

2024 ANNUAL REPORT



CODES

UNIVERSITY of
TASMANIA 
CODES



VISION

To be the premier international research centre in ore deposit geology.

MISSION

Significantly advance collaborative and innovative ore deposit research for Australian and international researchers and the minerals industry.

GOALS

- Undertake and publish high-quality research.
- Lead the global minerals industry in research on the exploration and recovery of new mineral resources.
- Equip the Australian minerals industry with world-class graduates.
- Communicate the Centre's research to the wider research, industry and general communities.

ABOVE: This photo was taken at Bellingham in northern Tasmania in mid-February 2024 during the second week of the Advanced Field Skills in Economic Geology short course. The students are (L–R): Megan Weatherman (MEconGeol), Fuseini Atanga (PhD) and Steven Rennick (MEconGeol).

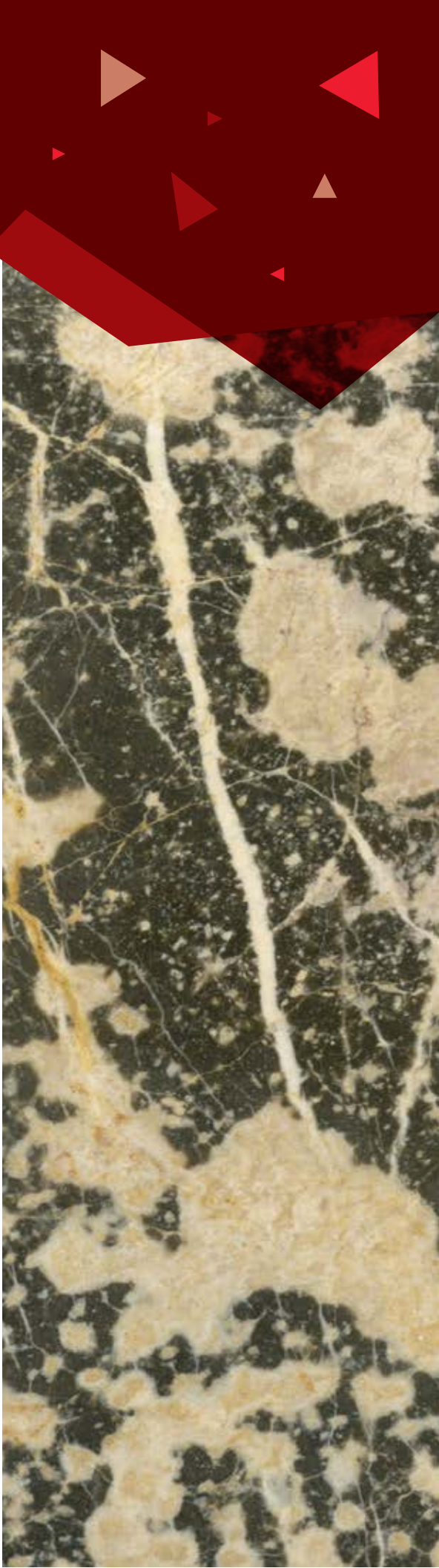
FRONT COVER: Associate Professor Lejun Zhang photographed by Professor David Cooke during a fieldwork trip to Nevada in late January 2024. Here Lejun is collecting white mica samples in Yerington as part of CODES' research activities within the Amira P1249 project.

BACK COVER: Course participants working hard in the Mineral Resources Tasmania core shed at Mornington in Hobart during the first week of the Advanced Field Skills in Economic Geology short course, February 2024.

OPPOSITE: Gusano texture from the Wagen Project, Nevada. White patches consist of pyrophyllite – topaz – alunite – diaspore in a massive quartz altered matrix.

Contents

DIRECTOR'S REPORT 2024	2
PROFILE AND RESEARCH STRUCTURE	8
STAFF AND MANAGEMENT 2024	11
PROGRAM 1: ORE DEPOSITS AND MINERAL EXPLORATION	16
PROGRAM 2: GEOMETALLURGY AND GEOENVIRONMENT	26
PROGRAM 3: SEDIMENTATION, TECTONICS AND EARTH EVOLUTION	34
PROGRAM 4: MAGMATIC AND VOLCANIC PROCESSES	42
PROGRAM 5: ANALYTICAL RESEARCH	54
PROGRAM 6: GEOPHYSICS AND COMPUTATIONAL GEOSCIENCES	60
REGIONAL RESEARCH COLLABORATION: CRITICAL METALS PROJECT	66
TRAINING AND EDUCATION	76
OUTREACH AND MEDIA	88
INDUSTRY LINKS AND RESEARCH COLLABORATIONS	92
TECHNOLOGY TRANSFER	94
PERFORMANCE INDICATORS	98
FINANCES	100
PUBLICATIONS 2024	104
APPENDICES	118



Director's report 2024



CODES was established in 1989 as an Australian Research Council (ARC)-funded key centre that focused on ore deposit and mineral exploration research and training. After many years of growth and evolution, 2024 marks 35 years of outstanding achievements and sustained excellence in research, graduate training, and industry engagement and impact by CODES' staff and students.

CODES is a genuine anomaly in the UTAS organisational structure. Its success caused it to rapidly grow to be far larger than its affiliated academic discipline (Earth Sciences) in terms of personnel, funding and stakeholder engagement, a situation that continues to the present day. CODES is also an anomaly in terms of its longevity, which is a testament to sustained research funding success. There are now very few employees remaining at UTAS who were employed by the university at the time of CODES' inception, including all the current CODES staff, although several of our adjuncts were part of the foundational team for our research centre, providing a connection to our foundations.

By achieving and sustaining its reputation for excellence over the past 35 years, CODES established a brand that today is globally recognised and highly valued by the international

minerals industry, and by our academic research colleagues in the field of Economic Geology. Our team is renowned in terms of applied research and training across the mining value chain, and for global leadership in several areas of fundamental Earth Sciences research, notably including volcanology, geodata analytics, analytical geochemistry, geochronology, geodynamics and igneous petrology. Our industry training opportunities are highly valued by industry professionals, through 35 years of delivery of the Master of Economic Geology program, which continues to grow steadily in terms of student enrolments and industry participation.

▼
2024 marks 35 years of outstanding achievements and sustained excellence in research, graduate training, and industry engagement and impact by CODES' staff and students

It is very pleasing to see our team's passion, drive and commitment to excellence has been sustained through 2024, with major and greatly appreciated contributions from our academic staff, postdoctoral fellows, PhD students and professional staff. The 2024 Annual Report highlights how we sustained excellence across key areas of academic endeavour at CODES, and showcases the significant contributions made by our research team members.

Research highlights

2024 saw unprecedented individual research success for CODES staff in the Australian Research Council (ARC) funding schemes. Associate Professor Rebecca Carey was awarded a four-year Future Fellowship from the ARC – these are one of the most prestigious individual grants awarded by the Australian Government and are extremely difficult to win as they are available across all areas of academic endeavour. Rebecca's success is testament to her sustained and impactful research excellence and science communication throughout her research career. The ARC funding of Rebecca's project into 'Decoding risks and unlocking rewards of oceanic volcanism' will allow Rebecca to substantially grow our volcanology research team in 2025 with the



In July 2024 CODES hosted a highly successful Critical and Strategic Metals Symposium, which brought together more than 100 participants from across Australia and the world. Here many of the more than 100 attendees are pictured outside the Geology building on the UTAS Sandy Bay campus.

recruitment of new research staff and graduate students. This funding will allow Rebecca to move from her current role as a balanced (teaching and research) academic who works in both CODES and Earth Sciences to a full-time CODES research scientist from 2025 to 2029.

Further success with regards to ARC funding came with Dr Sheree Armistead's success in winning a DECRA fellowship. The DECRA scheme is designed to accelerate the research careers of the most innovative and creative early career researchers, and this award establishes her as one of Australia's leading early career researchers in Australia's Earth Science community. Sheree's research, which is scheduled to commence in mid-2025 will resolve the plate tectonic and climatic processes that influenced the formation of the giant Neoproterozoic Cu-Co mineral systems of the Central African Copperbelt, the time-equivalent sediment-hosted Cu deposits of the Adelaide Superbasin and the apparently barren Neoproterozoic basin of NW Tasmania.

The Regional Research Collaboration (RRC) project 'Building capacity in Regional Australia to enhance Australia's economy through research, training and environmentally sustainable production of critical metals' entered its peak period of

field- and laboratory-based research in 2024. With 11 PhD students and 15 UTAS staff members from CODES, the School of Education, and the Central Science Laboratory, this project is the largest research effort investigating Tasmanian mineral deposits, their geological settings, and their mineral processing attributes, for over two decades. With PhD students working at 10 Tasmanian mine sites and exploration projects, the project has delivered major new insights into critical metal deportment and potential recovery strategies across Tasmania's diverse spectrum of base, precious, ferrous and critical metal deposits. The collaboration between CODES and staff from the School of Education has been highly productive, providing novel insights into the potential barriers to STEM engagement for young people living in the West Coast region of Tasmania. 2024 saw many members of the team presenting research findings at national and international conferences, and the first publications generated by the RRC team. The major highlight of the RRC's year was the three-day Critical and Strategic Metals Symposium organised by our early career researchers and PhD students, which was held at CODES in July 2024. This symposium brought together national and international academic, government and industry experts to discuss the geology, origins and

processing challenges of critical and strategic metal deposits, including REE, Cu, Co, Ni, PGE, Sn and W. A total of 97 participants attended in person, and another 37 joined online from seven countries.

Our largest collaborative research project, Amira P1249 'Exploring, characterising, and optimising complex orebodies – Integrated deposit knowledge to add value across the Mining Value Chain' reached the mid-point of its five-year research program in 2024, finalising its cohort of PhD and MSc students so that all subprojects in the program are now well underway. All three research modules achieved major milestones in 2024, with significant new insights into exploration vectoring and fertility assessments in the transition zones, significant advances in characterisation and domaining for improved orebody knowledge through the integration of geochemical, hyperspectral and geological data sets, and successful technology transfer workshops. These provided industry sponsors with practical applications, workflows and methodologies for integration of field- and laboratory-based geological and geochemical data sets to accelerate exploration decision making and discovery, and to provide robust mineralogical characterisation of orebodies across multiple scales.

Industry collaborations

As part of the undergraduate training delivered by the Discipline of Earth Science at UTAS, our third-year Mineral Exploration unit (KEA343 – coordinated by Associate Professor Lejun Zhang) has been running field training camps for the student cohort to give them field experience in mineral exploration. Through the strong support of the Bluestone joint venture at Renison Sn mine, in August 2024, our staff took a group of 20 third-year students to conduct magnetic and IP surveys and soil sampling across a near mine exploration target near the Renison mine site. The students gained the full western Tasmanian winter field experience – steep slopes, thick vegetation, heavy rain, freezing cold weather and a short lightning storm that delayed field activities – they loved it! After conducting the surveys, the students brought their samples back to Hobart and conducted laboratory analyses and data processing for their final report. They were very excited to have found coincident geochemical and geophysical anomalies that will be followed up by this year's class – a great outcome to inspire them at the start of their professional careers. A big thank you is owed to the Bluestone joint venture for allowing us to work with them on this inspiring training program for our undergraduate cohort.



Associate Professor Lejun Zhang (left) and PhD student Jaime Osorio seen here in Nevada, USA, during a two-week field trip in October working with Amira project sponsor AngloGold Ashanti on the codesign and implementation of a geochemical sampling and geological survey program.

On the research side, the P1249 team continually seek to find innovative ways to facilitate industry engagement and knowledge transfer as part of the project's third research module (Technology Transfer). In October 2024, three members of the Amira P1249 research team (Lejun Zhang, Jamie Osorio and David Cooke) spent two weeks working with project sponsor AngloGold Ashanti (AGA) on the codesign and implementation of a geochemical sampling and geological survey program in Nevada. This novel active exploration site test involved the three researchers along with 11 AGA geologists working in three teams to

conduct mineral and whole rock geochemical sampling across the study site. Every night during the field campaign, all participants would work together to review the day's observations and findings and to discuss their implications for exploration, and to help modify the sampling program as it evolved. The researchers provided nightly presentations to highlight the exploration and genetic significance of key features observed that day. All involved in this two-week field campaign found it a highly effective way to identify and test hypotheses, fast track exploration targeting, and to build strong collaborative relationships between industry and academia. The analytical program stemming from that work will be reported in 2025, with AGA to test the findings in their ongoing exploration throughout 2025 and 2026.

CODES staff and students delivered several workshops to our industry partners and at international conferences. These ranged from one-on-one training sessions with representatives of individual companies, to conference workshops involving up to 200 participants. Our major collaborative research projects delivered their latest research results to industry and government research partners through sponsors' research meetings on several occasions through the year. Most of these meetings involved in-person attendance at CODES together with online domestic and international participation. The RRC team delivered a one-day research update meeting in Tullah (Western Tasmania) in November

attended by approximately 40 people with guest speakers Professor David Giles (MinexCRC) and Professor Ross Large (CODES).

Awards and accolades

In addition to the Future Fellowship for Rebecca Carey and DECRA for Sheree Armistead, several of our staff, students and adjuncts were recognised by their peers for scientific excellence. Jamie Osorio was a coauthor on the prizewinning paper 'A reevaluation of the timing and temperature of copper and molybdenum precipitation in porphyry deposits' by Federico Cernuschi, John H Dilles, Jamie Osorio, John Proffett and Kalin Kouzmanov. This paper was awarded the SEG's Brian J Skinner Award for best paper in *Economic Geology* in 2024. Ivan Belousov was awarded a certificate by Wiley International for his top-cited article 'STDGL3, a reference material for analysis of sulfide minerals by laser ablation ICP-MS: An assessment of matrix effects and the impact of laser wavelengths and pulse widths'. CODES Adjunct and former Master of Economic Geology course coordinator Dr Tony Webster received the Distinguished Service Award from the Tasmanian Branch of the Australian Institute of Geosciences. Several of our students were awarded Hugh E. McKinstry Fund research grants from the SEG: Angela Costa, Javier Gil Rodriguez, and Jamie Osorio. Additionally, Giovana Pimentel was awarded an SEG Graduate Student Fellowship. Shannon Frey won the best student poster award at the 37th International Meeting of Sedimentology, and Peerapong Sritangsirikul was judged the best oral presentation at the 1st Mahidol University International Geoscience Conference in Thailand.



A large group of CODES staff and students attended the 2024 SEG Conference in Windhoek, Namibia, in September. They are (L–R): PhD students Nelao Natukondje Naimbale, Axel Cima, Poliana Vidal Salgado, Angela Costa and Damian Braize; staff members Dr Sheree Armistead and Professor David Cooke; Honorary staff member Dr David Selley and his daughter Frankie Selley (geology undergraduate). PhD student Victor Torres also attended.

Masters courses

2024 saw another full year of training for industry geologists enrolled in our Master of Economic Geology and Graduate Certificate in Economic Geology. A particular highlight was our biannual field course on Volcanology and Mineralisation in Volcanic Terrains, which involved two weeks of intensive field training in New Zealand and Tasmania in March, providing students with the opportunity to learn about volcanic processes and products from diverse subaerial and submarine volcanoes that spanned the basaltic to rhyolitic spectrum. They also learned about modern geothermal and ancient epithermal systems, and the VHMS deposits of western Tasmania. Our students also had the opportunity to

improve their structural and alteration mapping skills in our Advanced Field Skills in Economic Geology field course, which was delivered in western and NE Tasmania in February. Our flagship Ore Deposit Models and Exploration Strategies course included the three-day Critical and Strategic Metals Symposium, and was our most popular course for the year, with 134 attendees in-person and online. We also delivered our annual Fundamentals of Economic Geology and biannual Exploration in Brownfields Terrains unit. Domestic enrolments continue to grow, with the Graduate Certificate now providing an effective pathway for students to 'try before they buy' as they complete two units to assess whether to commit to the full Masters program, as the Graduate Certificate units also count towards the Masters.

Conferences and trips

In addition to the CODES Critical and Strategic Metals Symposium, our staff and students were actively involved in promoting their research results at multiple conferences, including Roundup (Canada), Australian Mine Waste Symposium (Brisbane), MetFest! (Burnie), IODP3 Workshop (Japan), Annual Geoscience Exploration Seminar (Alice Springs), IODP398 post-voyage workshop (Greece),



The 2024 Volcanology and Mineralisation in Volcanic Terrains Masters short course to New Zealand and western Tasmania was highly successful. Here participants are pictured in New Zealand with the Devil's Bath in the background.



Associate Professor Rebecca Carey received an ARC Future Fellowship in 2024, which will provide four years of funding for her project called 'Decoding risks and unlocking rewards of oceanic volcanism'.



Dr Sheree Armistead was awarded an ARC Discovery Early Career Researcher Award (DECRA) in 2024. Her project is entitled 'The interplay of tectonics and climate on critical minerals in deep time'.

Symposium on Mineral Exploration Methods (China), Gordon Research Conference (USA), International Meeting of Sedimentology (Scotland), European Workshop on Laser Ablation (Belgium), Hyperspectral Mineralogy Workshop (Canberra), International Cu-Ni Symposium (Canada), Goldschmidt Conference (USA), International Geological Congress (Republic of Korea), Australian Critical Minerals Conference (Brisbane), International Conference on Acid Rock Drainage (Canada) and the International Applied Geochemistry Symposium (Adelaide). Additionally, around 10 of our staff, students and adjuncts participated in the annual SEG Conference in Namibia, where PhD student Nelao Natukondje Naimbale was significantly involved in helping to organise and present the Early Career Researcher Day.

The CODES SEG Student Chapter organised a two-week field excursion to Japan in September 2024, where participants had the opportunity to learn about high and low sulfidation epithermal deposits, volcanology and geodynamics in Kyushu, and the Kuroko deposits and modern geothermal systems of Honshu. This trip was strongly supported by the Kyushu and Aikita universities' SEG student chapters and academic staff, and provided an excellent forum for scientific exchange and industry engagement, with seven industry geologists joining the trip from Newmont, Gold Road, AngloGold Ashanti and Lakeside Minerals.



Dr Paul Olin (right) pictured during an event to mark his departure from CODES in February 2024. Professor David Cooke (centre) expressed his thanks for Paul's contributions to CODES with support from Professor Sebastien Meffre.



