key geoscientific features derived from process models
- Reprocess geology, geochemistry, geophysics and mineral occurrence data to target identified features of importance
- Use the results from the activities above to produce a set of AOIs for NEM commodities in question.
- Spatial compilation of AOIs including data fields within the AOIs which set out the rationale for their identification
- Compilation of all project outputs into fully attributed GIS coverages in ESRI, Mapinfo and QGIS formats
- Production of a PDF report
- Delivery of an online tool which will allow explorers to select commodities and apply their own selection and weighting of targeting criteria.
- Staging of an industry workshop to present results of the study and seek industry feedback

Deliverables & links

(ctrl click icons for links)

Rick Valenta/Paul Gow Presentation November 2020

NE Queensland Mineral Deposit Atlas

The University of Queensland
Australia

Summary

The objective of this project is to produce deposit atlases for significant Sn-W deposits in NE Queensland. Knowledge relating to the geology, mineralogy and geochemistry of each deposit and its associated inner and outer haloes as they are expressed in common exploration datasets can provide important information for assessment of exploration projects in a number of ways including:

- Provision of a basis for assessment of mineral system affinity of a new early stage exploration target
- Provision of assistance in the vectoring of exploration drillholes on the basis of geochemical, geological, and/or mineralogical gradients found to exist in known deposits of similar type.

Background & aims

It is now well established that modern economies will increasingly depend on the supply of a broad and in some cases poorly understood and underexplored group of commodities termed the “New Economy Minerals” (NEM). Tin and tungsten are included in the group of NEM elements as well as Scandium, and Northeast Queensland is host to a province of deposits of this type with varying geoscientific characteristics. The aims are:

- to compile all relevant geoscientific information pertaining to the mineralisation and halo of the deposits, as well as to the disposition and characteristics of the associated mine wastes;
- to deliver that information in the form of A3 pdf documents of the type delivered for other deposit examples in the NW Queensland, and in the form of Geoscience Analyst 3D compilations;
- to include all of the underlying deposit information in a data package which can allow the data to be used in other packages

Collaboration & Details

The Project is being carried out by staff of the WH Bryan Mining and Geology Research Centre, part of the Sustainable Minerals Institute at the University of Queensland. The project is supported by the Geological Survey of Queensland, part of the Department of Resources. Many companies will be providing data to help with the compilation, including, Cronimet, Signature Metals and other project owners. GSQ and CSIRO have also provided data which have been included in the atlases

Project Leader:	Paul Gow (UQ)
Timing	2020 - 2021
Participants:	Paul Gow, Nathan Fox, Dave Esser, Jenna McGovern, Sasha Aivazpourporgou (UQ)

Outcomes

The aim is to provide a compilation of geoscientific information for each deposit, with a focus on:

- Location
- Basic resource and production information;
- Geology of host rocks and alteration;
- Orebody dimensions and geometry;
- Basic structural characteristics and history;
- Characteristics of the inner and outer halo of the deposit in terms of:
    - Extent;
    - Geophysical expression;
    - Exploration geochemistry;

Deliverables & links

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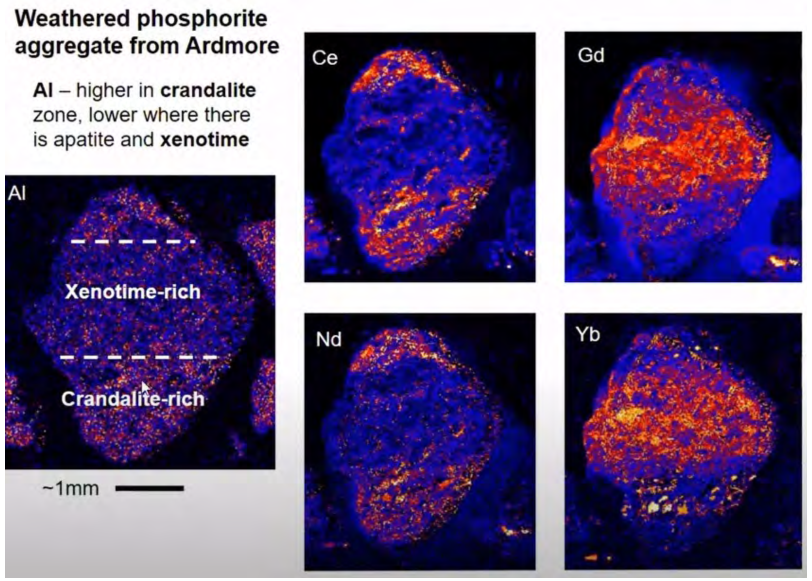
Link to SMI-BRC page with all downloadable atlases

Supergene enrichment of REE in phosphorite



Summary

Elevated rare earth element (REE) and Yttrium concentrations are recognised in phosphate rich marine sediments (phosphorites) in the Georgina Basin in Queensland. More specifically, there are notable enrichments of REE and Y in highly weathered phosphorite units. It is hypothesised that enrichments in REE + Y are due the formation of secondary minerals such as xenotime during weathering, which concentrates REE + Y in certain horizons. This project aims to characterise the mineralogy and REE+Y chemistry of weathered phosphorite horizons in the Georgina Basin. In doing so, a model of supergene enrichment of REE + Y during phosphorite weathering will be tested.

Background & aims

The objective of this project is to characterise the mineralogy and chemistry of highly weathered versus “fresh” phosphorite to understand the influence of mineralogy of the REE + Y concentration of phosphorites.

