THE UNIVERSITY OF QUEENSLAND
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CREATE CHANGE

Mine Waste Transformation through Characterisation (MiWaTCh)Group

Group Leader: Dr Anita Parbhakar-Fox

Anita has been working in environmental geoscience for 15 years. Anita started out in 2006 as an environmental consultant in London, UK after completing her geoscience degree at the Royal School of Mines, Imperial College, UK. Subsequently, she moved to Australia to work as a researcher in the AMIRA P843 geometallurgy project. This was her introduction to the Australian mining sector. Anita's role in this project was to investigate and develop new environmental applications for geometallurgical data with a focus on acid rock drainage (ARD) prediction. This planted the seeds for her subsequent PhD research at the Centre for Ore Deposit and Earth Sciences (CODES), University of Tasmania. During this time, she had the opportunity to explore and integrate a range of mineralogical and geochemical datasets with outputs from, what were at the time, new technologies in the mining sector (e.g., hyperspectral core scanners, microXRF instruments, field portable tools). Key outcomes of this research were the development of the acid rock drainage index and the geochemistry-mineralogy-texture-geometallurgy approach to ARD prediction. After completing her PhD in 2012 she started a postdoctoral position with CRC ORE and was part of the Environmental Indicators team. They developed small-scale and cost-effective methods for predicting the environmental impacts of future mine wastes with a focus on ARD, dust and metal bioaccessibility. Anita went on to work for the ARC Transforming the Mining Value Chain Research Hub where, in additional to continuing her research and supervision, she was additionally responsible for coordinating and lecturing into the Environmental Geology BSc and Geometallurgy MSc units from 2013-2018.

In 2019, Anita joined the W.H. Bryan Mining and Geology Research Centre as a Senior Research Fellow where she has founded a new team of Early Career Researchers- MIWATCH. In this role Anita has established major projects with both government and industry stakeholders looking at: i) new methods for extracting value from hyperspectral datasets to enable deposit-wide mine waste domaining, and ii) examining the secondary prospectivity of mine waste materials with many studied sites in Australia and South America. Anita is an active member of the geoscience community, as reflected by undertaking additional roles such as Assistant Editor of Minerals Engineering, guest editing special issues of Minerals and regularly leading international conference sessions on secondary prospectivity and ARD management (e.g., SGA 2019, PACRIM 2019, AESC 2021)

and giving keynotes and invited talks on similar topics. She is a passionate science communicator and was awarded the Materials World Award in 2018 from the UK's Institute of Materials, Minerals and Mining for an article on mine waste management.

Anita augering tailings, North Queensland

Dr Laura Jackson, Postdoctoral Research Fellow

Laura, is an environmental geologist, specialised in applied geochemistry and geometallurgy. Laura obtained her PhD at the Centre for Ore Deposit and Earth Sciences (CODES), University of Tasmania (2020). Her research was part of the ARC Transforming the Mining Value Chain Research Hub, developing new tests and protocols for improving waste characterisation with a focus on integrating waste characterisation across the entire mining value chain. Highlights of her research included the development of the geoenvironmental domaining index for neutralising potential domaining of waste rock using hyperspectral data. In addition to undertaking her PhD, Laura was extensively involved in science communication and outreach, including extending her knowledge of geoscience to primary school students through practical demonstrations and fieldtrips.

Professionally, Laura has worked at an environmental consultancy in Australia, as a senior geochemist. In this role Laura worked on a range of industry and government projects from prefeasibility through to closure and rehabilitation (2018-20). Highlights of this time included the development of new approaches towards geoenvironmental block modelling and investigations into neutralising capacity of different carbonate minerals.

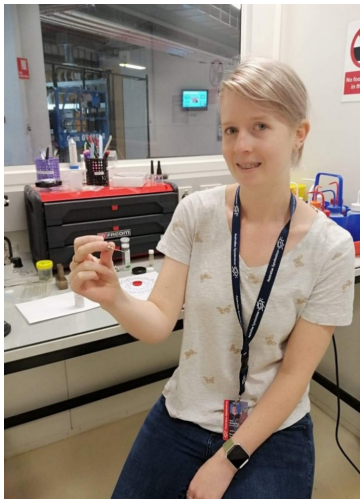
Laura's current focus is working with the Queensland State Government on a 4-year project focused on secondary prospectively of mine waste with a focus on critical mineral exploration. Laura has been leading stream 1 of this program, whereby mine waste across the state has been sampled and tested in a first-pass integrated geochemical and mineralogical work program to determine if there is critical metal endowment. Sites studied to date have included Mt Cuthbert, Horn Island, Rocklands, Mt Garnet, Herberton and Phosphate Hill. In addition, she has also established new projects back in her home state, Tasmania, looking at acid and metalliferous drainage mapping to inform effective management at historical mine sites.