During 2024 the CODES Analytical Laboratories took on three new staff members (L-R): Dr Alice MacDonald, Dr Carlos Carrasco Godoy and Dr Jack Ward.

Staff changes

Dr Paul Olin, Leader of CODES Analytical Laboratories, resigned from UTAS in February 2024 to take on an exciting new opportunity at the University of Adelaide. Paul worked in the laboratories for 11 years, and was enormously valued by all our team, thanks to his optimism, generous spirit and wicked sense of humour. His strong support and mentorship of the laboratory staff during two years of turbulence was vital to their health and wellbeing and helped the labs to evolve and grow. Laboratory Analyst Maxwell Morissette also departed CODES Analytical Laboratories in the first half of 2024 to take up a new career opportunity with the minerals industry in Western Australia, and Dr Max Hohl, who had been working on a casual basis in the laboratories since completing his PhD, departed CODES to take up a postdoctoral fellowship at MDRU in Canada.

Following Paul, Maxwell and Max's departures, several new appointments needed to be made in the laboratories to cover staff shortfalls and to ensure a smooth transition to the management of the laboratories. The laboratories' Deputy Leader, Dr Jeff Oalman, was appointed as the new Manager of CODES Analytical Laboratories. Additionally, three new staff were appointed in continuing full-time positions, providing stability to the laboratories and resolving the issues that staff shortfalls had created for some aspects of the labs' operations. Dr Carlos Carrasco Godoy was appointed as the Lead Laboratory Analyst, joining us after completing his PhD study of porphyry copper fertility using zircon chemistry in northern Chile, and a short stint as a postdoctoral research fellow at Curtin University. Dr Alice MacDonald was recruited to the role of Laboratory Analyst, joining us after completing her PhD on clinopyroxene chemistry from Mt Etna at the University of Queensland. Also joining us from the University of Queensland as Assistant Laboratory Analyst, Dr Jack Ward completed his PhD on the role of slab tears for magma fertility and porphyry mineralisation. Dr Valerie Yuleridge from James Cook University also worked in the laboratories on a casual basis for a six-month period during this protracted period of staff recruitment. These changes benefited us considerably, as the influx of passionate and enthusiastic early career researchers into the CODES Analytical Laboratories team has stimulated new research endeavours and analytical methods developments, allowing the laboratories to grow and diversify under Jeff's guidance while maintaining their global reputation for excellence in microanalysis and geochronology.

Other significant staff developments that we celebrated in 2024 included Dr Owen Missen, our Environmental Geochemistry lecturer, being converted from a fixed term to a continuing position. Research Fellow Dr Jeff Steadman was promoted from Level B to Level C, and Dr Zebedee Zivkovic joined CODES as a research fellow working on a Geoscience Australia-funded project after completing his PhD.

Sadly, 2024 saw the passing of Professor David H Green, former head of the UTAS and ANU Geology Departments, and a well-loved adjunct of our team since his return to Hobart in retirement in 2008. David was responsible for building UTAS' global reputation for petrology research, recruiting Tony Crawford, Trevor Falloon and many other impactful staff and students to UTAS during his tenure here. He was also a driving force in the establishment of IASOS (Institute of Antarctic and Southern Ocean Studies), the forerunner to IMAS (Institute of Marine and Antarctic Studies), UTAS' largest research institute. Vale David – you are deeply missed.

Publications

Our team continued to produce high-quality publications throughout 2024, although our annual publication output (41 papers) remains lower than we achieved in many years of the previous decade due to a higher

Statistics at a glance 2024	
Academic research staff	41
Postgraduate students	131
Major research projects	49
Countries involved	35
Publications in refereed journals	41
Research reports to industry	194
Worldwide collaborations	
Industry	60
Institutes and universities	73
Workshops and short courses	
Number	21
Countries	5 plus online delivery
Attendees	~780
Funding	
Industry	\$1.73 million
UTAS	\$2.35 million



CODES PhD students (L–R) Acacia Clark, Vinicius da Cruz and CODES/ES staff member Dr Owen Missen at the launch of the new edition of Professor Ray Cas's book *Volcanology: Processes, Deposits, Geology and Resources* in late October 2024.

emphasis on industry reporting from our applied research teams and laboratory staff (194 reports). In 2024 CODES and Monash University Adjunct and Emeritus Professor Ray Cas published a substantially updated and revised version of his iconic 1987 publication *Volcanic Successions*. The publication of *Volcanology: Processes, Deposits, Geology and Resources* was celebrated with a gathering of CODES staff and students, followed by two in-person presentations by Ray to CODES, and then to the broader Geological Society of Tasmania (Tasmania Division) membership in late October.

The year ahead

2025 looks to be another exciting and productive year for our team. Rebecca Carey and Sheree Armistead will commence their Future Fellowship and DECRA projects. The RRC team will have their final sponsors' meeting in October, and will showcase their research results to an international audience of industry, academic and government geologists as part of the seven-day field excursion called 'Tasmania's diverse array of base, precious, critical and strategic metal deposits' to be presented by CODES staff and students as part of the Society of Economic Geologists' annual conference. Our team will also present a five-day field excursion as part of the same conference that showcases our research findings on the 'Porphyry and epithermal deposits of the Macquarie Arc NSW'. The Amira P1249 research team will lead a five-day technology transfer field excursion to the Yerington porphyry district in Nevada, and our team will present new research findings

at major conferences, including PDAC, Goldschmidt, SGA, SEG and AEGS. Our SEG student chapter plans to collaborate with the student chapters from the Colorado School of Mines and Hefei University of Technology on a two-week field excursion to the skarn, porphyry and IOA deposits of the Middle and Lower Yangtze Metallogenic Belt in China.

In terms of new research initiatives, several exciting new research proposals are being developed that should lead to several new industry-funded and collaborative projects commencing in the new year. A high priority is for us to start our major new sediment-hosted copper research initiative, and so 2025 will see intensive industry engagement as we seek to finalise funding for that project. We also have some very exciting new research developments in spectral geology that will continue to grow our industry partnerships and engagement and will lead to a major new industry-funded research project opportunity in the new year. We will finalise the commissioning of our mineral processing laboratory, to facilitate research and commercial work into optimising critical and strategic metal processing options. CODES Analytical Laboratories will continue to work on new innovations in ICP-ToF and other analytical methods that we will apply to diverse geoscience issues across the applied to fundamental research spectrum.

David Cooke

Professor David Cooke
Director of CODES

Profile and research structure

An overview

CODES commenced operations in 1989, evolving over two-and-a-half decades from an Australian Research Council-funded Key Centre to a Special Research Centre and then a Centre of Excellence. Now in its fourth decade of operations, CODES is known as the Centre for Ore Deposit and Earth Sciences. Based at the University of Tasmania, CODES has grown substantially over the years and is regarded widely by industry and academia as a global leader in ore deposit research and postgraduate training. With 41 highly qualified research staff and 131 postgraduate

students, CODES is one of the largest university-based teams of ore deposit researchers in the world.

Highly productive worldwide collaborations have been developed with over 60 industry companies, plus a host of joint research initiatives with 73 institutions and universities – 17 in Australia and 56 overseas. It currently has 49 major research projects spanning 35 countries, across six continents. It is also a leading academic group to publish in *Economic Geology*. In 2024, CODES has maintained its reputation for delivering excellence in technology transfer by producing 194 reports to industry and

conducting 21 short courses, workshops, conferences and field trips. The online learning format continued to prove popular as it allowed participants from remote locations, who would not otherwise have been able to attend, to join these courses and workshops.

Industry-focused research

CODES' research is conducted within and across six research programs (see CODES Research Program Structure graphic below). Our research spans a range of fundamental and applied activities, and our industry-focused research aims to develop new exploration techniques for mineral discoveries,



The Master of Economic Geology short course Advanced Field Skills in Economic Geology ran in February 2024; here participants are pictured at Bluestone Bay on the Freycinet Peninsula in Tasmania, with Professor David Cooke standing on the right. The photo was taken by course co-ordinator Dr Robert Scott.

and new practices for sustainable mining, mineral processing and waste management. Our research across this spectrum of activities allows CODES to provide the minerals industry with a constant supply of world-class geoscience graduates and creates the platform for our training and upskilling of minerals industry professionals through our highly regarded Master of Economic Geology and Graduate Certificate in Economic Geology programs.

Training and education

As noted, training and education at CODES provides an ongoing supply of highly sought-after geoscience graduates, and delivers a range of professional development short courses and workshops tailored to meet the needs of the minerals industry in terms of upskilling its workforce. The schedule for these courses varies in line with demand. Postgraduate courses are offered at the following levels:

Honours

A one-year degree that will significantly increase employment options or can be used as a stepping-stone to a PhD. Courses are available in Economic Geology, Geophysics, Geochemistry and Environmental Geology.

Graduate Certificate in Economic Geology

This postgraduate offering, introduced in 2021, is designed for professional geoscientists keen to gain a stronger understanding of ore deposits, either for professional development, or as a foundation for further postgraduate training. This one-year degree requires completion of the unit 'Fundamentals of Economic Geology' and one other unit from the Master of Economic Geology coursework offering. Students who complete the GCert can attain the Master of Economic Geology by completing a further six units from the Masters program.

Master of Economic Geology

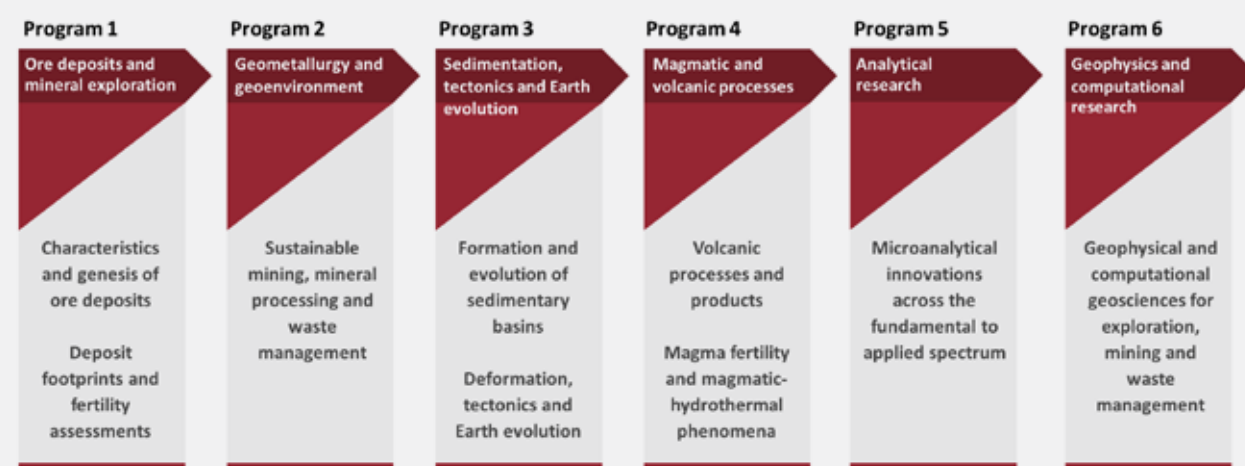
Industry geologists can participate in a series of intensive, predominately two-week courses aimed at the working geologist in order to upgrade their skills; the MEconGeol is available in coursework only (8 units) and coursework (6 units) plus research thesis options. The degree is part of the national Minerals Geoscience Masters (MGM) program. In 2024 a total of five MEconGeol units were offered: Advanced Field Skills in Economic Geology, Volcanology and Mineralisation in Volcanic Terrains, Fundamentals of Economic Geology, Ore Deposit Models and Exploration Strategies, and Exploration in Brownfield Terrains.

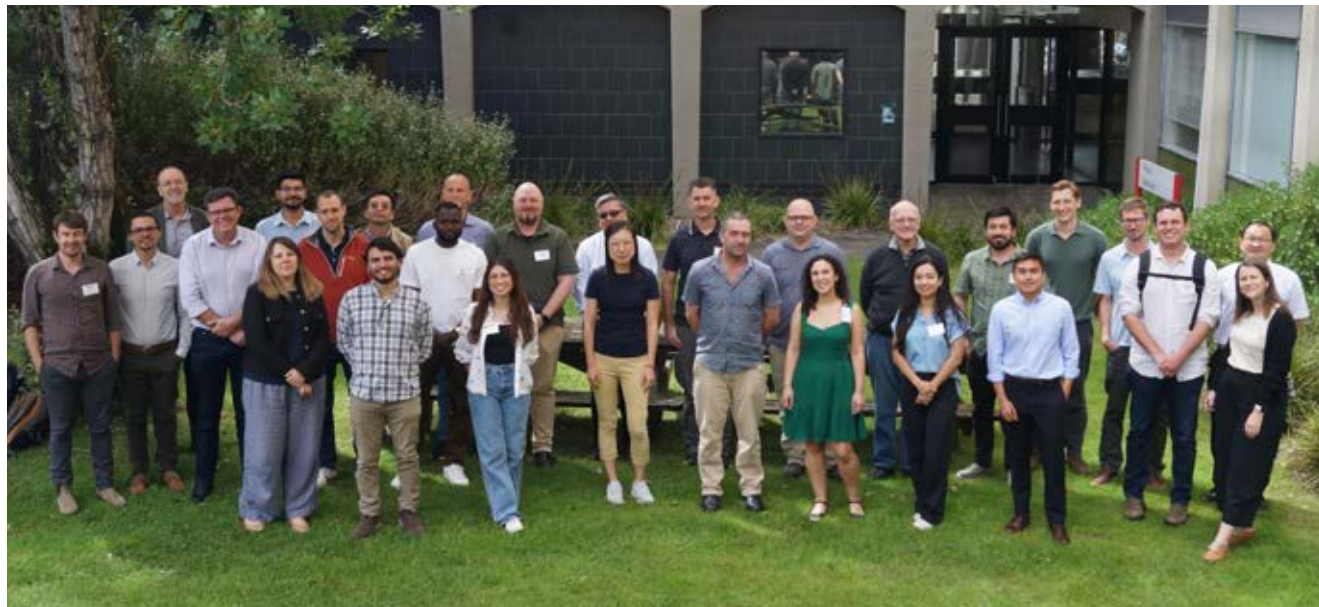
PhD and MSc

These higher degree by research (HDR) programs enable students to complete their theses in an environment that provides access to

CODES Research Program Structure

The CODES Research Program Structure covers the full spectrum of research from fundamental to applied:





Participants in the Amira P1249 Sponsors' Review Meeting 6, held in December 2024, pictured in the CODES Rock Garden at UTAS.

state-of-the-art technology, exceptional links with industry, and supervisors who are international leaders in their respective fields.

Research facilities

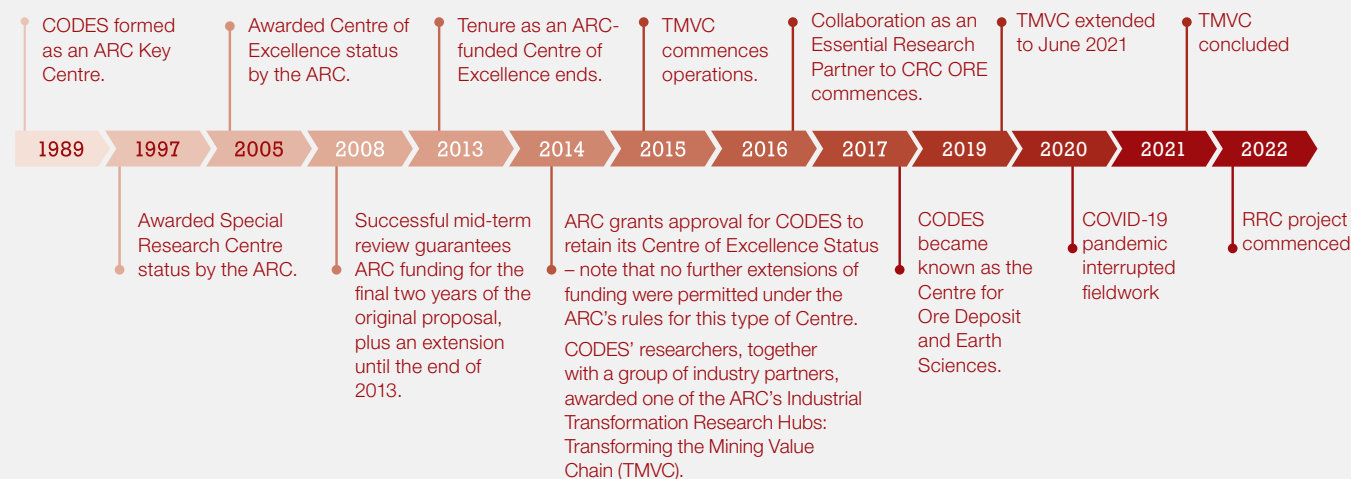
CODES Analytical Laboratories contain state-of-the-art analytical facilities for a wide range of geological analyses, encompassing the routine multielement analysis of sulphide and oxide minerals, including the full range of platinum group elements; U/Pb dating of a wide range of minerals including zircon, monazite, apatite, rutile and titanite; multielement analysis of silicates;

Lu/Hf dating of garnet and apatite; and elemental imaging of minerals and rocks. These facilities include four laser ablation ICP-MS laboratories specialising in ore deposit applications, an XRF laboratory, a solution ICP-MS laboratory and clean room, a fluid/melt inclusion laboratory, a lapidary department and sample preparation facilities. In addition, portable analytical techniques are provided, including shortwave infrared (SWIR) and portable XRF.

CODES has reciprocal access arrangements with the UTAS Central Science Laboratory, which has an

extensive suite of complementary equipment, particularly in the areas of electron microscopy and mineral liberation analysis (MLA), X-ray microanalysis, laser Raman and FTIR spectroscopy, and ICP-MS. CODES has established its position at the leading edge in mineral chemistry research for exploration through the development of unique analytical techniques, data processing and screening methods, and calibration standards, combined with employing staff who have extensive expertise in analytical protocols and the interpretation of results.