- Characterise mineralogy of phosphorites using MLA
- Characterise the major and trace element chemistry of phosphorites using micro-XRF
- Relate mineralogy and element abundance data to bulk geochemistry to understand REE + Y mobility during phosphorite weathering

Collaboration & Details

DNRME will supply UQ with 10 samples from the Ardmore and Phosphate Hill phosphorite deposits by 16 June 2020. These samples will comprise a combination of RC drilling chips phosphorite rocks. UQ will prepare the samples in polished epoxy mounts and characterise the samples in terms of mineralogy using MLA. The same samples will then be mapped for major and trace element abundances using micro XRF.

Outcomes

The data will be used to understand how variations in mineralogy relate to changes in chemistry. This in situ approach will be complemented by an existing bulk geochemistry database. The combination of these data, will inform a model of REE + Y mobilisation during weathering processes..

Deliverables & links

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Webinar – Matt Valetich Nov 2020

Project Leader:	Paul Gow (UQ)
Timing	2020
Participants:	Rick Valenta, Paul Gow, Nathan Fox (UQ); Matt Valetich (GSQ)

Massive geodata visualisation for New Economy Minerals

Summary

The aim of this project is to modify the existing udStream platform (developed for massive point cloud visualisation) to allow cloud-based simultaneous visualisation of regional and deposit-based 3D datasets. Modern mineral exploration produces an enormous amount of data, and the task of making sense of this data is often impeded by the lack of ability to visualise, analyse and cross-link the data using hardware that is accessible to most explorers. Most computer systems and software currently employed in exploration and mining are not able to open and simultaneously visualise regional data and multicale data from multiple deposits. The SMI is working with a Queensland-based technology company to develop a system which can allow cloud-based, seamless and real-time visualisation and analysis of massive 3D geological datasets from micro to crustal scale using a browser interface. Such a platform will improve the ability of explorers to identify exploration targets and to interpret their exploration results in the context of all available data in the fastest possible time.

Background & aims

It has commonly been observed that in the minerals industry our ability to collect data has far surpassed our ability to analyse and interpret it. In the case of data visualisation, there is no current tool which allows real-time cloud-based visualisation of massive exploration datasets.

Queensland is one of the world's premiere destination for minerals exploration and mining, bringing with it billions of dollars in jobs and investment. Queensland is an attractive destination because of political stability and the State's investment in massive amounts of freely available, precompetitive data. Such volumes of data have been instrumental in enabling companies to identify regions for exploration, including majors such as Anglo American and Rio Tinto. However, massive data also presents a challenge. How do industry and the general public make sense of it? How do they discover all the rich data they require for decision making? Can they visualise and search the State's data in one location before investing time in downloading it for their business needs?

BRC team with GSQ leaders and the Director General of the Department of Resources

Collaboration & Details

This project commenced as a collaboration between the SMI and Euclideon Pty Ltd, a Queensland-based technology company developiong products for visualisation of massive datasets.

Project Leaders:	Rick Valenta, Steve Micklethwaite (UQ)
Timing	2018 - 2022
Participants:	Rick Valenta, Steve Micklethwaite (SMI), Steve Amor, Braden Wockner (Euclideon)

Outcomes

There will be four key developments:

- Automatic pipeline between Open Data Portal (the Department of Resources digital data repository) and the 3D Earth model, so all data in the portal is visualised in the model;
- Data discovery tools, making it easy for users to query, navigate and identify the specific data or regions they are seeking;
- Custom built adaptations to the visualisation, which are purpose built for easy ways of fusing and viewing geoscience data, but also have wide application to other disciplines;
- Quick links back to the primary data so that users can download the required data they have identified in the 3D Earth model.

The project will provide deliverables in a staged development, starting with visualisation of data from the NW Minerals Province and ending with visualisation of the whole State. The project will also be a world-first, with no other state or nation boasting 3D data discovery tools, containing easy ways to search, find and visualise the massive amounts of data available here.

Deliverables & links

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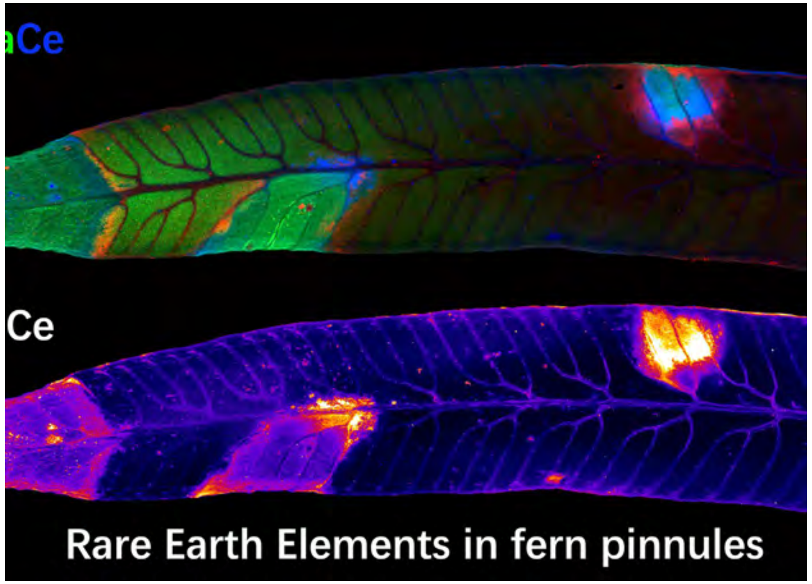
Euclideon demo page