Laura waste rock sampling in North Queensland

Dr Anne Whitworth, Postdoctoral Research Fellow

Anne is a geoscientist specialised in environmental geochemistry and hydrogeology. Anne completed her PhD at Monash University in 2020 where she studied and published multiple papers on the formation and behaviour of jarosite in acidic, sulphate-rich environments. Previously, Anne completed her honours research in geology and geochemistry at Agnew gold mine (operated by Goldfields Australia) in Western Australia. Anne then worked for BHP in Western Australia as a hydrogeologist where she was involved in surface and groundwater management, and acid mine drainage prevention and management, at planned, operating and historic mine sites. Anne's expertise includes experimental geochemistry, iron isotope geochemistry, applied mineralogy, sustainable groundwater management, and element analysis spectrometry. Anne also has significant experience in synchrotron X-ray powder diffraction and has been involved in several fieldwork programs including Monash University's meteorite expedition to the Nullarbor Plain in South Australia.

Currently, Anne is postdoctoral research fellow at the BRC. Anne is also involved in the four-year project on secondary prospectivity of mine waste in Queensland and is leading reviews examining the advances in mineral processing technologies suitable for extracting critical metals from secondary resources. Anne will be presenting findings from these reviews at the Sustainable Minerals '21 Conference in June. Outcomes from this project will also align with the drive to transform the mining industry into a circular economy system through sustainable and environmentally friendly practices, something Anne is passionate about. Anne plans to establish new research projects utilising geochemistry, applied mineralogy and hydrogeology to better understand the risks posed by mining and processing wastes to the environment, and examine and develop environmentally friendly practices to remediate these wastes and transform them into valuable materials.



Anne analysing jarosite at the Australian Synchrotron

Loren Nicholls, PhD Candidate

Loren is an experienced exploration geologist specialising in applied geochemistry, mineralogy and ore body knowledge, who has returned to the University of Queensland's Sustainable Minerals Institute (SMI) to undertake her PhD research.

Prior to joining the MIWATCH group, Loren spent 10+ years in the mining industry working as a mine and exploration geologist for Newcrest Mining and then as a senior exploration consultant. Her career has spanned projects in porphyry, epithermal, IRGS, skarn and reef-style sedimentary deposits across Australia, Fiji and Indonesia. Loren's technical expertise in geochemistry and geology focussed on building exploration models and ore body knowledge to drive strategic priorities, enhance resource models and improve mining processes. She has collaborated with multiple consulting and research groups in geochemical, spectral, geophysical, structural and metallurgical projects. Loren aims to apply her industry experience and knowledge to her research with MIWATCH and strengthen the link between research and industry applications.

Loren's PhD project is entitled "*Geometallurgical characterisation of mine waste at the Capricorn Copper Mine, Queensland: Exploring the potential for Cobalt recovery*" and is a collaboration between the Queensland Department of Resources and the Sustainable Minerals Institute. This research aims to integrate geochemistry, mineralogy, mineral processing, waste characterisation and environmental management into a framework for economic rehabilitation based on circular economy principles. She has a strong desire to improve sustainability within the mining industry through a multi-disciplinary approach to complex geological, metallurgical, and environmental challenges. Most recently, Loren has been awarded a 2021 Society of Economic Geologists Graduate Student Fellowship for her first year of PhD studies.

Loren at the Capricorn Copper Mine, Qld, Australia

Olivia Mejías, PhD Candidate

Olivia is a Chilean geologist with a master's degree in applied mineralogy to geometallurgy obtained at the University of Concepción in Chile. Olivia gained several years of industrial experience working at El Teniente underground mine (2012-19) where she worked in short-term geometallurgy and production geology and participated in the successful promoting of mine-plant integration. In this role Olivia introduced to the mine planning and mineral processing teams a data integration approach (using metallurgical chemical and mineralogical datasets on material from drawpoints) and through this defined new geometallurgical zones to assist with short-term mine planning. During this time, Olivia was the

supervisor of around 15 internships and undergraduate geology students. The geometallurgical methodology she developed was then introduced to another circuit plant, resulting in the establishment of more effective short-term mine planning for company.

Since 2020 Olivia has been working as a project geologist at SMI-ICE-Chile. She has been involved in several research projects where she has focused on the analysis of mineralogical, geochemical, and metallurgical data for applications with a focus on the recovery of cobalt. During this time, Olivia has been involved in extensive outreach through taking up a position as a blog writer for Geology for Global Development Blog (*https://blogs.egu.eu/network/gfgd/*) and she is part of the technical committee for Procemin-Geomet and Geomin-Mineplanning conferences. Olivia has presented research several webinars for Chile, Perú, Ecuador and Australia with the content focussed on "geochemistry and geometallurgy applied to critical metals: case studies in Chile" and "short-term geometallurgy applied at the El Teniente underground mine".