Timeline



Staff and management 2024



The CODES/ES team pictured on the Sandy Bay oval after the 2024 Garry Davidson Memorial Footy Match in May 2024. They are (L–R): Dr Matt Cracknell, Dr Owen Missen, Dr Rob Scott, Dr Karin Orth (holding trophy), Dr Mike Baker, Dr Martin Jutzeler, Professor Sebastien Meffre and Ryan Brunton (Digital Futures Manager for UTAS), who was drafted in to assist.

Centre Director

Professor David Cooke has been the Centre Director since mid-2017; he is responsible for the scientific leadership and operational management of the Centre. Also providing support to these roles are the Advisory Board and the Executive Committee.

Advisory Board

The Advisory Board meets at least once a year to review the progress of the Centre and to advise on future directions. The Board is composed of representatives from major Industry Partners, University of Tasmania senior management and key national geoscience organisations. It is chaired by Dr Paul Heithersay from the Department for Energy and Mining,

South Australia, who has extensive experience in the minerals industry and the public service. Dr Anthony Harris from Newmont was nominated as Deputy Chair following Paul Agnew's retirement during the year. In 2024 an Advisory Board meeting was held on 17 April and another took place on 4 December.

Executive Committee

The Executive Committee consists of the Centre Director, Deputy Director (vacant), Head of the Discipline of Earth Sciences, and a representative from the areas of applied research, fundamental research, education and administration. It meets approximately six times a year, working closely with the Director to develop the Centre's goals, strategies and research directions.

Annual Review

The Annual Review is an annual one-day forum of presentations relating to the Centre's research. The membership is wider than that of the Advisory Board and includes representatives from partner companies, research collaborators and other geoscience stakeholders. The Annual Review is designed to provide stakeholders and interested parties with an opportunity to see the breadth of the research conducted at CODES and to influence future research directions. In 2024 there was again no Annual Review in order to mitigate ongoing workload issues.

Staff movements

Appointments

Academic/research staff

Dr Zebedee Zivkovic, who completed a PhD at CODES in 2024, was appointed as a part-time Research Fellow in Economic Geology working on projects with Geoscience Australia.

Professional/technical staff

Dr Carlos Carrasco Godoy joined the CODES Analytical Laboratories as Lead Laboratory Analyst in early October. He did a Masters by research followed by a PhD at ANU. Fieldwork for his PhD was interrupted by Covid, so he pivoted his topic and compiled a global zircon geochemical and geochronological database, and developed methods to calculate models to predict zircon fertility.

Dr Alice MacDonald joined the CODES Analytical Laboratories as a Laboratory Analyst in mid-October. She completed her PhD on how clinopyroxene compositional and textural variations are influenced by

magmatic processes at the University of Queensland and worked briefly at the Radiogenic Isotope Facility there.

Dr Jack Ward joined CODES as an Assistant Laboratory Analyst in October. His PhD explored how complex subduction processes lead to the formation of spatially and geochemically ‘anomalous’ volcanoes in arc and intraplate settings.

Departures/role changes

Academic/research staff

Professor Emeritus David H. Green passed away in September and is remembered as one of the key academics in the original Geology Department at UTAS, who went on to play a leading role in the field of experimental petrology, mafic magmatism and the Earth’s upper mantle. He continued his work as an honorary staff member here at UTAS until his passing.

Professional/technical staff

Dr Max Hohl, who completed his PhD at CODES and then worked as a Laboratory Analyst in the CODES

Analytical Laboratories, left his role in early 2024 and took up a postdoctoral research fellow position at MDRU/UBC in May.

Maxwell Morissette left his role as a Laboratory Analyst in the CODES Analytical Laboratories in June and moved to WA to work at Glencore’s Murrin Murrin facility.

Dr Jeff Oalmann, who was working as a Laboratory Analyst here at CODES, took on the role as Manager of the CODES Analytical Laboratories in mid-2024 following the departure of Dr Paul Olin.

Dr Paul Olin left his role as Leader of the CODES Analytical Laboratories in early February and moved to the University of Adelaide where he is working in the Adelaide Microscopy unit.

Dr Valerie Yuleridge returned to James Cook University (EGRU) in June after working at the CODES Analytical Laboratories temporarily as a Laboratory Analyst from January 2024 where she was working on zircon U/Pb data reduction and reporting.



TOP LEFT: Founder of CODES, Emeritus Professor Ross Large (left), with Earth Sciences Head of Discipline Professor Sebastien Meffre at the launch of an updated edition of Professor Ray Cas’s book *Volcanology: Processes, Deposits, Geology and Resources* in October 2024. TOP MIDDLE: Honorary staff members Dr Karin Orth and Dr Peter McGoldrick pictured at a CODES gathering in December 2024. TOP RIGHT: Honorary staff member Dr Stuart Bull at the launch of the new edition of Ray Cas’s book on volcanology in October 2024.

BOTTOM LEFT: A welcome morning tea was held for new lab staff members in October 2024. Pictured here are (L–R): Dr Mohammad Fathi, Dr Owen Missen, Dr Yamila Cajal, PhD student Giovana Pimentel and Michele Chapple-Smith. BOTTOM RIGHT: Dr Robert Scott (left), Master of Economic Geology Program Coordinator, with Earth Sciences Honorary Researcher Dr Ron Berry at a CODES BBQ in December 2024.

CODES staff and management

CODES DIRECTOR

NAME	SPECIALISATION	%*
Professor David Cooke, BSc Hons (Latrobe), PhD (Monash)	Porphyry Cu-Au, fluid-rock geochemistry	50

CODES ACADEMIC/RESEARCH STAFF AT UTAS INCLUDING ONSITE HONORARIES

NAME	SPECIALISATION	%*
Dr Sharon Allen, BSc (Massey), MSc (Auckland), PhD (Monash)	Volcanic facies analysis	Hon
Dr Sheree Armistead, BSc Hons (Monash), PhD (UAdelaide)	Plate tectonics, isotope geochemistry, structural geology	70
Dr Mike Baker, BSc Hons (Sydney), PhD (UTAS)	Igneous petrology, mineral chemistry	100
Dr Ivan Belousov, BSc, MSc (Moscow), PhD (Vernadsky)	Igneous petrology, geochemistry, volcanology, LA-ICP-MS analysis	100
Dr Stuart Bull, BSc Hons, PhD (Monash)	Clastic and carbonate sedimentology and volcanology	Hon
Dr Yamila Cajal, BSc Hons (UdeC), PhD (ANU)	Geochemistry, petrology and economic geology	100
Associate Professor Rebecca Carey, BSc Hons (UTAS), PhD (U Hawaii)	Volcanology	50
Dr Matthew Cracknell, BSc Hons, PhD (UTAS)	Geophysics, machine learning and data mining	50
Dr Paul Davidson, BSc Hons, PhD (UTAS)	Melt and fluid inclusions	Hon
Dr Angela Escolme, MEarthSci Hons (Manchester), PhD (UTAS)	Geometallurgy, geochemistry, mineralogy	50
Dr Mohammad Fathi, BSc (SUT), MSc (TMU), PhD (AUT)	Mineral processing, hydrometallurgy	100
Professor J Bruce Gemmell, BSc (UBC), MA, PhD (Dartmouth)	VHMS deposits and epithermal Au-Ag	Hon
Dr Wei Hong, BSc (CUG), MSc (CAGS), PhD (UTAS)	Economic geology and mineral characterisation	100
Dr Julie Hunt, MSc (UBC), PhD (JCU)	Geometallurgy, economic geology	50
Dr Martin Jutzeler, MSc (U Lausanne), PhD (UTAS)	Volcanology and clastic sedimentology	20
Professor Khin Zaw, BSc (Rangoon), MSc (Queen's), PhD (UTAS)	Fluid inclusions, SE Asian metallogensis	Hon
Professor Ross Large, BSc Hons (UTAS), PhD (UNE)	Volcanic-hosted and sediment-hosted base metal and gold ores	Hon
Dr Charles Makoundi, MSc, PhD (UTAS)	Geochemistry (incl exploration and isotope geochemsitry), geochronology, clastic sedimentology	Hon
Professor Sebastien Meffre, BSc Hons, PhD (Sydney)	Petrology and tectonics of the SW Pacific	50
Dr Owen Missen, BSc, MSc (UMelb), PhD (Monash)	Environmental geology, mineralogy and biogeochemical cycling	50
Dr Paula Montoya, BSc, MSc (UTAS), PhD Hons (UNAM)	Orebody characterisation, economic geology, geometallurgy	100
Dr Robert Scott, BSc Hons, PhD (Monash)	Structural geology, gold deposits/Masters Program Coordinator	65
Dr David Selley, BSc Hons (Adelaide), PhD (UTAS)	Structural geology, basin analysis, ore deposit modelling	Hon
Dr Jeff Steadman, BSc (Central Missouri), MSc (Iowa), PhD (UTAS)	Ore and sedimentary pyrite geochemistry; seawater composition through geologic time	77
Dr Francisco Testa, MSc (UNS, Argentina), PhD (UTAS)	Magmatic-hydrothermal breccias, porphyry and epithermal deposits, geochemistry	50
Dr Tony Webster, BSc Hons (Latrobe), BA (UNE), BAVE, BEd Hons (UTAS), GDipMinEng (UNSW), MSc (JCU), PhD (UTAS)	Mining structural geology, complexly deformed deposits	Hon
Dr Lejun Zhang, BSc, PhD (HFUT)	Porphyry Cu-Au and HS epithermal	50
Dr Zebedee Zivkovic, BSc (UNSW), PhD (UTAS)	Exploration geochemistry, lithogeochemistry	40

*Research percentage

Staff who are 100% affiliated with the Discipline of Earth Sciences are not included in this listing.

CODES HONORARY ACADEMIC/RESEARCH STAFF BASED AT COLLABORATIVE INSTITUTIONS/INDUSTRY

NAME	INSTITUTION	%*
Dr Shaun Barker	MDRU, University of British Columbia	Hon
Dr Ana Liza Cuison	Independent	Hon
Dr Kathy Ehrig	BHP	Hon
Dr Alex Farrar	First Quantum Minerals	Hon
Dr Anthony Harris	Newmont Corporation	Hon
Professor Peter Hollings	Lakehead University	Hon
Mr Terry Hoschke	Consultant	Hon
Dr David Huston	Geoscience Australia	Hon
Mr Adi Maryono	J Resources	Hon
Dr John Walshe	Independent	Hon
Dr Tristan Wells	Fortescue	Hon
Professor Noel White	Independent	Hon

CODES TECHNICAL/ADMINISTRATIVE STAFF

NAME	JOB TITLE	%*
Dr Carlos Carrasco Godoy, MPhil, PhD (ANU)	Lead Laboratory Analyst	100
Mrs Michele Chapple-Smith, GDipAppSci (UTAS)	Lapidary Technician	80
Mr Alex Cuison, BSCE (SLU, Philippines)	Lapidary Manager	100
Mrs Fanghua Dai, MSc (CUGW)	Laboratory Analyst	80
Ms Karen Huizing	Executive Officer	100
Dr Elena Lounejeva, MSc (UNAM), PhD (UTAS)	Laboratory Analyst	100
Dr Alice MacDonald, BAdvSc Hons (ANU), PhD (UQ)	Laboratory Analyst	100
Mrs Michelle Makoundi, B Acc (U Marien Ngouabi)	Technical Officer	100
Ms Caroline Mordaunt, BA Hons (King's, London)	Editor and Administrative Officer	70
Ms Claire Newland, BBus (Acc) (RMIT)	Administrative Support Officer	80
Dr Jeffrey Oalmann, BSc (Kansas State), MSc (Texas Tech), PhD (KU)	Manager, CODES Analytical Laboratories	100
Ms Helen Scott, BSc Hons (UTAS), BEd (QUT)	Project Administration Manager Project Manager – Critical Metals RRC	100
Ms Isabella von Lichten, BSc Hons (UTAS)	Curator	25
Dr Jack Ward, BAdvSc Hons, PhD (UQ)	Assistant Laboratory Analyst	100

*Research percentage

ADVISORY BOARD

NAME	INSTITUTION
Chair: Paul Heithersay	Department for Energy and Mining, South Australia
Deputy Chair: Anthony Harris	Newmont Corporation
Rufus Black	Vice-Chancellor, UTAS
Dave Braxton	Anglo American
Angela Castles	College of Sciences and Engineering, UTAS
Vaughan Chamberlain	Amira Global
Mike Christie	First Quantum Minerals
David Cooke	CODES, UTAS
Mark Doyle	AngloGold Ashanti
Alan Kobussen	Rio Tinto
Anthony Koutoulis	Research, UTAS
Andrew McNeill	Mineral Resources Tasmania
Julianne O'Reilly-Wapstra	School of Natural Sciences, UTAS
Trevor Shaw	Mt Isa Mines (Glencore)
Anil Subramanya	Amira Global
Noel White	Independent
Dave Wood	Anglo American

EXECUTIVE COMMITTEE

NAME	ROLE
Chair: David Cooke	Director, CODES
vacant position	Applied Research
Rebecca Carey	Fundamental Research
vacant position	Deputy Director, CODES
Sebastien Meffre	Head, Discipline of Earth Sciences
Helen Scott	Administration
Robert Scott	Education

Program 1: Ore deposits and mineral exploration

► OBJECTIVE

This program aims to use newly developed geological, geochemical, mineral chemical and geophysical features of ore-forming systems and terrains in order to devise better means of discovering mineral resources at surface and under cover.

Introduction

Program 1: Ore deposits and mineral exploration provides industry-focused process-based models for the formation of base and precious metal ore deposits. It also seeks to develop innovative new tools for determining the most prospective regions for minerals exploration (fertility), and for targeting of buried ore deposits (vectoring). The projects that form Program 1 reflect the range of expertise and level of diversity in the field of hard-rock geology at CODES.

Highlights

CODES Program 1 has continued to produce quality applied research across a number of multi-year projects that have provided significant outputs to both the academic and professional community, both locally and around the world.

Research

In 2024, achievements in research across Program 1 have been spearheaded by our graduate student-led projects, with notable highlights including the recognition of multiple magmatic and mineralisation events across northern Laos as part of

Peerapong Sritangsirikul's PhD study within the 'Evolution and metallogenic significance of SE Asia' project.

Three new PhD sub-projects have commenced within the Amira P1249 footprints project: Poliana Vidal Salgado's study of the Magdalena VHMS deposit in the Iberian Pyrite Belt of southern Spain; Francisco Cuadra's study on geomettallurgical domaining of the Nautanen IOCG deposit in Sweden; and Eduardo Salazar's (U Austral) project on magnetite and actinolite mineral chemistry from the El Teniente deposit in Chile.

Victor Torres' study on the Cu-Au mineralised breccia pipes at Soledad, Peru, has correlated textural features with grade distribution, allowing for

▼
In 2024, achievements in research across Program 1 have been spearheaded by our graduate student-led projects...



Participants in the Amira P1249 Sponsors' Review Meeting 5 at CODES, which took place in June. They are pictured in the CODES Rock Garden at UTAS.

effective prediction of mining and mineral processing options for this unique deposit. Olive Poyalou has made significant progress in the first year of her study characterising the geology, alteration and mineralisation of the Kainantu Cu-Au district in Papua New Guinea. This is in large part due to the large drillcore sample suite provided by project sponsor K92, with on-site fieldwork commencing in December. Zebedee Zivkovic has commenced work on three new mineral system prospectivity maps focusing on porphyry Cu-Au-Mo, VHMS and epithermal mineral deposits as part of the National Mineral Potential Mapping project.

Publications

Two papers stemming from research within Program 1 were published in 2024, including 'Using compositions of zircon to reveal fertile magmas for the formation of porphyry deposits in the Loei and Truong Son fold belts, northern Laos' by lead author Peerapong Sritangsirikul in the *Journal of Asian Earth Sciences*, and 'Geochronology of the Mines Gaspé porphyry deposit, Québec, Canada' by lead author Mitch Marcelissen (Lakehead University Masters student who has now completed his studies) in the *Canadian Journal of Earth Sciences*.

Technology transfer

The Amira P1249 research project has continued its series of technology transfer workshops in conjunction with its biannual sponsors review meetings. In 2024 the P1249 project hosted workshops at CODES on the application of the mineral co-occurrence probability field (MCOFP) workflow, and navigating telescoped porphyry – HS epithermal systems using the Resolution porphyry Cu-Mo deposit as a case study.

Conferences

Program 1 research was presented at a number of international conferences in 2024, including Professor Khin Zaw and Peerapong Sritangsirikul presenting their research findings at the 1st Mahidol University International Geoscience Conference (MUGC 2024), in western Thailand. Victor Torres, and members of the Amira P1249 project including Professor David Cooke, Axel Cima and Poliana Vidal Salgado, attended the SEG 2024 Conference held in Windhoek, Namibia.



Professor Khin Zaw and CODES PhD student Peerapong Sritangsirikul pictured at the 1st Mahidol University International Geoscience Conference (MUGC 2024), at Kanchanaburi, western Thailand. Professor Khin Zaw gave a keynote address at this conference in January 2024 and Peerapong won a prize for best oral presentation in Session 3.