The University of Queensland
AUSTRALIA

Extracting Queensland’s Rare Earth Elements Sustainably



Rare Earth Elements in fern pinnules

Summary

This project aims to provide prospective explorers with a clearer understanding of possible approaches for economic extraction of REE from mineralisation associated with their exploration projects . The increasing demand for electric motors, solar panels, batteries and wind turbines has led to an increase in demand for Rare Earth Elements (REE). Many recent analyses (eg Austrade, 2019) have shown that Australia has good potential to address some of the current challenges relating to shortfalls and geographic constraints on availability of REEs. Queensland has potential to play an important role in this process as there are already several recognised potential sources of REE supply in the state. Researchers at UQ are well-placed to make advances in this area, with world-class capabilities in mineral characterisation, hydrometallurgy, bio-extraction and phytomining applied to REE deposits

Background & aims

In contrast to better-known precious and base metal mineralisation, the approaches and alternatives for extraction of REEs are not well-understood. This lack of understanding may discourage explorers from focusing their activities on REE projects, due to uncertainties around the pathways to economic production. In order to realise Queensland’s REE potential, it will be necessary to understand the best and most sustainable alternatives for extraction of REEs from known deposits and future discoveries. More detailed objectives include:

- to develop an understanding of the geochemistry and mineralogical deportment of a representative range of REE mineralisation types in Queensland;
- to provide a body of extractive test results relating to REE in this representative range of deposits;
- to use this information to produce a summary of processing alternatives and their high level economics for the main styles of REE mineralisation in the state

Collaboration & Details

Researchers from UQ’s Sustainable Minerals Institute (SMI), Faculty of Engineering Architecture and IT (EAIT), and School of Environmental and Earth Sciences (SEES) are exploring more sustainable methods of extracting Queensland’s rare earth elements (REE) as part of a new government-supported project.The 4.5 year, $920,000 project is part of SMI’s Complex Orebodies strategic program and supported by the Geological Survey of Queensland (part of the Queensland Department of Resources) through its recently-announced New Economy Minerals Initiative.

Project Leaders:	Paul Gow, Rick Valenta (UQ)
Timing	2020 - 2024
Participants:	Paul Gow, Antony van der Ent, Rick Valenta, Anita Parbhakar-Fox, Kate Tungpalan, Lizette Verster, Peter Erskine, Philip Nkrumah (SMI), Gordon Southam (SEES), James Vaughan, Weng Fu (EAIT)

Outcomes

This project will begin with an overview study of known REE mineralisation in Queensland. This study will be used as a basis for a sampling program focused on a range of deposits representative of the known variation in REE mineralisation styles in the state. It is expected that this will include known mineralisation styles such as IOCG, hydrothermal REE-bearing skarn and vein deposits, sedimentary Phosphorites, Lateritic Ni-Co-Sc, and primary igneous sources (such as the Peak Range Volcanics). REE-bearing mine wastes will also be considered. A key outcome of this phase of work will be the selection of case study areas for field investigation and sampling.

The samples collected during field investigations will be geochemically and mineralogically characterised, and will then be tested using a range of extraction approaches including hydrometallurgical leaching, bio-leaching and phytomining. Potential preconcentration approaches will also be tested where justified. A phase of assessment will take place following the testing to consider the significance of the results for the high level economics of REE recovery. Gap analyses at this stage will also identify further testwork to improve and refine extraction processes. Additional case study areas may also be chosen at later project stages, depending on results

Deliverables & links

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Paul Gow Presentation November 2020

Philip Nkrumah Presentation November 2020

James Vaughan Presentation November 2020

Lizette Verster Presentation November 2020

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Optimized X-ray ore sorting technologies and material handling concepts for historic tungsten mine waste transformation

Summary

This project will establish the physical controls on separation efficiency of low grade stockpile materials at Mt Carbine to develop new mine planning and scheduling models and optimise scale-up application of ore sorting technologies. Understanding the physical controls on separation efficiency will allow predictive geometallurgical models to be developed with the aim to re-initiate tungsten production in Australia.

A geometallurgical characterisation program led by researchers from the Sustainable Minerals Institute (SMIUQ) will utilise a pilot-scale X-ray transmission ore sorter installed on site. Batch sorting and characterisation campaigns will be conducted in parallel to evaluate the effects of variable feed material characteristics (particle size, grain-size, gangue mineralogy) on separation decision-making (e.g. ore or waste classification). New analytical protocols will be developed to analyse multidimensional datasets. Predictive models of separation performance based on material feed characteristics will be integrated into a dynamic mining plan using COMET software. The project will improve sector confidence in adopting new ore sorting technologies for processing heterogeneous, low grade materials and drive economic growth and mine rehabilitation in Australia.

Collaboration & Details

This project commenced as a collaboration between the SMI, Cronimet, Specialty Metals, Tomra Sorting and DAS Mining Solutions. The project is the recipient of funding from METS Ignited as part of the Queensland METS Collaborative Project Fund

Project Leaders:	Nathan Fox (UQ)
Timing	2018 - 2022
Participants:	Nathan Fox, Kieran White (SMI), Ruan Kroukamp, Damien Lefevre (Cronimet)

Background & aims

In this pilot study, a multidisciplinary approach is chosen to transform waste materials with very low tungsten grades at Mt Carbine into a saleable concentrate and a benign waste stream suitable for industrial reuse. The proposed workflow follows an iterative approach with optimization based on responsive feedback loops:

- Site geological and geometallurgical characterisation, covering geological review of deposit physiology including ore deposit model, host rock and alteration mineralogy and mineralization characteristics. Initial desktop review of historical and modern mining operations at Mt Carbine, flow sheets and existing characterization work from trenching and grab sampling;
- Installation of Tomra X-ray transmission ore sorter on site with trial processing of sample lots (each campaign with minimum 1000 tons) from the low-grade waste rock pile (12 Mt in total) through the sorter;
- Geometallurgical characterization of ore sorter accept and reject streams with a focus on identifying the mineralogical and textural drivers for ore sorter decision-tree responses to optimize recovery. Correlate ore sorter response to the geological attributes of the deposit and evaluate the amenability of other tungsten deposits to ore sorting technologies;
- Evaluate and trial cost optimised material handling concepts (e.g., autonomous material loading). Considering the inherently low grade nature of the material, significant volumes are required to be rehandled to achieve industrial scale tungsten production

Outcomes

This project will benefit the wider minerals sector in Australia through alignment with the priority agenda of the Australian Government to expand its critical minerals industry and enhance the capabilities with regards to mine waste management and social licence to operate. The consortium is committed to responsible mining and sustainability with the aim to proactively minimise waste though reprocessing and innovative reuse of waste materials to generate a new, sustainable supply of (critical) minerals..

Deliverables & links

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Cronimet Presentation – November 2020

Exploration of new economy metals in Queensland’s mine waste

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Summary

This project will focus on secondary prospectivity. This is defined as the examination of previously unconsidered mining opportunities in existing and abandoned mines, with this pursuit in keeping with circular economy principles. The project will examine mine waste at a number of sites across the state (operational and abandoned) to determine their new economy mineral endowment, and will also investigate the mining technologies and techniques required to recover these metals as part of an economic rehabilitation approach. The project will be arranged into three streams:

- Stream 1: First pass investigation of mine waste at operational and abandoned sites
- Stream 2: Detailed investigations at sites representative of Queensland’s main ore deposit types and new economy metal toolbox development
- Stream 3: Bespoke mineral processing methodologies suitable for mine waste

Background & aims

The complexity of mine waste management continues to be one of the greatest challenges the mining industry faces with ‘license to operate’ again ranked as the number 1 business risk in 2019-20. Increasing global awareness of the negative impacts that incomplete, or inadequate, mine closure can have on the environment has caused increased demand on the mining industry to commit to improving environment management standards during and beyond the life-of-mine.

The Project will apply a geometallurgy characterisation approach to mine waste (whereby the bulk mineralogical and chemical properties, insitu mineralogy and texture, mineral chemistry and acid-base accounting properties of waste are assessed) the mining industry can more effectively de-risk mine waste and enhance operations by either: i) potentially revealing secondary deposits or; ii) gain an detailed understanding of the waste properties thereby allowing effective rehabilitation strategies to be developed. .

Collaboration & Details

This collaborative project is supported by the Geological Survey of Queensland (GSQ), within the Department of Resources. Staff from UQ’s SMI, School of Earth and Environmental Sciences, School of Civil Engineering and School of Chemical Engineering will work together to build a multidisciplinary team to address the project challenges. The project will also involve collaboration from industry partners including

Project Leader:	Anita Parbhakar-Fox (UQ)
Timing	2020 - 2024
Participants:	Rick Valenta, Mansour Edraki, Nathan Fox, Sasha Aivazpourporgou, Liza Forbes, Kym Runge (SMI); Emma Gagen (SEES); Denys Gomez, James Vaughan (EAIT)

Outcomes

A key outcome of Stream 1 will be the provision of data to build a secondary prospectivity map of Queensland informing future brownfields exploration in the state.

Stream 2 will build new detailed knowledge, in terms of how new economy metals are hosted and cycled in sub-tropical surficial environments, with these outcomes directly applicable to other sites in the state. Further, it will also deliver multi-scale workflows for low-cost new economy metal identification in waste domains.

A key outcome of Stream 3 will be the delivery of successful mineral processing tools to the mining and METS sector to facilitate practical economic rehabilitation.

Deliverables & links

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Link to Anita Parbhakar-Fox Ore Deposits Hub Presentation

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Assessing Recommercialisation Potential at the Mary Kathleen mine, Queensland

Summary

As part of the research conducted at the SMI, the geometallurgical characterisation of mine waste, specifically tailings and waste rock, is a key focus of the program with the team committed to establishing practical and efficient methodologies for undertaking such site-based research, particularly for the recovery of rare earth elements (REEs) and critical metals. In this project, SMI is collaborating with the Queensland Department of Resources to better define the recommercialisation potential of the mine waste at the former Mary Kathleen uranium mine, located 60 km east of Mt. Isa, Queensland. The DNRME Abandoned Mines group are currently in the process of prioritising the abandoned mine sites in Queensland in the context of potential mineral resource evaluation and environmental management with Mary Kathleen as a high priority.

The focus of this project is on the Mary Kathleen uranium mine in North Queensland where the primary interest is recovery of REEs (including La, Ce, Pr, Nd) in tailings.

Background & aims

The project will focus on additional characterisation of mine tailings to address existing knowledge gaps, evaluating the properties of drill core and interpretation of new datasets with the following objectives:

- Collate and evaluate all mineral resource information including geological, geophysical and mineralogical data (potentially also supplemented with HyLogger data collected on existing and new drill core materials) to characterise the mineral resource.
- Build upon previous SMI research to characterise the commercial extractability of REEs throughout the (full) depth of the tailings dam by undertaking a geometallurgical study on sample splits. Geoenvironmental properties (as determined by acid base accounting, bulk mineralogy, bulk geochemistry, leaching tests) of the new tailings will also be measured to assist with environmental risk forecasting and identify appropriate new processing methodologies.