Olivia recently joined the BRC as a PhD candidate at the BRC-SMI. Olivia's PhD project is focussed on "*Understanding indium cycling and recovery in mine waste environments: a geometallurgical approach*". Olivia will be focussed on sites in NE Queensland with her research also part of the Queensland State Government´s 4-year New Economy Minerals Initiative (NEMI program). Olivia is passionate about being part of the team that brings sustainable mining to its applicability, and through this program, is seeking to acquire multidisciplinary experience at the SMI before returning to Chile.

Olivia is keen to put her knowledge into practice, encourage the circular economy, value mining waste, have a look far beyond copper, and of course train future generations with a focus on sustainable mining.

Olivia underground at the El Teniente Mine, Chile

Enrique Sáez Salgado, PhD Candidate

Enrique is a Chilean geologist with experience in both mineral exploration and academia. Enrique obtained his BSc in 2013 and professional degree in 2016, working in polymetallic deposit tailings from southern Chile, participating as a researcher in the project "Secondary Mining - Recovery of strategic elements from mining residue deposits from selected locations in Chile". This was undertaken through the 'SecMinStratEl' project sponsored by the Universidad de Concepción (Chile) and TU Bergakademie Freiberg (Germany). Enrique participated as an associate lecturer in Mineralogy, Petrology and Structural Geology at the Profesional Institute Virginio Gómez and as a researcher for the Institute for Applied Economic Geology (GEA-UdeC). He has also worked as an exploration geologist and information support officer in Quantum Pacific Exploration Chile and Laguna Gold Ltd. Currently, he is part of the Water Research Center for Agriculture and Mining (CRHIAM), UdeC, as an associated researcher, and works also as a geotechnical geologist for engineering and construction companies in mining projects.

Enrique was recently awarded a "Becas de Doctorado en el Extranjero, Becas Chile, Convocatoria 2020" scholarship by the Chilean Government, through the National Agency for Research and Development (ANID). Enrique's PhD research, starting in July 2021, will focus on "*Forecasting the geoenvironmental properties of the Quebrada Blanca porphyry Cu-Mo mine wastes*" where he will primarily focus on extracting environmental features and developing indices using hyperspectral mineralogy.

Enrique undertaking fieldwork and drill core analysis in Chile

Kristen Isbel, PhD Candidate

Kristen is a geoscientist whose studies focused on geochemistry, hydrogeology and water chemistry. Kristen completed her Honours at Monash University in 2020. Her thesis studied the effects of soil wettability on water repellency and the rate of recovery of eucalypt

soils post bushfire in Eastern Victorian. Over 8 months, the hydrophobicity of soil samples collected from a prescribed burn area were studied. In petri dishes, water droplets were dropped from above onto the soil surface from to replicate low-intensity rainfall on the soil surface. Varying degrees of soil saturation were also used to examine if hydrophobicity was dependent on the level of soil saturation. During her studies, Kristen worked as an assistant Chemist at Nature's Organics formulating personal care and household products. While working as a chemist Kristen was tasked with reducing the aquatic and eco toxicity of products, reformulating products with palm-oil free raw materials as well as exploring the stability of new products.

Kristen has worked as a Consultant Hydrogeologist at Klohn Crippen Berger. Her most recent project analysed the geochemistry of groundwater tables in regional NSW. Post-fieldwork, the water levels and mineralogy of the groundwater samples were investigated to see how groundwater is used in regional NSW. Management programs and bore integrity assessments have been suggested alongside the chemical analysis of samples. Kristen has also performed desktop studies on the Condamine River as well as rainfall and recharge dataset for Office of Groundwater Impact Assessment.

Kristen will join MIWATCH as a PhD student in July 2021. Kristen's project will focus on "*Determining the geochemical and mineralogical properties of spent heap leach materials: Opportunities for economic rehabilitation*". Sites in NW Queensland will be studied as a part of her research, which aligns with Kristen's passions in the field of sustainable maintenance and closures of mines and active materials.

Kristen conducting groundwater sampling, NSW, Australia

MIWATCH's Research Focus

The global interest in mine waste reuse has increased significantly over the past five years motivated primarily by the mining sector seeking to reduce environmental footprints and legacies (motivated by the sustainable development goals) and the desire to satisfy the growing demand for critical (or technology) metals with mine waste viewed as a potential supplementary secondary resource. Motivated by this, the BRC have established the Mine Waste Transformation through Characterisation or 'MIWATCH' group. Their mission statement is to apply geometallurgical tools to enable the geoenvironmental characterisation of mine waste across the life-of-mine.

Research focus areas for the MIWATCH team

For More Information, please contact:

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