The program team

LEADER MIKE BAKER
DEPUTY LEADER LEJUN ZHANG



TEAM MEMBERS:

Sheree Armistead, Ivan Belousov, Ron Berry, Stuart Bull, Yamila Cajal, David Cooke, Matthew Cracknell, Angela Escolme, Wei Hong, Julie Hunt, Ross Large, Charles Makoundi, Adi Maryono, Sebastien Meffre, Paula Montoya, Michael Roach, Thomas Rodemann (CSL), Robert Scott, David Selley, Jeff Steadman, Francisco Testa, Khin Zaw, Zebedee Zivkovic

PHD STUDENTS:

CODES: Fuseini Atanga, José Barillas Diaz, Billy Beas, Isaac Brown, Axel Cima, Takeshy Coaquira, Stephen Cooke, Francisco Cuadra, Vinicius da Cruz, Isaac Evinemi, Alex Farrar, Javier Gil Rodriguez, Rhannon Jones, Nelao Natukondje Naimbale, Jaime Osorio, Giovana Pimentel, Olive Ponyalou, Arka Sahu, Angela Santos Costa, Xin Ni Seow, Emily Smyk, Peerapong Sritangsirikul, Markus Staubmann, Yi Sun, Victor Torres, Poliana Vidal Salgado, Shouchun Yu, Emreacan Yurdakul, Zebedee Zivkovic

AUSTRAL DE CHILE:
Eduardo Salazar

MASTERS STUDENTS:

CODES: Joshua Greene, Ashleigh Ball, Lieth de Selincourt, David Portocarrero, Henry Schaumburg

LAKEHEAD UNIVERSITY: Jason Dyer, Nafiu Sulyman, Chase Turner

HONOURS STUDENTS:

CODES: Sarah Purdom

AUSTRAL DE CHILE:
Ricardo Navarro, Ivania Rojas

COLLABORATORS:

ANGLO AMERICAN
Iain Dalrymple, Victor Torres, David Wood

ANGLOGOLD ASHANTI
Jing Chen, Ben Hames, Andrew Jenkins, Xin Ni Seow, Luke Swift

AKITA UNIVERSITY, JAPAN
Yasushi Watanabe

BHP
Natalie Caciagli, Gisela Cobenas

BOLIDEN
David Drejing-Carroll, Tobias Hermansson, Helen Thomas

CHAKANA COPPER CORP
David Kelley

CHENGDU RESEARCH CENTRE, CHINA GEOLOGICAL SURVEY, CHINA
Linnan Guo, Meifeng Shi

CHULALONGKORN UNIVERSITY, THAILAND
Arkar Moe Myint, Pitsanupong Kanjanapayont

CMOC/NORTHPARKES
Jon Hoyer

CODELCO
Martin Kock, Sergio Pichott, Carolina Rodriguez

CONSULTANT
Mike Crow, Noel White

DEPARTMENT OF GEOLOGY, POLYTECHNIC COLLEGE, LAOS
Patthana Bounliyong

DEPARTMENT OF MINERAL RESOURCES, THAILAND
Punya Charusiri

DGO GOLD
Eduard Eshuys

EVOLUTION MINING
Ned Howard

FIRST QUANTUM MINERALS
David Arribasplata, Federico Cernuschi, Alex Farrar, Tim Ireland, Luis Quispe Renteria

FORTESCUE METALS GROUP
Kit Lai, Dana Olafson, Cam Quinn

GEOSCIENCE AUSTRALIA
Jonathan Cloutier, Karol Czarnota, Michael Doublier, Arianne Ford, David Huston, Anthony Schofield

GLENCORE/MT ISA MINES
Trevor Shaw

INSTITUTE OF TECHNOLOGY OF CAMBODIA, CAMBODIA
Seang Sirisokha

K92 MINING INC
Thomas Adamson, Lachlan Burrows, Chris Muller, Aria Nauna, Michael Parak, Robert Smillie, Ivan Stelzner, Felix Wanis, Paul Wiley

LAKEHEAD UNIVERSITY, CANADA
Peter Hollings

MAHASARAKHAM UNIVERSITY, THAILAND
Clive Burrett

MAHIDOL UNIVERSITY, THAILAND
Patchawee Meow, Pyrynya Putthapiban

MATSA MINING
David Le Madec, James Royall

MAWLAMYINE UNIVERSITY, MYANMAR
Zin Mar Oo

MINERAL MAPPING
Scott Halley

MINERAL RESOURCES TASMANIA
Ralph Bottrill, Clive Calver, Grace Cumming, John Everard, Andrew McNeill

MONASH UNIVERSITY
Laurent Aillères, Ray Cas

MYINGYAN UNIVERSITY, MYANMAR
Htet Sandar Aung

NAGA MINERALS LAOS CO LTD, THAILAND
David Meade

NEWMONT
Jeff Bigelow, Russell Fitzpatrick, Rizal Fraval, Karyn Gardner, Anthony Harris, Richard Inglis, Hana Lee, Simon Marshall, Jessica Silcock, Ally Willcox

NO.2 MINING ENTERPRISE, MINISTRY OF NATURAL RESOURCES AND ENVIRONMENTAL CONSERVATION, MYANMAR
Kyaw Thu Htun

REGULUS RESOURCES
Kevin Heather

RIO TINTO
Scarlett Blewett, Harrison Button, Kate Cocker, Ingrid Flemons, Mohsen Hadizadeh, Alan Kobussen, Adam Pacey, Ivan Semenov, Marina Veter, Mike Whitbread

SANDFIRE RESOURCES
Kristyn Adamczyk, Joel Kitto, Peter Willems

SOUTH32
Renato Bobis

UNIVERSIDAD AUSTRAL DE CHILE, CHILE
José Piquer

UNIVERSITI KEBANGSAAN, MALAYSIA
Mohd Basril Iswadi Bin Basori, Mazlinalina Mohd Zin

UNIVERSITY OF MELBOURNE
Roland Maas

UNIVERSITI SAINS MALAYSIA, PENANG, MALAYSIA
Zakaria Endut

UNIVERSITY OF NEW SOUTH WALES
Ian Graham

US GEOLOGICAL SURVEY, USA
Jay Thompson

Projects

Evolution and metallogenic significance of SE Asia

Amira P1249: Exploring, characterising, and optimising complex orebodies – upscaling orebody knowledge to add value across the mining value chain

Porphyry research

National mineral potential mapping

Project summaries

EVOLUTION AND METALLOGENIC SIGNIFICANCE OF SE ASIA

(This project was formerly known as Tectonic-magmatic processes and mineral deposits in SE Asia)

Leaders: Khin Zaw, Sebastien Meffre

Team members: David Cooke, Charles Makoundi, Lejun Zhang

Student: Peerapong Sritangsirikul

Collaborators: Pitsanupong Kanjanapayont, Arkar Moe Myint, Mohd Basril Iswadi Bin Basori, Clive Burrett, Mike Crow, Punya Charusiri, Pyrynya Putthapiban, David Meade, Seang (Sokha) Sirisokha, Ian Graham, Patthana Bounliyong, Zakaria Endut, Htet Sandar Aung, Kyaw Thu Htun, Zin Mar Oo, Linnan Guo, Meifeng Shi, Yasushi Watanabe, Mazlinalina Mohd Zin

Southeast Asia hosts several fold belts rich in diverse mineral resources, including copper, gold, silver, base metals, rare earth elements (REE), gemstones, tin and tungsten. These deposits occur in various geological settings, such as Cu-Au porphyry-skarn systems, epithermal gold deposits, tin-tungsten vein systems, and orogenic gold deposits. Significant progress has been made in understanding the region's geodynamic evolution, magmatic history, and associated mineralisation, contributing to advancements in mineral exploration and economic geology. The objectives of this project are to understand the metallogenic processes, and the geochemical and geochronological aspects of different deposit types within these fold belts. The investigation uses zircon geochronology alongside trace elements, whole-rock geochemistry, and Hf isotopes to assess magma fertility and differentiate the geochemical characteristics of mineral-rich and non-productive intrusions. Peerapong Sritangsirikul's recent work in northern Laos for his PhD recognised three magmatic and mineralised events occurred between 434–411 Ma, 299–277 Ma, and



The Anglo American Northern Limb Regional Exploration Geology Core Yard at Mokopane, South Africa. PhD student Giovana Pimental worked here in April–May 2024 as part of her research for the Amira P1249 project.



Fieldwork for the Amira P1249 project took place in Arizona in January 2024. Here Associate Professor Lejun Zhang (right) and Dr Paula Montoya are observing and sampling an outcrop near the Resolution deposit in Superior.

253–243 Ma. Zircon compositions provided potential porphyry-related fertile magmas. A research paper entitled ‘Using compositions of zircon to reveal fertile magmas for the formation of porphyry deposits in the Loei and Truong Son fold belts, northern Laos’ has been published in the *Journal of Asian Earth Sciences* (<https://doi.org/10.1016/j.jseaes.2024.106244>).

This project is linked with several others in the region, including the ‘Geochronology of ore deposits in Cambodia’, led by Dr Seang (Sokha) Sirisokha from the Institute of Technology, Cambodia. This project is supported by the Japan International Cooperation Agency (JICA), focusing on U-Pb zircon geochronology on mineralised porphyry intrusions in Cambodia along the Loei fold belt.

In partnership with the University of Technology Petronas (Malaysia), Dr Charles Makoundi is co-supervising a PhD project titled ‘Characterisation of the Pulai Gold Prospect in the Central Gold Belt of Peninsular Malaysia: Implications for gold metallogeny’. The aim of the PhD project is to determine the timing of gold mineralisation and source of alluvial gold. The project uses Pb isotope, Laser Raman,

microthermometry, EPMA and LA-ICP-MS. Dr Charles Makoundi continues to work with Dr Zakaria Endut from the University Sains Malaysia on ‘Pyrite geochemistry, isotopes, ore fluids and geochronology of orogenic gold deposits in Central Malaysia’ supported by the Malaysian Government.

Southeast Asia holds immense potential for the discovery of world-class granite-related lithium and other critical battery minerals. However, the region’s progress towards green energy, low-carbon development and advanced technologies is hindered by the lack of comprehensive data and large-scale studies on critical minerals and metal systems. To address this gap, an advanced collaborative project is underway with Professor Pyrynya Putthapiban and Dr Patchawee Meow (Mahidol University), Professor Punya Charusiri (DMR), Professor Zin Mar Oo (Mawlamyine University, Myanmar) and Peerapong Sritangirikul (CODES PhD student). This research focuses on W-Sn-REE-Li mineralisation and its associated granitoid host rocks along the Thai Myanmar border. Recently Professor Khin Zaw and Peerapong Sritangirikul presented their research findings at the 1st Mahidol University International Geoscience Conference (MUIGC 2024), western Thailand.

AMIRA P1249: EXPLORING, CHARACTERISING, AND OPTIMISING COMPLEX OREBODIES – UPSCALING OREBODY KNOWLEDGE TO ADD VALUE ACROSS THE MINING VALUE CHAIN

Leader: David Cooke

Team members: Sheree Armistead, Mike Baker, Ivan Belousov, Yamila Cajal, Matthew Cracknell, Angela Escolme, Wei Hong, Julie Hunt, Paula Montoya, Thomas Rodemann (CSL), Lejun Zhang

Students: Fuseini Atanga, Billy Beas, Axel Cima, Takeshy Coaquira, Stephen Cooke, Francisco Cuadra, Jason Dyer (Lakehead U), Isaac Evinemi, Patrick Hamilton (Lakehead U), Rhiannon Jones, Ricardo Navarro (U Austral), Giovana Oliveira Pimentel, Jaime Osorio, Ivania Rojas (U Austral), Arka Sahu, Eduardo Salazar (U Austral), Xin Ni Seow, Emily Smyk, Markus Staubmann, Nafiu Sulyman (Lakehead U), Yi Sun, Chase Turner (Lakehead U), Poliana Vidal Salgado

Collaborators: Laurent Aillères, Jeff Bigelow, Scarlett Blewett, Renato Bobis, Harrison Button, Natalie Caciagli, Federico Cernuschi, Jing Chen, Gisela Cobenas, Kate Cocker, Iain Dalrymple, David Drejing-Carroll, Alex Farrar, Russell Fitzpatrick, Ingrid Flemons, Karyn Gardner, Mohsen Hadizadeh, Scott Halley, Ben Hames, Anthony Harris, Tobias Hermansson, Peter Hollings, Ned Howard, Jon Hoye, Richard Inglis, Tim Ireland, Andrew Jenkins, Alan Kobussen, Martin Kock, Kit Lai, David Le Madec, Hana Lee, Simon Marshall, Dana Olafson, Adam Pacey, Sergio Pichott, José Piquer, Cam Quinn, Luis Quispe Renteria, Carolina Rodriguez, James Royall, Ivan Semenov, Xin Ni Seow, Jessica Silcock, Luke Swift, Helen Thomas, Victor Torres Pacheco, Marina Veter, Mike Whitbread, Noel White, Ally Willcox, Peter Willems, David Wood

The five-year Amira Global P1249 project ‘Exploring, characterising, and optimising exploring complex orebodies – Upscaling orebody knowledge to add value across the mining value chain’ entered its third year in 2024. This project provides its sponsors with new tools for recognising proximity to high-grade ore, and new tools, methods and workflows for translating and upscaling mineralogical, geochemical and hyperspectral data into quantitative mineralogy for complex orebodies of copper, gold, critical and other metals. The project team will aim to optimise orebody knowledge and provide the information required for mineralogical domaining and resource definition at the mine scale. P1249 is focused on transition zones – the alteration domains that extend from the orebody into the surrounding unmineralised rocks. Although the primary focus of the project is on porphyry, epithermal, carbonate replacement and skarn deposits, the project also has active sub-projects studying Mt Isa-style Cu, IOCG, orogenic Au, Ni-Cu-PGE and VHMS deposits.

By delivering new and more effective methods and workflows for mineralogical characterisation in the

transition zone, P1249 will deliver better exploration models, facilitate informed decision making at all stages of the mining value chain, and identify value opportunities in waste streams that may help reduce waste volumes, thereby providing new orebody knowledge essential for optimising ore extraction and recovery from complex orebodies. The research team will provide new and refined geochemical and geological tools for fertility assessments to establish whether there is a significant mineral resource nearby (i.e., how large is the resource?) and to ensure that deposits are discovered more quickly and at less cost by reducing the amount of drilling required for discovery (vectoring – how far, how deep and in what direction?). These tools will be designed to ensure cost-effective exploration through implementation early in an exploration program, allowing opportunities to be recognised from near-miss drilling, and to allow the presence, location, and potential size of porphyry, epithermal, skarn, carbonate replacement and other resources to be determined rapidly.

Amira P1249 is being conducted by a large team of researchers including 13 UTAS staff, six collaborators and 23 students (PhD, Masters and Honours)



Professor David Cooke (in CODES red shirt) visited the Freeport McMoRan exploration team at Tucson, Arizona, in early January 2024. He was able to briefly review core from several mine and exploration sites in Arizona as part of research for the Amira P1249 project.

from three academic institutions (UTAS, Lakehead University and Universidad Austral de Chile). Several sub-projects within P1249 involve postgraduate students. Continuing PhD students and their projects include: Fuseini Atanga (Akyem orogenic Au deposit, Ghana), Billy Beas (halogen chemistry in the Northparkes E44 deposit), Axel Cima (influence of mineral micro-inclusions on porphyry prospectivity), Takeshy Coaquira (Resolution porphyry Cu-Mo deposit, USA), Stephen Cooke (computer-based modelling of geochemical data), Isaac Evinemi (deep learning-driven ore deposit models for exploration of porphyry deposits), Rhiannon Jones (Northparkes E26 porphyry Cu-Au deposit, New South Wales), Giovana Oliveira Pimentel (mineralogical characterisation of the Platreef Ni-Cu-PGE deposit, South Africa), Jaime Osorio (Rincones de Araya prospect, Argentina and Valeriano porphyry Cu-Au deposit, Chile), Arka Sahu (data mining of multi-scale hyperspectral and mineral chemistry data sets), Xin Ni Seow (alunite and

APS group mineral chemistry), Emily Smyk (Christmas porphyry Cu-Mo deposit, USA), Markus Staubmann (Cowal GRE46 gold deposit, New South Wales) and Yi Sun (Lepanto district, Philippines). Xin Ni, Yi and Rhiannon each had their final theses corrections accepted in 2024. Three Masters projects based out of Lakehead University, Canada, also continued in 2024: Chase Turner's study of the Northisle NW Expo lithocap on Vancouver Island, Canada; Jason Dyer's study of sulfide chemistry from the McFinley Au deposit, Canada; and Nafiu Sulyman's study of sulfide chemistry from the Red Lake orogenic Au belt of central Canada.

Three new P1249 PhD sub-projects commenced in 2024: Poliana Vidal Salgado commenced her study of the Magdalena VHMS deposit in the Iberian Pyrite Belt of southern Spain in April; in November Francisco Cuadra commenced his study on mineral chemistry variance mapping and geometallurgical domaining of the Nautanen IOCG deposit in Sweden; and Eduardo Salazar (U Austral)

commenced his project on magnetite and actinolite chemistry from the El Teniente deposit in Chile. Other P1249 study sites where field and analytical work commenced or continued in 2024 include Nolasco and Porfido Norte (Chile), Ventana (Argentina), Galore Creek (Canada), and Ocelot, Wagen and Yerington (USA).

The total cost of the Amira P1249 project over the five years will be AU\$16.1 million including research organisation and in-kind contributions of AU\$6.8 million and Amira Global development and oversight fees. The total industry and government investment required to fully fund the project is approximately AU\$9.31 million over five years. As of December 2024, 13 companies sponsor P1249, including Anglo American, AngloGold Ashanti, BHP, Boliden, CODELCO, Evolution Mining, First Quantum Minerals, Fortescue Metals Group, Glencore (Mt Isa Mines), Newmont, Rio Tinto, Sandfire Resources, and South32.



CODES PhD student Poliana Vidal Salgado at work on core from the Sandfire Resources-MATSA Magdalena VHMS deposit in the Iberian Pyrite Belt, Spain, during a field trip to the region in May 2024.

PORPHYRY RESEARCH

Leader: David Cooke

Students: Lieth de Selincourt, David Portocarrero, Victor Torres

Collaborators: Kevin Heather, David Kelley, Joel Kitto

Victor Torres' PhD study of Cu-Au mineralisation of the Soledad tourmaline breccia complex, central Peru, has been supported by Chakana Copper Corp. The study involves comprehensive geological, geochemical and geometallurgical investigations that provide comprehensive orebody knowledge of the Soledad breccia pipes, including their geological setting, age, alteration and mineralisation features, controls on mineralisation and mineral processing characteristics. Key findings of Victor's study were presented at the SEG Annual Conference in Namibia in September 2024, highlighting how logging of textural features correlates well with grade distribution and allows effective prediction of mining and

mineral processing options for different parts of the vertically extensive Cu-Au mineralised breccia pipes at Soledad. All analytical work is completed, with writing and revising of the thesis being the major task remaining for completion in 2025.

Multi-stage intrusion, brecciation and mineralization at the Antakori Cu-Au-Ag project, northern Peru Cu-Au-Mo

Leaders: David Cooke, Lejun Zhang

Student: David Portocarrero

Collaborator: Kevin Heather

The characteristics and origins of epithermal, porphyry and skarn mineralisation in the Antakori Cu-Au deposit, northern Peru are being investigated by David Portocarrero for his Master of Economic Geology research project, supported by Regulus Resources. Only limited progress on this study was made in 2024 due to other work commitments,

with additional geochronological, geochemical and geological data generated to help finalise the data acquisition and to facilitate completion of the thesis in 2025.