Collaboration & Details

The project is being carried out by researchers from the SMI's WH Bryan Mining and Geology Research Centre, Julius Kruttschnitt Mineral Research Centre, and the Centre for Mined Land Rehabilitation, supported by the Geological Survey of Queensland

Project Leaders:	Anita Parbhakar-Fox, Paul Gow(UQ)
Timing	2020 - 2021
Participants:	Rick Valenta, Mansour Edraki, Cathy Evans, Liza Forbes, Peter Erskine, Antony van der Ent (SMI), James Vaughan, Weng Fu (EAIT)

Outcomes

- A compilation of all relevant geoscientific information pertaining to the mineralisation and halo of the deposit, as well as to the disposition and characteristics of the associated mine wastes;
- Delivery of that information in the form of an A3 pdf document of the type delivered for other deposit examples in the region, and in the form of a Geoscience Analyst 3D compilation;
- Information on the mode of occurrence in the fine fractions (< 75 µm) and extractability of REEs from mineral residues and their oxidation products and characterisation of new tailings to assist with planning economic recovery of REEs and the remediation of the site.
- An appreciation of the remaining in-ground resource based on new geophysical and mineralogical data.

Deliverables & links

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Peter Erskine Presentation November 2020

Mine Waste

Unlocking the value of mining wastes at abandoned mines of Queensland – Wolfram Camp

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

Summary

There are about 15,000 abandoned mine sites in Queensland. A few of these sites, which are managed by state government, can potentially pose environmental and human health risks due to the dispersion of contaminants through air and aquatic pathways. There are limited resources for the rehabilitation of these sites. However, there are potential opportunities for repurposing the residual mineral wastes left onsite. The overall aim of relevant research at CMLR is unlocking the value of mineral waste and at the same time reducing or eliminating any potential risks and liabilities for the environment and community. The focus of this particular project is on Wolfram Camp tungsten mine in North Queensland, however the project applies an SMI work plan that can be applied to any or all abandoned mines in Queensland. This project will evaluate the environmental conditions of the Wolfram Camp site, characterise waste materials, assess the chemical forms, the mode of occurrence of elements of interest and their spatial distribution, and investigate mineral separation pathways. The project will in the end make recommendations for the scale up trials of waste utilisation and land rehabilitation.

Collaboration & Details

The project is being carried out by researchers from the SMI's Centre for Mined Land Rehabilitation and the WH Bryan Mining and Geology Research Centre, supported by the Geological Survey of Queensland

Project Leader:	Mansour Edraki (UQ)
Timing	2020 - 2021
Participants:	Anita Parbhakar-Fox, Artem Golev, Zhengdong Han, Amelia Corzo Remigio (SMI)

Background & aims

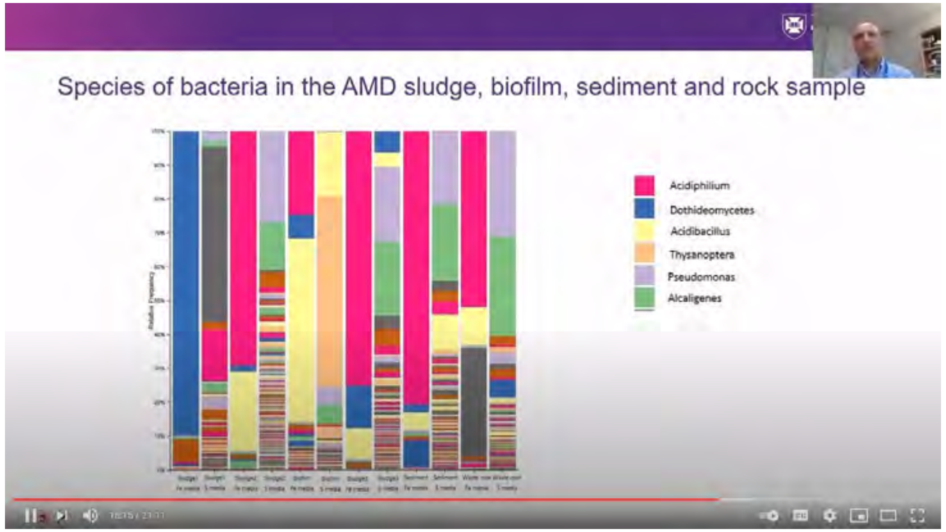
- Evaluate the potential and extent of any current and future environmental risks arising from the depository of existing tailings and mine wastes on site.
- Establish the mode of occurrence and chemical forms of elements of interest and their spatial distribution, from both environmental and resource recovery perspectives.
- Investigate potential pathways for mineral separation, repurposing of tailings and mine waste and concurrent land rehabilitation.

The scope of this project includes the following activities and outputs:

- Overview of available historic data and global best practice in managing similar types of mine waste;
- Sampling and assessment of the mineralogical, geochemical and physical properties of tailings;
- Assessment of the mode of occurrence, chemical forms, and bioavailability;
- Estimation of the elemental distribution and quantities within the tailings storage facility;
- Evaluation of tailings for mineral separation and decontamination for the purpose of potential reprocessing for mineral recovery and/or reuse of the tailings; and
- Recommendations for pilot scale field trials.

Outcomes

- Alignment of the site management plans with those of best practice examples globally.
- Improving understanding of environmental values and risks associated with tailings and mine waste at Wolfram Camp in particular with respect to the risks of any acid and metalliferous drainage and metal leaching, dust propagation and radioactivity. This will include identifying areas that require short, medium and long-term management actions.
- Information on the mode of occurrence and extractability of elements from mineral residues and their oxidation products.
- An appreciation of the spatial distribution and tonnages of the elements of interest.
- Providing sufficient information on material properties including quality and quantity of existing benign materials and those produced through repurposing of mine waste and tailings that can be used for rehabilitation and closure of the site.