Cu-Au-Mo porphyry mineralisation in the Temora district, New South Wales, Australia

Leaders: David Cooke, Sebastien Meffre, Michael Baker, Matthew Cracknell

Student: Lieth de Selincourt

Collaborators: Kristyn Adamczyk, Joel Kitto

Lieth de Selincourt's Master of Economic Geology research is investigating the porphyry Cu-Au prospects of the Temora district in the Junee-Narromine belt of the Ordovician Macquarie Arc, Central West NSW, supported by Sandfire Resources. Lieth has completed all field and analytical work and continued to progress the writing of his thesis through 2024, with the aim of thesis submission in 2025.



Geology, genesis, and exploration significance of Cu-Au veins and altered rocks in the Kainantu Cu-Au district, PNG

Leaders: David Cooke, Owen Missen, Lejun Zhang

Student: Olive Ponyalou

Collaborators: Thomas Adamson, Lachlan Burrows, Chris Muller, Aria Nauna, Michael Parak, Robert Smillie, Ivan Stelzner, Felix Wanis, Paul Wiley

In December 2023, Olive Ponyalou commenced a PhD study of the Kainantu Cu-Au district in Papua New Guinea, supported by K92. The main objectives of Olive's research are to characterise the geology and Cu-Au mineralization of the Kora, Judd and Irumafimpa veins within Kainantu mine, and the Arakompa quartz-sulfide vein system based on mineralogy, geochemistry, geochronology and structural controls to understand their genesis and define potential vectors to

additional orebodies. Olive completed her first field season in December 2024, but made significant progress on the deposit geology, alteration and mineralisation throughout 2024 and prior to the first field campaign thanks to a large drillcore sample suite provided by K92. Analytical work and field campaigns will continue throughout 2025.

NATIONAL MINERAL POTENTIAL MAPPING

Leader: Zebedee Zivkovic

Collaborators: Jonathan Cloutier, Karol Czarnota, Michael Doublier, Arianne Ford, David Huston, Anthony Schofield

CODES maintained its partnership with Geoscience Australia in 2024 with the ongoing development of the national prospectivity assessment maps for mineral exploration. This is a continuation of prior work by GA and CODES, led by Dr Jonathan Cloutier, who developed mineral prospectivity

maps for a number of mineral systems including carbonatite-hosted REE, sediment-hosted base metals and IOCG mineral systems under the federal *Exploring for the Future* program (<https://www.eftf.ga.gov.au/mineral-potential-mapping>). These maps are available through the GA data portal (<https://portal.ga.gov.au/>).

The current work, led by Dr Zebedee Zivkovic, seeks to expand on the existing project with the addition of three new mineral system prospectivity maps focusing on porphyry Cu-Au-Mo, VHMS and epithermal mineral deposits. This work involves a detailed review of each mineral system model with a specific focus on the Australian context. Primary controls on mineral deposit formation are identified and linked to proxies for these controls from a diverse range of geoscience data sets. Geodata analysis and machine-assisted interpolation is then used to produce the final mineral prospectivity images covering the entire continent. This project was begun in December 2024 and will be ongoing through 2025.

▶ LOOKING FORWARD

The Amira Global P1249 project is continuing through to the end of 2026 and will provide longer-term contributions to the excellent applied research into magmatic-hydrothermal systems by the research team and collaborating institutions. Research into W-Sn-REE-Li mineralisation will also continue into 2025 as part of the SE Asia metallogeny project. In the field of porphyry research, we expect the completion of Leith de Selincourt's Master of Economic Geology project on Cu-Au-Mo mineralisation in the Temora district, NSW, and David Portocarrero's Masters project on the Antakori deposit in northern Peru. Victor Torres is also nearing completion of his PhD project on the Soledad tourmaline breccia complex, with submission expected in late 2025 or early 2026.

Postgraduate student research projects within Program 1 continue to generate high-quality research outcomes, with several manuscripts in preparation for publication heading into 2025 focused on characterisation of mineralisation and alteration from a range of deposit types, and the development of workflow for mineralogical domaining and classification. Program 1 postgraduate research projects continuing into 2025 include 12 CODES PhD sub-projects within Amira P1249 (students: Fuseini Atanga, Billy Beas, Axel Cima, Takeshy Coaquira, Stephen Cooke, Francisco Cuadra, Isaac Evinemi, Giovana Oliveira Pimentel, Jaime Osorio, Arka Sahu, Markus Staubmann, Poliana Vidal Salgado).



Amira P1249 research (L-R): PhD student Axel Cima, Associate Professor Lejun Zhang and Dr Paula Montoya during a field trip to Ocelot, Arizona, in February 2024.

Program 2: Geometallurgy and geoenvironment

► OBJECTIVES

This program aims to facilitate sustainable mining, mineral processing and waste management practices in the minerals industry. Our goals are to minimise the impacts and maximise the benefits of metallic mining in diverse environments, at all stages of the production chain, to assist with remediation of legacy issues and to develop innovative solutions for the production of commodities from mining waste streams.

Introduction

Program 2: Geometallurgy and geoenvironment addresses some of the challenges the minerals industry faces in the accurate prediction of processing performance and variability in performance due to the limited number of samples that can be tested for metallurgical parameters. Significant technical and operational risks exist where orebodies are poorly characterised.

Work within geometallurgy at CODES/UTAS seeks to efficiently integrate and use tools that help characterise geological parameters, particularly mineralogical and geochemical attributes, to undertake deposit-wide characterisation in order to maximise orebody knowledge. Through a holistic approach, geometallurgy activities identify attributes that contribute to the realised value of a resource and enable ore variability to be factored into the flowsheets, infrastructure design, and

the production and quality forecasts over the life-of-mine. This includes variability in traditional attributes, such as grade, as well as less traditional factors, such as hardness (crushability, grindability), mineral species and abundance, mineral liberation, metallurgical recovery, concentration of deleterious elements, acid generating potential, neutralising potential and smelter enabling characteristics.

Geoenvironmental research at CODES is integrated with the ore deposit characterisation and geometallurgy research to fully understand the potential environmental impacts of orebody mineralogy and processing technologies. Tailings and waste rock samples feature strongly, especially analysing changes in mineralogy that occur in mine waste storage facilities. Complementary research is also undertaken on other environments such as wetlands and rivers, especially where mining has historically impacted, or is presently impacting, other natural systems.



In 2024, Program 2 research was focused on critical metals within the Regional Research Collaboration (RRC) project.



Several CODES staff and students took part in a guided tour of the Iron Ore Pelletizing Plant at Port Latta, operated by Grange Resources; this tour was part of the MetFest! conference that took place in Burnie in February 2024.

In 2024, Program 2 research was focused on critical metals within the Regional Research Collaboration (RRC) project. Several other projects are also ongoing as part of the Amira P1249 project, CSIRO Futures project and MRT-funded research. Dr Owen Missen accepted an ongoing Lecturer in Environmental Geology position with UTAS Earth Sciences, with the majority of his research continuing in the RRC alongside other geoenvironmental endeavours.

The year also saw the continuation of three PhD projects as part of the RRC: Alfredtina Appiah: 'Pathways to production: Magnesite deposits at Prospect Ridge, northwestern Tasmania'; Emmanuel Dogara Musa: 'Pathways to production for critical metals: Kara W deposit, Western Tasmania'; and Pratiche Mondal: 'Mineral and geoenvironmental characterisation of, and pathways to production for, critical metals from Western Tasmania', which is focused on the Savage River deposit.

Highlights

Research

- Dr Mohammad Fathi submitted:
 - a large metallurgy grant proposal to Amira and
 - a research proposal to Tungsten Mining NL.
- Dr Mohammad Fathi began the establishment of a metallurgy/processing lab with the purchase of new equipment ongoing throughout 2024.

Publications

- Dr Julie Hunt published a paper in Minerals on computed tomography with collaborators from RWTH Aachen University: <https://www.mdpi.com/2075-163X/14/4/345>
- Dr Owen Missen published a paper on cobalt-manganese environmental geochemistry with collaborators from Museums Victoria; ESRF, France; and the University of Graz, Austria: <https://www.publish.csiro.au/en/EN23093>

- Dr Mohammad Fathi published a paper in *Materials* on rhenium adsorption with collaborators from Curtin University and Urmia University, Iran: <https://www.mdpi.com/1996-1944/17/11/2737>

Technology transfer

- The 3D visualisation for the Kara mine was shown to a wide audience at the Critical and Strategic Metals Symposium at CODES in July 2024. While metallurgy and geoenvironmental work were not the focus of the Symposium, some of the Program 2 work was showcased in an RRC summary talk presented by Dr Owen Missen.
- Dr Michael Roach collected data at the Renison mine to develop his 3D visualisation project.

Conferences

In 2024 research outcomes were presented by staff and students at several conferences and geological society meetings, including:

- MetFest! Burnie, Tasmania. The following talks were presented: Alfredtina Appiah (Processing challenges in magnesite beneficiation: Arthur River magnesite deposit); Emmanuel Dogara Musa (Scheelite processing challenges and opportunities: A case study of coarse flotation); and Dr Mohammad Fathi (Slime generation in critical mineral processing: Challenges, processing issues, and potential remedial strategies).
- Inaugural Australian Mine Waste Symposium, Brisbane, Queensland. Dr Owen Missen presented a short talk and poster entitled 'Unlocking critical metals in mine wastes: Potential for bismuth, indium, cobalt and more in Tasmania'. Third-year student Anthony Tai also attended, having won sponsorship to allow him to do so.
- AusIMM Critical Metals, Brisbane, Queensland. Two posters were presented: Alfredtina Appiah (Selectivity of magnesite from dolomite during flotation with sodium hexametaphosphate (SHMP) and citric acid (CA)); and Emmanuel Dogara Musa (Scheelite processing challenges and opportunities: An example from Kara magnetite-scheelite mine, Tasmania). Dr Mohammad Fathi presented a talk entitled 'Exploring anisotropic effects of grinding media for selective separation of scheelite and fluorite'.
- ICARD, Halifax, Nova Scotia, Canada. Chris Allen presented on 'Electrical geophysical methods for characterising a valley infill waste rock dump'.
- Responsible Raw Materials, online. Dr Owen Missen presented on 'Could harnessing natural processes be a potentially viable method to extract critical elements from mine wastes?'.
- European Mineralogical Conference, online. Dr Owen Missen presented on 'Determination of Great Barrier Reef Ca-C-O mineralogy and trace element systematics using synchrotron X-ray techniques'



The CODES contingent at the 2024 AusIMM MetFest! event in Burnie (L-R): PhD students Emmanuel Dogara Musa and Alfredtina Appiah; Dr Julie Hunt and Dr Mohammad Fathi.



Dr Owen Missen presenting at the 2024 Australian Mine Waste Symposium.

- IAGS, Adelaide, South Australia. Dr Owen Missen presented a short talk and poster entitled 'Cobalt environmental geochemistry across Australian surface environments'.
- CRITICAL MINERALS '24 Conference, Cape Town, South Africa. Dr Mohammad Fathi presented a talk on 'Extraction of vanadium from the enriched slag of melting titanomagnetite ores'.
- The 'Tasmanian Critical Metals Workshop' was held in Tullah, western Tasmania, on 27 November. This event was a chance to report on the progress of the Regional Research Collaboration project to industry and government partners, and featured guest talks by Professor David Giles from the University of South Australia and Emeritus Professor Ross Large (CODES).



CODES PhD student Emmanuel Dogara Musa examines spiral concentrators at the Kara Mine prior to collecting scheelite samples.

The program team

LEADER JULIE HUNT
DEPUTY LEADER OWEN MISSEN*



TEAM MEMBERS:

Ivan Belousov, Ron Berry, David Cooke, Matthew Cracknell, Angela Escolme, Mohammad Fathi, Lydia Mackenzie (Geography), Sebastien Meffre, Paul Olin, Vishnu Prahalad (Geography), Michael Roach

PHD STUDENTS:

Christopher Allen, Alfredtina Appiah, Takeshy Coaquira, Pratichee Mondal, Emmanuel Dogara Musa, Markus Staubmann, Victor Torres

MASTERS STUDENT:

Lucy Jones

THIRD-YEAR STUDENTS:

Claire Evans, Anthony Tai

COLLABORATORS:

ALS GLOBAL
Shengli Zhao, Drew Redpath

ANGLOGOLD ASHANTI
Vaughan Chamberlain

BHP
Kathy Ehrig

BLUESTONE MINES TASMANIA
Colin Carter, Kate Cheesman, Brian Dalton, Esther Little, Bill Oats, Derek Sutton

BOLIDEN
Tobias Hermansson

CENTRAL SCIENCE LABORATORY (UTAS)
Sandrin Feig, Karsten Goemann, Thomas Rodemann

COPPER MINES OF TASMANIA
Geoff Cordery

CORESCAN Powered by Epiroc
Lionel Forteneau

CSIRO
Vladimir Jokovic, Paul Revell

DIAMONDBACKS PTY LTD
Greg Wilkie

EVOLUTION MINING
Karyn Gardner, Ned Howard

GeologicAI
Adam MacInnis

GEOSCIENCE AUSTRALIA
Jonathan Cloutier

GRANGE RESOURCES
Kathleen Bowron, Roger Hill, Alexey Lygin

GWR GROUP
Mick Wilson, Teck Wong

MERDEKA COPPER GOLD
Wulandari Mandradewi

MINERAL MAPPING PTY LTD
Scott Halley

MINERAL RESOURCES TASMANIA
Ralph Bottrill, Simon Enman, David Green, Verity Kameniar-Sandery, Andrew McNeill, Jake Moltzen, Jessica Renaud, Carol Steyn, Lia Unwin

MMG
Corey Jago, Don Macansh, Steve Scott

NAGROM
Rain Lewis

NORTHERN STAR RESOURCES
Natalee Bonnici

OKANE CONSULTANTS
Mike Okane

RWTH AACHEN UNIVERSITY
Leonard Krebbers, Bernd Lottermoser

SIMSAGE
Toni Kojovic

TASMANIA MINES PTY LTD
Greg Doherty, Marcus Mollison

UNIVERSITY OF SOUTH AUSTRALIA
George Abaka-Wood

VOCONIQ
Sefton Derby

**(Angela Escolme was on extended parental leave.)*



Dr Mohammad Fathi with one of the pieces of lab equipment that was acquired in 2024. This spiral will be used for gravity separation-based preconcentration processes for scheelite.



Environmental geology fieldwork at a saltmarsh near Richmond, Tasmania, during March 2024: Lecturer in Environmental Geology Dr Owen Missen with (L–R): Claire Evans (third-year research student), Lydia Mackenzie (Geography lecturer) and Molly Robinson (third-year research student).

Projects

RRC project: Environmentally sustainable production of critical metals; Element 2: Pathways to production

Amira P1249: Exploring, characterising, and optimising complex orebodies – upscaling orebody knowledge to add value across the mining value chain

CSIRO Futures project: A methodology for measuring and modelling gangue liberation using geological analysis and particle grade distributions

Geoenvironmental research

Project summaries

RRC PROJECT: ENVIRONMENTALLY SUSTAINABLE PRODUCTION OF CRITICAL METALS; ELEMENT 2: PATHWAYS TO PRODUCTION

(See the RRC project section on page 66 for full details of this project including all collaborators.)

The second year of geometallurgy work within Element 2 of the RRC project focused on three critical metal commodities: magnesite, scheelite and magnetite, as well as looking at associated critical elements in waste products from these commodities.

Student: Alfredtina Appiah

PhD student Alfredtina Appiah joined CODES in January 2023 to undertake her project entitled 'Pathways to production: Magnesite deposits at Prospect Ridge, northwestern Tasmania'. She has geochemically domained magnesite ore and been conducting extensive metallurgical test work on magnesite ore to separate

magnesite from gangue minerals. In 2024 she visited the University of South Australia to conduct high-level metallurgical measurements.

Student: Emmanuel Dogara Musa

PhD student Emmanuel Dogara Musa joined CODES in March 2023. He is conducting test work on scheelite flotation at Kara Mine, currently focusing on coarse flotation which requires less energy to grind the ore. He is also using existing and new combinations of reagents to optimise scheelite flotation conditions at Kara Mine in his project entitled 'Pathways to production for critical metals: Kara W deposit, Western Tasmania'.

Student: Pratiche Mondal

Pratiche Mondal joined CODES in late 2023 to embark upon her research at Savage River. Her research in 2024 began with ore geology of magnetite at Savage River, characterising economic and non-economic ore zones using a range of analytical techniques. In 2025 she will work on detailed characterisation of tailings samples. Her research project is entitled 'Mineral

and geoenvironmental characterisation of, and pathways to, production for critical metals from Western Tasmania'.

Dr Mohammad Fathi dedicated his research to developing flotation kinetics models for scheelite in Kara Mine samples, investigating different reagents in the desulfurisation process to minimise scheelite losses, an essential pre-treatment step in scheelite processing. He has also been working on developing a conceptual processing flowsheet for the recovery of strategic and critical minerals from Mt Lyell tailings. His research involves:

- Detailed characterisation of samples using SEM and ICP-MS to determine the main phases of critical minerals and assess key properties such as size, shape, surface area, liberation degree and associated minerals.
- Comminution, desliming, magnetic separation and flotation tests to determine optimal process conditions.

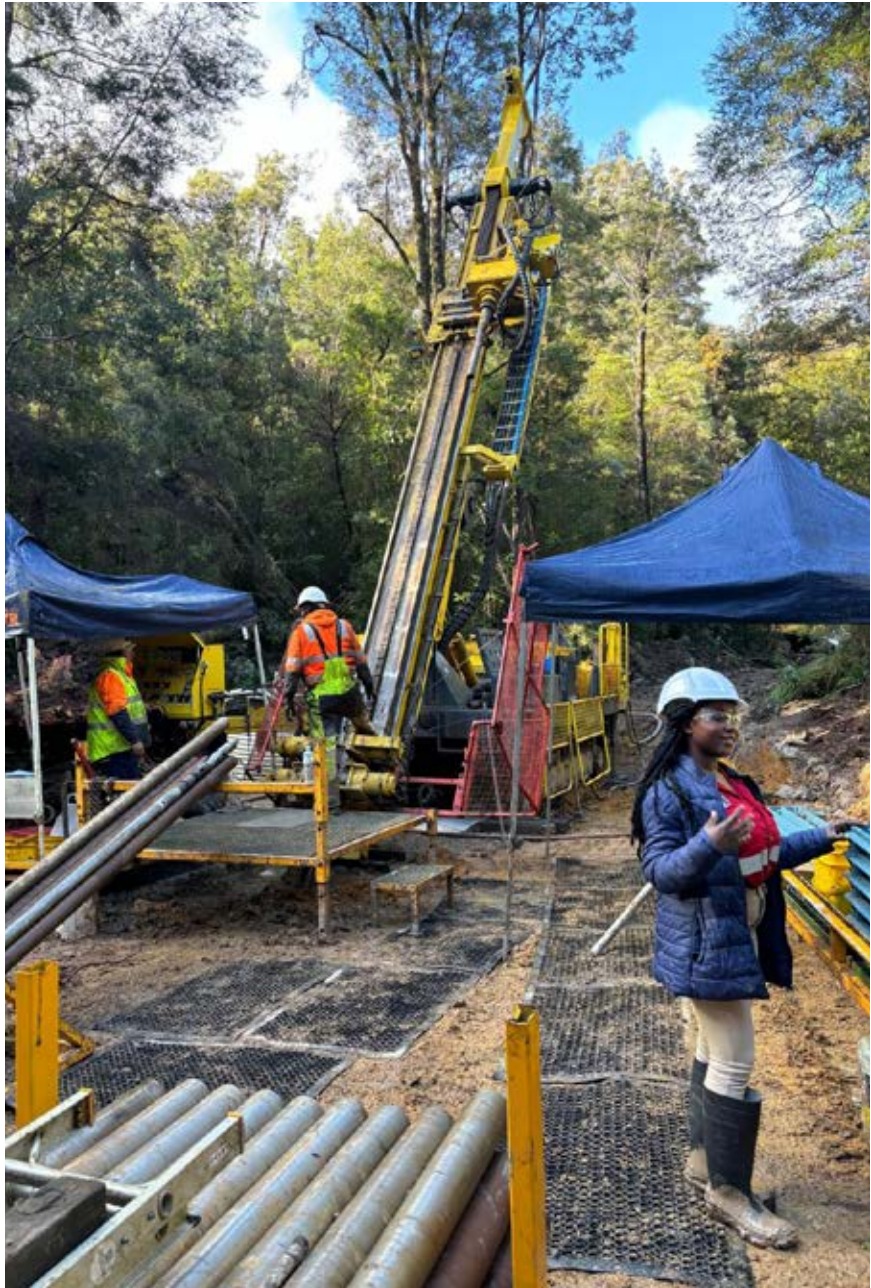
Two papers are in progress: a review titled 'Mineralogical and crystal chemical insights in scheelite processing', which has been completed and is under review, and a research paper based on the flotation kinetics study, which is currently being prepared for submission.

Dr Julie Hunt focused on the results of electric pulse fragmentation of scheelite-bearing samples from the Kara Fe-W mine and greisen samples from eastern Tasmania that contain Li-bearing mica. Her research work involves:

- SEM-based mineral mapping to determine size and liberation of valuable minerals.
- Analysis of element distribution within valuable minerals via LA-ICP-MS to assess co-product critical metals (e.g., Bi, REEs).

A paper for publication is underway that includes results from some of this work – 'Critical metal potential of Tasmania greisen: Li, REEs, Bi distribution and implications for processing'. Publication is planned for 2025.

See RRC section on page 66 for further details.



Prospect Ridge, western Tasmania, the site for PhD student Alfredtina Appiah's research. Here a diamond drill rig operated by Tasmanian Magnesium Pty Ltd is being used to drill down to the bedrock, while Alfredtina stands by.

AMIRA P1249: EXPLORING, CHARACTERISING, AND OPTIMISING COMPLEX OREBODIES – UPSCALING OREBODY KNOWLEDGE TO ADD VALUE ACROSS THE MINING VALUE CHAIN

(See Program 1 on page 16 for full details about this project including all collaborators.)

Student: Markus Staubmann

The Amira P1249 project includes geometallurgy and geoenvironmental research within Program 2.

Markus Staubmann continued work on his PhD project entitled 'Integrated ore deposit knowledge: Optimising mineralogical characterisation through the mining value chain'. He is developing workflows, methods and tools for mineralogical characterisation that allow effective upscaling from the microscopic to the deposit-scale, and aid opportunity recognition and decision-making through all stages of the mining value chain.



CODES PhD student Pratiche Mondal examining samples collected from the waste rock piles at the Savage River magnetite iron ore mine facility owned by Grange Resources.

**CSIRO FUTURES PROJECT:
A METHODOLOGY FOR
MEASURING AND MODELLING
GANGUE LIBERATION USING
GEOLOGICAL ANALYSIS
AND PARTICLE GRADE
DISTRIBUTIONS**

Leader: Julie Hunt

Collaborators: Vladimir Jokovic,
Paul Revell, Greg Wilkie

The CSIRO Futures project continues the work developed in CRC ORE on pre-concentration, i.e., exploitation of the natural heterogeneity of an orebody to divert gangue or low-value material out of the mining value chain at relatively coarse particle sizes prior to fine crushing and milling.

The extension project is a collaboration between Diamondbacks, CSIRO Mineral Resources and CODES, and is focused on the liberation of gangue material and the inherent particle grade distributions present in these coarse particle size ranges. The objective of the project is to combine geological

characterisation with different analytical techniques (chemical analysis, X-ray tomography) to characterise coarse ore feeds that cannot be analysed by traditional automated mineralogy methods due to the large size of the particles. Particle grade distributions are being examined to determine the particle size where liberation of gangue occurs. Results from this approach can be used to model gangue liberation and predict mass and value flows going to accept and reject streams.

▼
**The objective of
the [CSIRO Futures]
Project is to
combine geological
characterisation with
different analytical
techniques to
characterise coarse
ore feeds...**

This project was completed in December 2023 and a final report submitted to CSIRO in January 2024. The report was accepted by CSIRO and the project closed in June 2024.

**GEOENVIRONMENTAL
RESEARCH**

Dr Owen Missen collected sediment cores from a saltmarsh, collected waste rock samples and performed characterisation work on samples from several industrial and impacted sites across western Tasmania. He is working closely with the RRC project. He delivered final reports to MRT for the project 'Sources and drivers of neutral mine drainage at the former Merrywood Coal Mine'. He also collected metallurgical samples from Wetar Island, Indonesia.

Third-year undergraduate student Claire Evans completed a project on metal(loid) contamination in Richmond Park Estate saltmarsh to Hobart's east, supervised by Dr Owen Missen, Professor Sebastien Meffre and in collaboration with UTAS Geography (Dr Vishnu Prahalad, Dr Lydia Mackenzie).



Dr Owen Missen on Wetar Island, Indonesia, pictured with Irzal Ramadhan, Syafiq Arifullah and Jeffrey Halim (mine and exploration geologists from Merdeka Copper Gold) while on a fieldwork trip during which drill core, pit outcrop and metallurgical samples were collected for a study on the Wetar Copper Mine.

**Geoenvironmental
and geometallurgical
characterisation of weathered
polymetallic wastes**

Student: Christopher Allen

Christopher Allen continued work on his PhD focused on 'Geoenvironmental and geometallurgical characterisation of weathered polymetallic wastes: Implications for mine closure, western Tasmania' and is jointly supported by MRT, Bluestone Mines Tasmania Joint Venture, Okane Consultants and Copper Mines of Tasmania. In 2024 his work focused on running kinetic weathering columns, comparing different conditions and lithologies from weathering waste rocks from a northwest Tasmanian site, and beginning to analyse the weathered materials from the completed kinetic columns. He is working closely with the RRC team.

► LOOKING FORWARD

- Program 2 RRC staff and students have submitted abstracts and plans to present their research at the following conferences in 2025:
- SEG, Brisbane, Queensland (Owen Missen)
 - AusIMM Critical Metals, Perth WA (Emmanuel Dogara Musa)
 - Extraction 2025 Meeting and Exhibition, Phoenix, Arizona, USA (Emmanuel Dogara Musa and Mohammad Fathi)
 - Minerals Engineering Flotation, Cape Town, South Africa (Alfredtina Appiah)
- Papers on the following topics are expected to be published in 2025:
- C.C. Allen et al. Practical application of geophysical methods for characterisation of mine waste rocks
 - A.A.A. Appiah et al. Geometallurgical characterization of the Arthur River magnesite deposit, Northwestern Tasmania for Pathways to Production
 - M.E. Dogara et al. Optimising scheelite recovery by coarse froth flotation: A case study from Kara Magnetite-Scheelite Skarn Deposit in Northwestern Tasmania, Australia
 - O.P. Missen et al. Late stage hydrothermal and weathering processes in tellurium deposits: insights from the laboratory and Nature
 - O.P. Missen et al. Aqueous chemistry and mineralogical drivers of alkaline drainage from a former coal mine: Merrywood Creek, northeastern Tasmania

Program 3: Sedimentation, tectonics and Earth evolution

► OBJECTIVE

This program aims to understand the formation and evolution of sedimentary basins, including their ore deposits and metamorphic and deformation histories, within the broader context of geodynamic processes and Earth evolution. This program also includes the study of catastrophic submarine mass-wasting events, which pose a substantial risk to coastal infrastructure and populations. Our goal is ultimately to develop new and refined geological and tectonic models to enhance exploration success for diverse sediment-hosted mineral systems formed throughout Earth history.

Introduction

Program 3: Sedimentation, tectonics and Earth evolution

encompasses all aspects of tectonic and sedimentary basin evolution and how these influence the spatial and temporal distributions of sediment-hosted ore deposits. This has a direct impact on the search for, and understanding of, a vast array of ore types, including sedimentary exhalative (SEDEX) Zn-Pb-Ag, Broken Hill-type Ag-Pb-Zn, sediment-hosted orogenic Au, and sediment-hosted Cu-Co-Au. Fundamental research in this program aims to understand the development of life on Earth, including how cycles revealed in marine geochemistry profiles and craton amalgamation may influence the location and timing of sediment-hosted mineral systems.

Catastrophic events occur intermittently through the geological record, and these occasional but extreme events may affect and modify entire basins and coastlines. Further, modern submarine landslides are substantial risks to coastal populations and underwater structures, and studying their deposits will allow us to refine tsunami models for the Australian coast.

Highlights

Research

2024 yielded a bumper crop of PhD graduates whose projects were linked to Program 3 research areas:

- After publishing a landmark paper on Central Andean lithospheric architecture in 2023, which departed in significant ways from previous models and thus generated much interest (and a little controversy!), **Alex Farrar** saw the rest of his PhD through to the end in 2024. He is currently Principal Geologist (Copper) with First Quantum Minerals.
- **Max Hohl** wrapped up a very successful mineral chemistry study of the Starra 222 and 276 IOCG deposits in northwest Queensland's prolific Cloncurry district, with two papers published at the time of writing. He is currently a postdoctoral researcher at MDRU.
- **Colin Jones** examined the chemistry and origin of Devonian granites on the east coast of Tasmania, yielding important new results that can help explorers distinguish the metallogenic signature of different granite bodies (e.g., Au, Sn, Sn-W, etc.)

- **Elena Lounejeva** – our marathon PhD candidate – made a final push towards completion of her thesis in 2023, culminating in two published papers (and a third on the way) and glowing examiners' reports for a job very well done. She graduated in May 2024 and is presently employed in the CODES Analytical Laboratories.

Publications

Two notable publications published in 2024 with input from the Program 3 team were:

- 'Magnetite-apatite ores record widespread involvement of molten salts', Xu et al., 2024, *Geology* (<https://doi.org/10.1130/G51887.1>). This paper documented the ubiquitous presence of solidified 'molten salts' (i.e., inclusions of multiphase solids rich in Fe, Na, Ca, K, and/or S) hosted in minerals like magnetite, apatite and amphibole in dozens of iron oxide-apatite (IOA) systems around the globe. These inclusions point to a common origin, namely, the anatexis and assimilation of evaporitic sedimentary rocks by intruding magmas during IOA development. Of special note is that this study recorded molten salt inclusions from the Savage River Fe mine in western Tasmania, which adds a new dimension to the ongoing debate regarding Savage River's origins.
- 'Trace element systematics of magnetite from the Starra iron oxide-copper gold deposits reveals early fluid conditions characteristic for Cu mineralization', Hohl et al., 2024, *Chemical Geology* (<https://doi.org/10.1016/j.chemgeo.2024.121960>). This paper, the first of Max Hohl's PhD project papers on the Starra IOCG deposits in the Cloncurry district, NW Queensland, provided a comprehensive overview of magnetite paragenesis and trace element characteristics at Starra 222 and 276, two of the main deposits in the camp. Importantly, Max identified that V and Ga concentrations vary in concert with distance from the main mineralising structure in both deposits, which points to magnetite's importance as a potential vector towards Au-Cu ore in the Starra camp and potentially elsewhere in the Cloncurry district.



Fieldwork in Zambia (L-R): Munshya Zimba, Dr Subaru Tsuruoka, Dr David Selley and Dr Sheree Armistead (project leader) pictured at the First Quantum Minerals exploration site in Ndola as part of preparatory work for the 'Sediment-hosted Cu-Co deposits' project.

Technology transfer

Dr Jeff Steadman presented at a pre-conference workshop on IOCG deposits in October for the International Applied Geochemistry Symposium in Adelaide. This was a two-day workshop featuring presentations from world-leading researchers on the origins of IOCG and IOA systems. Jeff spoke on the use of mineral chemistry as a tool to aid explorers in the search for Cu-Au resources.

Conferences

During 2024 members of the Program 3 team attended several conferences and presented papers at many of them, both here and overseas including:

- Dr Jeff Steadman attended Goldschmidt2024 in Chicago, USA, in August and delivered a presentation on the Ernest Henry and Hillside IOCG deposits.
- Dr Martin Jutzeler attended the IODP3 Workshop in March, held in Nachikatsuura, Japan, where he presented plans for drilling submarine volcanoes in the Kermadec Arc.
- Dr Jeff Oalman attended the 16th European Workshop on Laser Ablation in Ghent, Belgium, and presented a poster.
- Dr Ivan Belousov attended the 16th European Workshop on Laser Ablation in Ghent, Belgium, and gave a talk on trace element compositions of microinclusions in minerals. He also attended the International Applied Geochemistry Symposium in Adelaide.

- Dr Sheree Armistead attended the SEG 2024 Conference in Windhoek, Namibia, in September and gave a paper.
- Professor David Cooke attended the SEG 2024 Conference in Windhoek, Namibia and presented a paper.
- Dr Matthew Cracknell attended the International Applied Geochemistry Symposium in Adelaide in October and presented a paper.
- CODES PhD student Damian Braze attended the SEG 2024 Conference in Windhoek, Namibia, and also went to the Annual Geoscience Exploration Seminar in Alice Springs during April.

Award

During 2024 Dr Sheree Armistead was awarded an Australian Research Council Discovery Early Career Researcher Award (DECRA) of \$487,886 for her innovative project aimed at unravelling the formation of sediment-hosted copper and critical mineral deposits over the past billion years of Earth's history. Titled 'The interplay of tectonics and climate on critical minerals in deep time', this project will integrate plate tectonic models, ore deposit data and geochemical analysis to explore how Earth's tectonics and climate have influenced ore deposit formation. The findings could help discover new critical minerals in Australia, supporting the country's move to sustainable energy. The project will commence in mid-2025.

The program team

LEADER ROBERT SCOTT
DEPUTY LEADER JEFF STEADMAN



TEAM MEMBERS:

Sheree Armistead, Ivan Belousov, Ron Berry, David Cooke, Matthew Cracknell, Julie Hunt, Martin Jutzeler, Ross Large, Sebastien Meffre, Jeff Oalman, Karin Orth, David Selley

PHD STUDENTS:

Jessica Askew, Damian Braize, Alex Farrar, Max Hohl, Colin Jones, Elena Lounejeva, Thomas Schaap, Peerapong Sritangsirikul, Shouchun Yu

MASTERS STUDENT:

Calvin Hayre

UNDERGRADUATE STUDENT:

Molly Robinson

COLLABORATORS:

CARNEGIE INSTITUTION, USA
Robert Hazen

CENTRAL SCIENCE LABORATORY (UTAS)
Sandrin Feig, Karsten Goemann

CSIC, UNIVERSITY OF MADRID, SPAIN
Fernando Tornos

EMMERSON RESOURCES
Mike Dunbar

GEOLOGICAL SURVEY OF QUEENSLAND (DEPARTMENT OF RESOURCES)
Elena Belousova, Rhiannon Jones, Alkis Kontonikas-Charos, Vladimir Lisitsin

GEOLOGICAL SURVEY OF SOUTH AUSTRALIA
Adrian Fabris

GEOSCIENCE AUSTRALIA
Antony Burnham, Yanbo Cheng, Jonathan Cloutier, Andrew Cross, Geoff Fraser, David Huston, David Mole

INSTITUTE FOR MARINE AND ANTARCTIC STUDIES (UTAS)
Neville Barrett, Jacqui Halpin, Rafael Leon, Vanessa Lucieer, Joanne Whittaker

ISTITUTO ITALIANO DI PALEONTOLOGIA UMANA, ROME, ITALY
Alan Cannell

MINERAL RESOURCES TASMANIA
Ralph Bottrill, Clive Calver, Grace Cumming, Mark Duffett, John Everard, Claire Kain, Andrew McNeill, Nick Roberts, Mike Vicary

NEWMONT
Alexander Willcox

NORTHERN TERRITORY GEOLOGICAL SURVEY
Dorothy 'Dot' Close, Pablo Farias, Jo Whelan

RUSSIAN ACADEMY OF SCIENCE, RUSSIA
Valeriy Maslennikov

TASMANIAN INSTITUTE OF AGRICULTURE (UTAS)
Ross Corkrey

UNIVERSIDADE FEDERAL DE MINAS GERAIS, BRAZIL
Fabricio Caxito

UNIVERSIDADE FEDERAL DE RIO DE JANEIRO, BRAZIL
Renata Schmitt

UNIVERSITY OF ADELAIDE
Jacob Mulder

UNIVERSITY OF BERGEN, NORWAY
Frida Snilstveit Hoem

UNIVERSITY OF MELBOURNE
Stephen Gallagher

UNIVERSITY OF NEW SOUTH WALES
Indrani Mukherjee

UNIVERSITY OF SYDNEY
David Airey, Tom Hubble

UNIVERSITY OF UTRECHT, NETHERLANDS
Peter Bijl

WARATAH MINERALS
Peter Duerden



Dr Jeff Steadman giving a presentation about progress with the IOCG³ project at the CODES Critical and Strategic Metals Symposium, which was held in July 2024 on the UTAS Sandy Bay campus.