Deliverables & links

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Mansour Edraki Presentation November 2020

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Cobalt in Copper Tailings

Summary

The project seeks to undertake first-pass characterisation assessments in terms of critical metal abundances and their modes of occurrence in tailings and other mine wastes in north Queensland.

The mine waste features at 9 sites in Queensland (Lady Annie, Capricorn Copper, Century, Osborne, Selwyn, Baal Gammon, Wolfram Camp, Mt Oxide, Pindora) have been sampled for new economy metal exploration funded by the GSQ. Preliminary assay data for these samples has been collected (NB. some samples require additional analysis) so only limited interpretations are presented in this interim report. Samples were collected from 6 sites in January-February 2020, with tailings samples also provided from the New Century, Osborne and Chinova sample stores).

Mineralogy (XRD and MLA) and mineral chemistry (LA-ICPMS) data is outstanding. A UQ honours student, Ruby Fritz, has joined this project and is working on identifying indigenous bacteria at Capricorn Copper.

Background & aims

Australia is well endowed in base and precious metals, but to date critical metals (e.g., Co, In, W, Ga, Ge) have not been the focus of the Australian mining industry, and are instead by-products of mining for other commodities (i.e., Cu, Pb, Zn). The 2019 Critical Metal Strategy commissioned by the Australian Government identified that out of 30 critical metals, Australia was the top global producer for just one, lithium. With increasing global pressure to utilise low-carbon technologies there is greater demand for critical metals to support this development with mine waste materials representing a potential resource to help supplement the supply of these sought after metals and minimising potential environmental impacts they may have on the surrounding environment, such as the release of acid and metalliferous drainage (AMD). However, determining their contents and mode of occurrence in mine waste is vital in assessing if a potential economic deposit exists and indeed, the most appropriate metallurgical processing pathways suited to their extraction. The Queensland State Government recognise there is great potential to explore for these critical or 'new economy' metals in mine waste materials produced by mines across the state and is the focus of this project.

Collaboration & Details

Site-based sample collection for the project is being undertaken as a cooperative effort involving both BRC and GSQ staff. Support has been provided by several NWMP Companies including Glencore, Capricorn Copper, New Century, Chinova and Lady Annie

Project Leader:	Anita Parbhakar-Fox – UQ SMI BRC
Timing	November 2019– June 2020
Participants:	Anita Parbhakar-Fox, Nathan Fox, Ruby Fritz, Rick Valenta, BRC Dominic Brown, Friedrich von Gnielinksi, GSQ

Outcomes

Field-based sampling activities for the project are now complete and preliminary analyses have been received. An interim report has been delivered to the GSQ, and final reporting will be complete by the end of June

In the next two months, collection of the outstanding MLA, XRD and LA-ICPMS data is the priority activity. In addition, micro-XRF images are being collected on slabbed waste rock samples collected from the sampled sites. It is anticipated that this will provide some context with regards to new economy metal deportment in-situ, in these materials

Deliverables & links

(ctrl click icons for links)

Presentation December 2019

Webinar 14 May 2020

Mining, biodiversity and the transition towards a renewable-energy-based economy

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

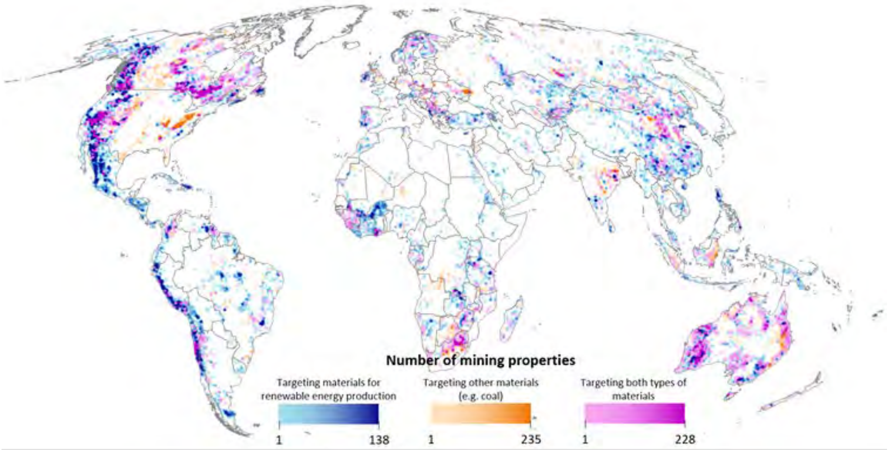
Summary

To date, studies exploring relationships between mining and biodiversity typically focus on fossil fuel extraction. However, global initiatives to mitigate climate change seek to shift reliance towards renewable sources of energy, including wind and solar (ICSU, ISSC 2015). Such a transition will increase demand for metals critical for renewables infrastructure (copper, lithium, cadmium; Ali et al. 2017). Relationships between these critical metals and biodiversity is largely unknown. It is also unclear if factors enabling development of new resources (e.g. existing infrastructure, political stability) will amplify biodiversity risks; past studies ignore these dynamics (Murguia et al., 2016). Therefore, project seeks to map the spatial coincidence between critical metals, factors enabling resource development, and terrestrial biodiversity

Background & aims

Mining poses serious threats to biodiversity worldwide. Management efforts and policies are strengthening in some high- risk places; however, relationships between mining and biodiversity are not static. Notably, the global mining sector is currently undergoing a transition, with demand shifting away from fossil fuels and towards metals critical for renewable energy infrastructure. These shifts will, in turn, affect biodiversity, potentially pushing risks towards remaining intact wilderness, in countries lacking political will and management capacity. This study aims to investigate the spatial coincidence between "critical metals" (i.e. those needed for renewable energy infrastructure) and terrestrial biodiversity. Specifically, we propose the following three research objectives:

- Identify and map critical metal reserves, and compare these maps with spatial distributions of:
- Factors enabling resource development, including infrastructure and political stability; and
- Biodiversity indicators, including distributions of threaten species and protected areas.



Collaboration & Details

The project is bveing carried out by researchers from the SMI's WH Bryan Mining and Geology Research Centre, supported by the Geological Survey of Queensland

Project Leader:	Laura Sonter (UQ - SEES)
Timing	2020 - 2021
Participants:	Rick Valenta (SMI); Marie Dade, Tom Lloyd, James Watson (SEES)

Outcomes

This project seeks to address these challenges by quantifying the spatial coincidence between critical metals, factors enabling resource development, and terrestrial biodiversity indicators. We will produce the first global map of biodiversity risks due to likely development of critical metal resources, and illustrate how these risks differ from those due to fossil fuel extraction. Analysis for one critical metal (Cobalt) suggests risks may shift towards the world's remaining wilderness areas, in countries lacking political will and management capacity (Ali et al. 2018). Building on this, our global-scale analysis will provide a powerful new tool to prioritise conservation efforts. This tool will also enable mining companies to predict where development may risk environmental conflict and thus identify opportunities to contribute to, rather than detract from, biodiversity conservation goals.

Deliverables & links

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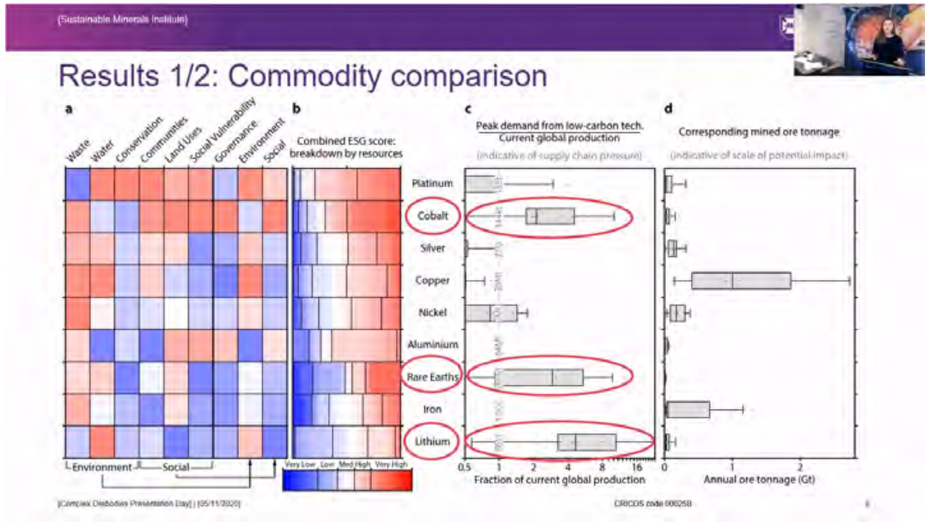
Laura Sonter Presentation November 2020

Open Access Paper Sonter et al – Nature Communications

Article – the Conversation

The Social and Environmental Complexities of Extracting Energy Transition Metals

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA



Summary

As low-carbon energy technologies advance, markets are driving demand for energy transition metals (ETM). Increased extraction rates will augment the stress placed on people and the environment in extractive locations. To quantify this stress, we develop a set of global composite environmental, social and governance (ESG) indicators, and examine mining projects across 20 ETM commodities to identify the co-occurrence of ESG risk factors. Our findings show that 84% of platinum resources and 70% of cobalt resources are located in high-risk contexts. Reflecting heightened demand, major metals like iron and copper are set to disturb more land. Jurisdictions with high rates of ETM extraction in low risk contexts are positioned to develop and maintain safeguards against mining-related social and environmental risk factors. ESG pressures should feature in any future scenario planning in the transition to a low carbon future.

Background & aims

Improvements in material efficiency and recycling are not sufficient to meet the increasing demand for ETMs. Demand would have to be met through significant growth in resource extraction. The social and environmental implications of the anticipated rise in ETM extraction are rarely acknowledged in energy transition scenarios. This project aims to produce a global assessment of Environmental, Social and Governance (ESG) complexities associated with the extraction of ETMs. It uses a methodology developed to categorise and quantify 'source risks', i.e. risks surrounding the point of extraction. A global dataset of 6,888 mining projects covering 20 ETMs was analysed against seven ESG risk dimensions. Each dimension is a composite indicator built from aggregate measures available in the public domain. The geographic distribution of risk factors and their co-occurrence indicate varying levels of complexity within the contexts that host extractive activities. High-risk scores across multiple dimensions translate into a high degree of difficulty in mitigating future impact scenarios. Depending on the spatial distribution of extractive projects, ETMs exhibit different global risk profiles.

Collaboration & Details

The project is being carried out by researchers from various centres within the SMI with support from the UQ Complex Orebodies Strategic Program.

Project Leader:	John Owen, Eleonore Lebre (SMI)
Timing	2018 - 2021
Participants:	Rick Valenta, Deanna Kemp, Claire Cote, Kamila Svobodova, Martin Stringer, Andrea Arriata del Solar (SMI)

Outcomes

This research represents the first attempt to carry out a global assessment of the social and environmental complexities of extracting energy transition metals. It is important to note that the outcomes to date face uncertainties relating to the potential that available data is incomplete; external factors of vulnerability; and the use of proxies.