Projects

Iron oxide copper-gold deposits: Geochemistry and geometallurgy (IOCG³)

Mineral chemistry and event chronology of the Tennant Creek, Rover and East Tennant IOCG districts, Northern Territory

Temporal controls on Tasmanian and eastern Australian ore deposits

Stability of the Australian continental shelf

The geological and tectonic evolution of Tasmania

Ore deposits and tectonic evolution of the Lachlan Orogen, SE Australia

Trace elements in ancient oceans

Sediment-hosted Cu-Co deposits: Developing new mineral chemistry exploration tools

Stratigraphic analysis of the Upper Blake Beds, Dead Bullock Soak, Tanami, NT

Project summaries

IRON OXIDE COPPER-GOLD DEPOSITS: GEOCHEMISTRY AND GEOMETALLURGY (IOCG³)

Leader: Jeff Steadman

Team members: Sheree Armistead, Matthew Cracknell, Karsten Goemann (CSL), Julie Hunt, Sebastien Meffre

Students: Damian Braize, Shouchun Yu

Collaborators: Ralph Bottrill, Grace Cumming, Adrian Fabris, Fernando Tornos

The IOCG³ project, which began in September 2022 at CODES, completed its second year in 2024. No fieldwork was completed in 2024, but drill core sampling was done in both South Australia and Queensland for the Con Ryan and E1 prospects, respectively. A sponsors' review meeting was held at CODES in October.

The IOCG³ team was pleased to welcome new PhD student Shouchun Yu, who commenced in September. His focus will be on the geochemistry of hydrothermal alteration minerals in all study sites, utilising machine learning algorithms to interrogate the existing data as well as generating new trace element data on selected mineral groups.

Key outcomes of research efforts in 2024 included the continued analyses of multiple hydrothermal minerals at all study sites, for trace element, radiogenic, and stable isotopic compositions. Additionally, significant steps were taken to begin classifying and domaining the trace element data using multivariate statistical methods. The aim of this module is to enhance the trace element signatures of the main hydrothermal mineral phases by making them more statistically robust and less subject to individual user interpretation. Dr Jeff Steadman also presented at a pre-conference workshop on IOCG deposits in October for the IAGS symposium in Adelaide.

MINERAL CHEMISTRY AND EVENT CHRONOLOGY OF THE TENNANT CREEK, ROVER AND EAST TENNANT IOCG DISTRICTS, NORTHERN TERRITORY

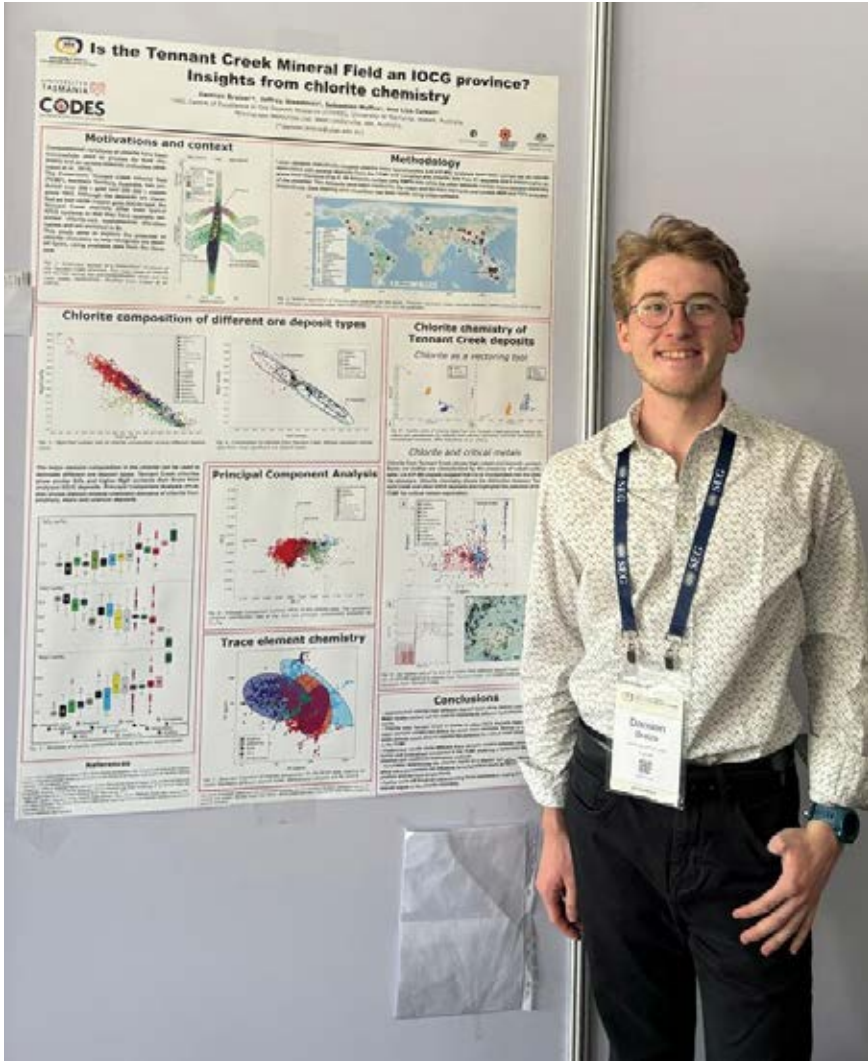
Leader: Jeff Steadman

Team member: Sebastien Meffre

Student: Damian Braize

Collaborators: Yanbo Cheng, Dorothy 'Dot' Close, Jonathan Cloutier, Mike Dunbar, Pablo Farias, Jo Whelan

Damian Braize was welcomed to CODES in March 2024 to work on this project, which investigates the mineral chemistry and geochronology of the Tennant Creek district and surrounding mineral fields in the Northern Territory.



CODES PhD student Damian Braize at the SEG 2024 Conference in Windhoek, Namibia, with the poster he presented about his research into the Tennant Creek district.

Tennant Creek contains several high-grade past-producing Au-Bi-Cu deposits and remains an active area of exploration. However, the geology of Tennant Creek and the surrounding areas is not well understood, owing in part to their remote location and relatively small endowment.

The first component of the project focuses on the use of chlorite mineral chemistry as an exploration tool. Initial results from Damian Braize's PhD project show that chlorite chemistry can be used to classify deposit types and reveal mineralogical similarities between Tennant Creek and other iron oxide copper-gold (IOCG) systems elsewhere. His work has also demonstrated the potential of chlorite chemistry to vector towards mineralisation in the vicinity of known deposits, and efforts are underway to extend this approach to regional sites across the province.

The second component aims to provide new geochronological constraints on mineralisation. In 2024, monazite- and xenotime-bearing ore samples from Warrego, the largest known deposit in the Tennant Creek district, were dated using LA-ICP-MS at CODES. These new U/Pb results identified a previously unrecognised Au-Bi-Cu mineralisation event at ~1720 Ma, which overlaps with the crystallisation age of the Warrego Granite. These valuable insights into the genesis of the Tennant Creek deposits provide justification for fine-tuning existing regional exploration models, with the aim of increasing exploration success.

Research efforts in 2025 will continue to focus on the use of mineral chemistry as both a vectoring and fertility tool, contributing to a deeper understanding of the Tennant Creek mineral field and surrounding regions.

TEMPORAL CONTROLS ON TASMANIAN AND EASTERN AUSTRALIAN ORE DEPOSITS

Leaders: Sebastien Meffre, Sheree Armistead

Team member: Jeff Steadman

Collaborators: Ralph Bottrill, Andrew Cross, Grace Cumming, Geoff Fraser, David Huston, Jacob Mulder

This two-year project was part of the Temporal Controls on Mineralisation Module within Geoscience Australia's 'Exploring for the Future' Program, which aimed to stimulate mineral exploration investment, including critical minerals, and to open new mineral provinces.

In 2024 two new papers were published summarising the ages of monazite, apatite and xenotime in the Interview River, Strickland and Balfour deposits in western Tasmania. These deposits previously had few temporal constraints on mineralisation and are difficult to characterise in terms of genetic models. These new publications contributed to a better understanding of the geology of Tasmania and increased the mineral prospectivity of NW Tasmania.

STABILITY OF THE AUSTRALIAN CONTINENTAL SHELF

Leader: Martin Jutzeler

Collaborators: Neville Barrett, Peter Bijl, Grace Cumming, Mark Duffett, Stephen Gallagher, Tom Hubble, Claire Kain, Rafael Leon, Vanessa Lucieer, Nick Roberts, Frida Snilstveit Hoem, Joanne Whittaker

Western Tasmania submarine slide

Dr Martin Jutzeler is studying a giant submarine continental shelf landslide offshore SW Tasmania. The landslide scar runs >50 km along the shelf and shows an abrupt headscarp failure associated with a gigantic multi-100 km³ submarine landslide deposit. The submarine landslide and associated



Dr Martin Jutzeler (orange jacket) attended the IODP3 Workshop in March 2024, held in Nachikatsuura, southern Honshu, Japan; the trip was in connection with planning further scientific drilling programs and was funded by the Australian and New Zealand International Scientific Drilling Consortium (ANZIC).

turbidites were deposited 30–120 km downslope and at 2,000–4,500 m water depth. The headscarp attests to a single (or a few), catastrophic event(s) with minimal post-event sediment remobilisation. The morphology of the submarine landslide deposit suggests it to be relatively recent (Pleistocene–Pliocene). The main submarine landslide is potentially the biggest recent slide offshore Australia. It is more than twice the size of the 1929 Grand Banks slide offshore Newfoundland that created a 3–8 m tsunami 400 km away and damaged seafloor infrastructure.

Martin is using data and samples that were collected through a \$4.2-million voyage he led on the CSIRO Research Vessel RV *Investigator* in 2023. Seismic reflection and sub-bottom profiler data allow us to identify the landslide and its scarp in its entirety, whereas sediment cores collected failed blocks material at the base of the slope, and turbidites in the abyssal plain. Landslides initiating at continental shelves have national and global impacts due to their likelihood of creating tsunamis and damage to submarine and/or coastal infrastructure. This project provides novel data on

catastrophic tsunamigenic submarine mass-wasting events to be used by modellers for tsunami mitigation.

THE GEOLOGICAL AND TECTONIC EVOLUTION OF TASMANIA

(This project was formerly known as Building Tasmania: the Cambrian and beyond)

Leaders: Sebastien Meffre, Robert Scott

Team members: Ron Berry, Martin Jutzeler, Karin Orth

Student: Thomas Schaap

Collaborators: Ralph Bottrill, Clive Calver, Grace Cumming, John Everard, Jacqui Halpin, Andrew McNeill, Jacob Mulder, Mike Vicary

This project, focused on Tasmanian-based geochronology and tectonics, has been running for many years and has provided some major new insights into the tectonic history of the island. In 2024, Dr Ron Berry submitted a paper

summarising the chemostratigraphy of the pre-Carboniferous sedimentary rocks of the island and began working on a number of other papers focused on the geology of the pre-Carboniferous rocks in the transition between western and eastern Tasmania. This work is focused on constraining how eastern and western Tasmania were amalgamated and the deep crustal structure of the island.

The voyage IN2023_V02 led by Dr Martin Jutzeler on the RV *Investigator* in March–April 2023 also provided new data allowing key elements of Tasmania's onshore geology to be mapped deep into the offshore realm. This new information improves constraints on the gross geometry of geological boundaries within the Tasmanian continental crust. The voyage carried out high-resolution (1–3 m) bathymetry on the continental shelf and dredged Precambrian to Tertiary formations on the continental slope and shelf. Bathymetry, dredge sampling and seismic reflection survey data have yielded important new insights into the make-up of the submerged continental blocks that

flank southwestern Tasmania, and have provided the research team with an unprecedented view of the continental rift architecture formed during Tasmania’s initial separation from Antarctica during the Cretaceous. In collaboration with Grace Cumming at MRT, a selection of dredged samples has been successfully dated using U-Pb LA-ICP-MS on zircons to refine the stratigraphic model of the seismic reflection transects.

ORE DEPOSITS AND TECTONIC EVOLUTION OF THE LACHLAN OROGEN, SE AUSTRALIA

Leaders: Sebastien Meffre, David Cooke, Matthew Cracknell

Team members: Ron Berry, Jeff Steadman

Student: Jessica Askew

This project, aimed at understanding the geology, tectonic evolution and ore deposits of the Lachlan Orogen in southeastern Australia, has been running since 2016 building on earlier projects. In 2024 a new phase of the

project, focused on the genesis and geochronology of the Cargo Deposit near Orange in NSW, was started with a collaboration with Waratah Minerals.

TRACE ELEMENTS IN ANCIENT OCEANS

Leader: Ross Large

Team member: Jeff Steadman

Collaborators: Alan Cannell, Fabricio Caxito, Ross Corkrey, Robert Hazen, Valeriy Maslennikov, Indrani Mukherjee

This project uses the trace element content of sedimentary pyrite through time to interpret changes in the trace element content of past oceans and relationships to atmospheric oxygen. This study combines the results from two totally different methods to estimate atmosphere oxygen concentrations during the Precambrian and Phanerozoic.

Collaboration with Dr Indrani Mukherjee at the University of New South Wales has resulted in a manuscript submitted

to *Gondwana Research* on the intersection of geological, geochemical and biological events during the Boring Billion. This will be the final output from this very productive project.

SEDIMENT-HOSTED CU-CO DEPOSITS: DEVELOPING NEW MINERAL CHEMISTRY EXPLORATION TOOLS

Leader: Sheree Armistead

Team members: David Selley, David Cooke, Ivan Belousov, Matt Cracknell, Jeff Oalmann, Robert Scott

Student: Molly Robinson

In 2024, significant progress was made in establishing the new sediment-hosted copper research initiative at CODES. This project focuses on developing innovative mineral chemistry tools to refine exploration models, especially for Cu-Co deposits. Dr Sheree Armistead, Professor David Cooke and Dr David Selley led fieldwork in Zambia’s Central African Copperbelt, examining deposits at First Quantum Minerals’ Trident project, including Sentinel Cu and Enterprise Ni deposits, and KoBold’s high-grade Mingomba Cu project. Fieldwork highlighted interesting geological features such as vaesite (NiS₂) and hydrothermal kyanite, and samples were collected from the Mingomba deposit to investigate apatite chemistry as part of the project’s focus on resistate indicator minerals (RIMs).

Additionally, third-year undergraduate student Molly Robinson conducted a research project on tourmaline geochemistry from the Kamo-a-Kakula deposit, supervised by Dr Armistead. Her work using SEM and LA-ICP-MS techniques provided insights into trace-element vectors and redox-sensitive mineralisation indicators, demonstrating tourmaline’s potential as a geochemical vector in sediment-hosted copper exploration. These foundational activities have set the stage for an ambitious project launch planned for 2025.



Dr Sheree Armistead gives a presentation at the SEG 2024 Conference in Windhoek, Namibia.

STRATIGRAPHIC ANALYSIS OF THE UPPER BLAKE BEDS, DEAD BULLOCK SOAK, TANAMI, NT

Leader: Martin Jutzeler

Team member: Matthew Cracknell

Student: Calvin Hayre

Collaborator: Alexander Willcox

Dr Martin Jutzeler and Dr Matt Cracknell are supervising Calvin Hayre, an MSC student at CODES and employed by Newmont at Tanami, NT. The world-class Dead Bullock Soak mining camp is located within the Granites–Tanami Gold Province, which is situated approximately 650 km NW of Alice Springs within the North Australia Craton.

The Granites–Tanami Gold Province consists of folded Palaeoproterozoic meta-turbidites and volcanic units of the Tanami group, overlying Archean crystalline basement rocks. The province is host to several orogenic gold deposits that formed between 1805 and 1790 Ma. At Tanami, gold mineralisation is hosted by the ~1-km-thick Dead Bullock Formation, a sequence of

metasedimentary rocks formed in low energy environments and intruded by dolerite sills.

Calvin will focus on the Upper Blake Beds, which are dominated by siltstone, carbonaceous siltstone and less abundant sandstone grading into chert-bearing iron-rich siltstone and carbonaceous siltstone. This sequence has been poorly explored despite being between two major gold-mineralised sequences that are the focus of the mining efforts. The aims of this project are twofold. First, the team will conduct a stratigraphic and sedimentological analysis of the Upper Blake Beds by combining visual core logging with geochemical analyses with pXRF. Second, the team will build a machine-learning library to recognise bedding contacts in the formation, which shows strong contrast between grey fine sandstone and black siltstone. This library will be used as a first proof of concept that may be exported to the entire stratigraphy at the mine site if successful. Dr Martin Jutzeler will visit Calvin Hayre at the mine site in early 2025 to support him on the core logging of the sedimentary succession. Dr Matthew Cracknell will assist Calvin with the machine-learning technique later in 2025.

LOOKING FORWARD

2025 is poised to be a highly prolific year in terms of research for Program 3. Dr Sheree Armistead’s DECRA grant will commence in mid-2025, and brings with it great potential to advance the understanding of Cu-Co ore formation in what is arguably the world’s preeminent copper (and cobalt) ore district. 2025 will also see the sunset of other successful projects in Program 3, such as Dr Jeff Steadman’s IOCG³ research collaboration and the highly productive ‘Trace elements in ancient oceans’ project, led by Emeritus Distinguished Professor Ross Large.