The project is successfully highlighting the complexities and potential constraints attached to the global supply of particular metals. It has also successfully identified hotspots and locations with particular combinations of ESG risks which may prompt gvernments, investors and other institutional actors to address acute forms of risk.

Deliverables & links

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Eleonore Lebre Presentation November 2020

Open Access Paper Lebre et al – Nature Communications

Melting metals as sustainable needs heat up

09/12/2019 - 12:42

Melting and recovering metals from scrapped electronic devices is just one of the solutions for the sustainable supply of critical materials being investigated by UQ researchers.

UQ's Pyrometallurgy Innovation Centre (PYROSEARCH) Director, Professor Eugene Jak, said the metals were needed for a new generation of electrical devices, including solar panels, computers, smartphones, batteries and fuel cells for electric cars and more.

"Part of the answer to ensuring a consistent supply lies in our existing electronic and other obsolete devices and how we dispose of them when they reach the end of their lifecycle," Professor Jak said.

"A smartphone alone can hold up to 20 different metals, which could be re-used in other technologies.

"By melting down these devices in high temperature processes, the critical metals can be retrieved and separated back into their original forms to be used again."

Associate Director of PYROSEARCH Professor Peter Hayes said the team had been working with industry for over two decades helping to develop technologies for the circular economy.

"PYROSEARCH is becoming an internationally recognised centre of expertise in the high-temperature processing and refining of metals," said Professor Hayes, a veteran pyrometallurgy researcher with around 50 years' experience in the field.

"We're working to establish advanced chemical databases, which will allow researchers to predict complex reactions, and refine high-temperature copper and lead processing technologies used to recycle these critical metals.

"This will ultimately lead to improvements in the production and recovery of key metal elements, enabling improvements in recycling and energy savings."

Professor Jak said the team was also focusing its attention on changing metals demand, such as copper, cobalt and nickel, which are essential for e-mobility, incorporating electric vehicles and batteries.

"Our research will enable industry to adapt to the changes in chemistry demands, modify existing and develop new technologies, increase efficiencies, improve recovery levels, reduce energy consumption and improve environmental impact," he said.

The projects are funded by a major Australian Research Council linkage grants and supported by a number of industry partners from around the world, including Umicore, a global materials technology and recycling group renowned for its sustainability practices.

UQ researchers recently met with leading metallurgical, recycling and advanced materials companies to discuss research collaborations.

"This is a new era for metallurgy; it's a very exciting time to be working in this field," said Professor Jak.

Media: EAIT Communications, comms@eait.uq.edu.au.

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Downstream Processing

Queensland spin-out set for a jump-start on electric vehicle battery supply

9 July 2018

With rising sales of electric cars, a new company developing more efficient production of essential battery materials is raising funds to build a demonstration plant.

Dr James Vaughan

Based on technology developed by The University of Queensland, Pure Battery Technologies Pty Ltd is commercialising a process to extract nickel and cobalt from low grade ores more cheaply and effectively than current methods.

The technology has been licensed to Pure Battery Technologies by UniQuest, UQ's commercialisation company.

Pure Battery Technologies Managing Director and CEO Bjorn Zikarsky said global demand for batteries was growing at about 15 per cent a year.

"This is driving up demand for both nickel and cobalt, with the demand for cobalt exceeding supply globally," Mr Zikarsky said.

"We are using UQ's patented acid leaching process to produce battery-ready nickel and cobalt products more easily, and at lower capital and operational expense."

"This process also offers a higher cobalt recovery than is currently possible, is energy efficient with little solid waste or tailings, and has a very small footprint."

Mr Zikarsky said the affordability and profitability of the electric vehicle industry had increased with game-changing advancements in battery technology.

"It's estimated that by 2025, almost half of all new energy generation will be renewable, and demand is increasing for battery-supported clean energy such as wind and solar," he said.

"Nickel is also used in the production of stainless steel and other metal alloys, and our process has very little environmental impact and consumes less carbon dioxide and chemicals compared to other processes."

Following the licence agreement with UniQuest, Mr Zikarsky said the company was working to raise the investment needed to build a demonstration plant to produce up to 5000 tonnes of nickel a year.

"We are excited by the interest from industry, which we believe is driven by a real need for this technology, together with greater consumer and corporate environmental consciousness."

"We are pursuing a diversified corporate strategy - in addition to developing our own battery material products, we aim to partner with other producers to enable them to benefit from this technology in other applications."

UniQuest CEO Dr Dean Moss said the technology was the result of eight years of research and development by UQ hydrometallurgists Dr James Vaughan and Dr Will Hawker.

"We have been working with Dr Vaughan and Dr Hawker since 2011 to commercialise this technology and to help them carry out extensive testing with major nickel laterite producers," he said.

"We're looking forward to Pure Battery Technologies taking the technology to market."

Media: UniQuest, Nicole Cowan, n.cowan@uniquest.com.au, +61 409 767 199.

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THE UNIVERSITY OF QUEENSLAND AUSTRALIA

Hydrometallurgy

The UQ Hydrometallurgy Research Group is developing a portfolio of high quality fundamental research across a range of hydrometallurgical processes relevant to industry sectors from base metals to Bayer alumina processing. Currently research is focused on a number of key aspects of processing including precipitation from aqueous solutions, ion exchange and membrane separations and leaching of minerals. The hydrometallurgy group is part of a holistic extractive metallurgy program and maintains close interaction with pyrometallurgists and mineral processers, with the aim of improving process routes for metal extraction and product recovery.

Downstream Processing

Thank you

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