Other projects continuing in 2025 include the ‘Temporal controls’ project, co-led by Dr Sheree Armistead and Professor Sebastien Meffre, and Dr Martin Jutzeler’s research into the Cretaceous rifting of Antarctica from Australia.

Program 4: Magmatic and volcanic processes

► OBJECTIVE

This program investigates magmatism, volcanism, volcano-sedimentary processes, and magmatic-hydrothermal mineral systems to unravel the interactions and connections between the mantle, crust and Earth's surface.

Introduction

Program 4: Magmatic and volcanic processes focuses on conducting fundamental research related to magma genesis and ascent, volcanic eruptions and associated volcano-sedimentary processes. We apply that science to magmatic-volcanic-hydrothermal mineral systems in various tectonic settings, and in both subaerial and submarine environments. The understanding of magmatic and volcanic environments can have implications for natural hazards, and efficient and effective vectoring towards ore deposits.

This program fosters collaboration and maintains a diverse network of partners, including national and international industry stakeholders, research institutions and geological

surveys, marine research centres, and observatories. The contributions and expertise of these partners are highly valued in driving the program's research goals and outcomes.

Highlights

Research

Well done to our PhD students who have successfully submitted or finalised their theses in 2024:

- Zebedee Zivkovic successfully completed his thesis corrections, with graduation and celebration anticipated in 2025.
- Hannah Moore and Malai Ila'ava submitted their PhD theses in 2024 and are expected to graduate in 2025 as well.



The contributions and expertise of [our] partners are highly valued in driving the program's research goals and outcomes.



Participants on the March 2024 Volcanology and Mineralisation in Volcanic Terrains Masters short course, pictured in the Tarawera 1886 fissure, New Zealand.

Publications

Malai Ila'ava published his first peer-reviewed paper in the *Australian Journal of Earth Sciences*, titled '3D modelling of subsurface ancient volcanic successions: a workflow developed during regional reconstructions of the Cowal Igneous Complex in the Ordovician Macquarie Arc of NSW, Australia'. This work integrates traditional volcanic facies analysis with advanced 3D modelling techniques, offering a novel workflow for interpreting ancient, buried volcanic terrains.

Zebedee Zivkovic published two papers in 2024:

- 'Whole rock lithogeochemical analysis of the Mount Read Volcanics: A new tool for geochemical exploration', published in *Geochemistry: Exploration, Environment, Analysis*.

- 'Yampi Peninsula felsic Hart Dolerite: re-evaluating the Nellie Tonalite using evidence from whole rock, petrography and geochronology', published in the *Australian Journal of Earth Science*.

In October 2024, CODES/ES hosted the launch of the updated and revised edition of CODES and Monash University Adjunct and Emeritus Professor Ray Cas's landmark publication on volcanology. The two-volume revised edition is titled *Volcanology: Processes, Deposits, Geology and Resources*. The event was attended by a large group of CODES/ES academics and students.

Awards

Future Fellowship: Associate Professor Rebecca Carey was awarded an ARC Future Fellowship in 2024, recognising her leadership in volcanic systems research. As part of the fellowship,

she is bringing on a postdoctoral researcher and two PhD students to advance research on powerful submarine volcanic eruptions and the role of deep magmatic systems in driving these events. The title of her Future Fellowship project is: 'Decoding risks and unlocking rewards of oceanic volcanism'.

In Memoriam

**David H Green
(1936–2024)**

We acknowledge with sadness the passing of Professor David H Green in September 2024. His contributions to experimental petrology and mantle geochemistry have left a lasting legacy in the geoscience community.

The program team

LEADER REBECCA CAREY
DEPUTY LEADER MARTIN JUTZELER



TEAM MEMBERS:

Sharon Allen, Mike Baker, Ivan Belousov, Yamila Cajal Contreras, David Cooke, Matt Cracknell, Paul Davidson, Trevor Falloon, Jodi Fox, Bruce Gemmell, David H. Green, Maya Kamenetsky, Ross Large, Charles Makoundi, Jocelyn McPhie, Sebastien Meffre, Jeff Oalmann, Paul Olin, Karin Orth, Michael Roach, Robert Scott, Lejun Zhang

PHD STUDENTS:

Billy Beas, Catherine Brown, Acacia Clark, Vinicius da Cruz, Shannon Frey, Fumihiko Ikegami, Malai Ila’ava, Bridie Le’Gallais, Catherine Lit, Hannah Moore, Poliana Vidal Salgado, Peerapong Sritangsirikul, Zebedee Zivkovic

UNDERGRADUATE STUDENT:

Ellyse Noy

COLLABORATORS:

AUCKLAND MUSEUM, NZ
Tom Trnski

BHP
Kathy Ehrig

CATALYST METALS LTD
Keith Cameron-Smith

CENTRAL SCIENCE LABORATORY (UTAS)
Christian Dietz, Sandrin Feig, Karsten Goemann, Thomas Rodemann

CONSULTANT
Anthony (Tony) Brown, Vadim Kamenetsky

DATAROCK
Yasin Dagasan, Liam Webb

DREADNOUGHT RESOURCES
Dean Tuck

DURHAM UNIVERSITY, UK
Matthieu Cartigny

EVOLUTION MINING
Ned Howard

FLEET SPACE TECHNOLOGIES
Gerrit Olivier

GEOLOGICAL SURVEY OF NEW SOUTH WALES
Chris Folkes

GEOMAR, GERMANY
Steffen Kutterolf, Janne Scheffler

GEOSCIENCE AUSTRALIA
Jonathan Cloutier

GNS SCIENCE, NEW ZEALAND
Cam Asher, Ery Hughes, Paul Jarvis, Geoff Kilgour, Michael Rosenberg

HELMHOLTZ INSTITUTE FREIBERG FOR RESOURCE TECHNOLOGY, GERMANY
Alkiviadis (Alkis) Kontonikas-Charos

INSTITUTE OF MARINE AND ANTARCTIC STUDIES (IMAS)
Zanna Chase, Mike Coffin, Jacqui Halpin, Peter T Harris, Vanessa Lucieer, Taryn Noble, Joanne Whittaker

JAPAN AGENCY FOR MARINE SCIENCE AND TECHNOLOGY
Iona McIntosh

LOS ALAMOS NATIONAL LABORATORY, USA
Brent Delbridge

MACQUARIE UNIVERSITY
Nathan Daczko

MDRU, CANADA
Shaun Barker

MINERAL MAPPING
Scott Halley

MINERAL RESOURCES TASMANIA
Ralph Bottrill, Grace Cumming, John Everard, David Green, Andrew McNeill

MMG
Corey Jago

MONASH UNIVERSITY
Ray Cas

MURORAN INSTITUTE OF TECHNOLOGY, JAPAN
Yoshi Goto

NATIONAL INSTITUTE OF WATER AND ATMOSPHERIC RESEARCH, NEW ZEALAND
Emily Lane, Erica Spain, Sally Watson, Suzi Woelz, Richard Wysoczanski

NATIONAL MUSEUM OF NATURE AND SCIENCE, JAPAN
Kenichiro Tani

NATIONAL OCEANOGRAPHY CENTRE, UK
Michael Clare, Isobel Yeo

NORTHWEST UNIVERSITY, XI’AN, CHINA
Simon Williams

OCEANAGOLD, NEW ZEALAND
Shannon Richards

OREGON STATE UNIVERSITY, USA
Robert Duncan

PENNSYLVANIA STATE UNIVERSITY, USA
Tushar Mittal

QUEENSLAND UNIVERSITY OF TECHNOLOGY
Patrick Hayman, Jess Trofimovs

UNIVERSITÉ CLERMONT AUVERGNE, FRANCE
Tim Druitt

UNIVERSITY OF AUCKLAND, NEW ZEALAND
Michael Rowe, Julie Rowland

UNIVERSITY OF CALIFORNIA, BERKELEY, USA
Michael Manga

UNIVERSITY OF CALIFORNIA, DAVIS, USA
Cathy Busby

UNIVERSITY OF CANTERBURY, NEW ZEALAND
Ian Wright

UNIVERSITY OF HAWAII AT MANOA, USA
Bruce Houghton

UNIVERSITY OF MELBOURNE
Stephen Gallagher

UNIVERSITY OF OTAGO, NEW ZEALAND
James White

UNIVERSITY OF OXFORD, UK
Jane Barling

UNIVERSITY OF RHODE ISLAND, USA
Adam Soule

UNIVERSITY OF STRASBOURG, FRANCE
Michael Heap

UNIVERSITY OF SYDNEY
Maria Seton

UNIVERSITY OF TOKYO, JAPAN
Yusuke Yokoyama

UPPSALA UNIVERSITY, SWEDEN
Abigail Barker

VANDERBILT UNIVERSITY, USA
Ralf Bennartz, Kristen Fauria, Ashok Kumar Gupta, Liam J Kelly, John Rausch

Projects

Volcanology and geochemistry research related to ore deposits

Subaerial and submarine volcanology and natural hazards

Sedimentary volcanology

Olympic Dam fluid/melt inclusion project

The tectonic significance of mafic/ultramafic igneous rocks in western Tasmania

Pegmatites and pegmatite-related ores

VHMS research – ancient

Project summaries

VOLCANOLOGY AND GEOCHEMISTRY RESEARCH RELATED TO ORE DEPOSITS

Leader: Rebecca Carey

Team members: Bruce Gemmell, Martin Jutzeler, Ross Large, Jocelyn McPhie, Sebastien Meffre, Karin Orth, Michael Roach, Robert Scott

Students: Billy Beas, Vinicius da Cruz, Malai Ila’ava, Poliana Vidal Salgado, Zebedee Zivkovic

Collaborators: Ray Cas, Yasin Dagasan, Robert Duncan, Ned Howard, Corey Jago, Andrew McNeill, Liam Webb

Our research spans the continuum from fundamental science – exploring mechanisms of geological systems – to applied science that addresses pressing societal challenges. Whether informing natural hazard mitigation, resource discovery and management, our scientific insight delivers practical outcomes.

ARC Linkage Project – Exploration targeting from next-generation volcanic facies reconstruction

This Linkage Project represents a comprehensive and multidisciplinary study aimed at enhancing our understanding of the volcanic architecture in mineralised terrains, and to inform on the relationships between alteration and mineralisation processes with volcanic lithologies. The project seeks to reconstruct volcanic architectures by combining traditional facies analysis and geochemistry, with a novel approach involving modern image analysis and machine learning techniques applied to phenocryst populations in volcanic rocks. The project is based at Cowal gold mine (NSW), Waihi mine (New Zealand) and the Mt Read Volcanics (Tasmania), and is a collaboration with Evolution Mining, OceanaGold, Mineral Resources Tasmania, the University of Auckland, the University of Strasbourg and Datarock.

The image analysis project aims at improving stratigraphic reconstructions in volcanic terrains by complementing the traditional facies analysis and geochemistry techniques and using the phenocrysts, one of the most common attributes in volcanic rocks. The technique uses simple photographs of volcanic facies in core samples to quantitatively assess shape, abundance and size distribution of feldspar and pyroxene phenocrysts. Outputs from this multidisciplinary technique allow for stratigraphic correlations between different volcanic units, and fingerprint



A view of Tongariro volcano (foreground) and Ngauruhoe volcano (Mt Doom, background) taken during the New Zealand leg of the 2024 Volcanology and Mineralisation in Volcanic Terrains short course in March 2024.

key markers across fault blocks. This research is led by Dr Martin Jutzeler at CODES, and the machine learning aspect of the project is carried out in collaboration with Datarock. Martin and co-authors published a paper in December 2024 in the Nature journal *Scientific Reports* based on dacite rocks in the Mt Read Volcanics.

Malai Ila’ava’s PhD project is focused on reconstructing the basin scale volcanic facies architecture for the oldest known volcanics of the Cowal Igneous Complex (CIC). This project may have regional and tectonic implications as (i) the CIC is one of only a few localities that records the entire Ordovician history of the Macquarie Arc, and (ii) the earliest phase of volcanism is poorly constrained. Malai is currently writing up his thesis comprised of three publication-ready papers. In 2024, Malai published his first paper in the *Australian Journal of Earth Sciences* and describes the integration of traditional facies analysis with current 3D modelling techniques based on his experiences at the CIC. The second paper (in preparation) focuses on facies architecture reconstructions and volcanic and sedimentary processes based on rocks at Cowal.

The third paper (in preparation) is based on integration of mine-geochemistry, U/Pb geochronology from zircons and local structural data to reconstruct the CIC volcanoclastic basin. These will be the most robust and detailed constraints ever documented for any of the earliest volcanics in the Macquarie Arc. At a tectonics scale, this project has implications for reconstructions of Gondwana’s eastern margin, which are ambiguous and debated due to several uncertainties about the Lachlan Orogen’s Ordovician history.

A collaborative research team composed of Associate Professor Rebecca Carey, Dr Shaun Barker, Shannon Richards and Professor Michael Heap is currently investigating the physical and thermal properties of volcanic rocks and shallow intrusive rocks. One project is investigating the physical properties of intermediate-felsic rocks that favour high-grade mineralisation sourced from OceanaGold’s Waihi mine in New Zealand. We have conducted a series of rock properties measurements and stress tests to gain an understanding of how the process of alteration influences the strength and fracture characteristics of rocks, particularly in

relation to fluid transport. While alteration clearly leads to a heightened variability in mechanical properties of rocks, the type and degree of alteration is critically important, and less so the original rock porosity and permeability. This information together with the paragenesis of mineralisation will hold some insights into the evolution of fluid flow drivers and timing of mineralisation.

PhD projects

Billy Beas

Supervisors: David Cooke, Lejun Zhang, Rebecca Carey

Project title: Characterisation and geological evolution of the E44 Au-Cu deposit, Northparkes District, NSW

Billy’s PhD research, part of the Amira P1249 global initiative, focuses on the E44 Au-Cu deposit in the southern Northparkes district, hosted in Ordovician–Silurian volcanoclastic rocks. His work aims to define the stratigraphy, alteration and mineralisation stages, and to develop a geological model with tools for vectoring high-grade zones.

Fieldwork and analytical techniques – including petrography, spectroscopy, isotopic analysis and LA-ICP-MS – have revealed a volcanic sequence deposited in submarine to shallow marine settings. Three mineralisation stages have been identified: a base metal skarn, an epithermal Au-carbonate vein system and a deeper Cu-bearing breccia with widespread white mica.

Vinicius da Cruz

Supervisors: Rebecca Carey, David Cooke, Lejun Zhang

Project title: Characterisation of the complex orebodies in the Rosebery Middle Mine: implications for ore processing and mineral exploration

Vinicius’ project aims to characterise the geology of the southern end of the Rosebery polymetallic VHMS deposit and assess the potential for critical metal mineralisation as a by-product of sulphides. Rosebery spans over 4 km along strike and comprises more than 21 discrete ore lenses, each potentially hosting different sulfide assemblages. Continuity of operations on the deposit is reliant on near-mine discovery, requiring continuous updates to the understanding of mineralisation controls. The polymetallic concentrate is amenable to critical metal recovery from trace elements, and rising demand highlights the need to characterise their distribution. In 2024, Vinicius’ work clarified the nature, timing and mineralogical assemblages of metasomatic overprinting in the southern part of the deposit, linking it to Late Devonian granitoid emplacement in western Tasmania. His analysis of sulfide-hosted trace elements, using new and compiled data, reveals systematic variation across the deposit, with enrichment of indium and bismuth in the south relative to the north.

Poliana Vidal Salgado

Supervisors: Mike Baker, Yamila Cajal, Jeff Steadman

Project title: Characterisation and paragenesis of the Magdalena VHMS deposit, Spain



Associate Professor Rebecca Carey at the October 2024 launch of Professor Ray Cas’s new edition of *Volcanology: Processes, Deposits, Geology and Resources*

The Northern Iberian Pyrite Belt (Spain and Portugal) is considered one of the world’s most fertile provinces in terms of base, critical and precious metals (e.g., Zn, Cu, Au) hosted in massive sulphides. The region has been extensively explored since before 2000 BCE.

Different host rocks, mineralisation styles and blind deposits have been spotted within the belt through the years. Deep below the surface of the Northern Iberian Pyrite Belt, the Magdalena VHMS deposit holds 25.4 Mt @ 2.2% Cu, 2.5% Zn, 0.8% Pb, and 37.5 g/t Ag (Sandfire Resources Ltd, 2024). The Cu-Zn polymetallic massive sulphide orebodies sit in a complex region, where magmatism, folding and suture zones play an intrinsic and yet poorly understood role in the mineralisation and deformation of the deposit. Poliana’s project aims to fill this gap, focusing on understanding the geological setting, and possible mineral, geochemical and hyperspectral vectors to prospective orebodies. This study may lead to new and efficient targeting in the Iberian Pyrite Belt and similar areas.

SUBAERIAL AND SUBMARINE VOLCANOLOGY AND NATURAL HAZARDS

Leader: Rebecca Carey

Team members: Sharon Allen, Ivan Belousov, Trevor Falloon, Jodi Fox, Martin Jutzeler, Jocelyn McPhie, Karin Orth

Students: Catherine Brown, Acacia Clark, Shannon Frey, Fumihiko Ikegami, Hannah Moore, Catherine Lit, Poliana Vidal Salgado

Collaborators: Ralph Bottrill, Ray Cas, Grace Cumming, Robert Duncan, John Everard, Tim Druitt, Michael Heap, Bruce Houghton, Geoff Kilgour, Steffen Kutterolf, Michael Manga, Michael Rosenberg, Maria Seton, Adam Soule, Kenichiro Tani, Jess Trofimovs, James White, Joanne Whittaker, Simon Williams, Richard Wysoczanski



CODES PhD student Acacia Clark examining Minoan deposits in April 2024 on Santorini, Greece, during a field trip following the one-year post-cruise meeting for IODP Expedition 398.

Late Bronze Age eruption of Santorini volcano

In 2023, PhD student Acacia Clark was Australia’s scientist on board the International Ocean Discovery Program’s (IODP) drilling ship, the RV *JOIDES Resolution*. The purpose of the voyage was to understand the tectonic and volcanic history of volcanic arcs and volcanoes in the Mediterranean. Acacia is currently working on the stratigraphic reconstruction of the Late Bronze Age eruption of Santorini, by studying clast componentry in multiple cores spread around Santorini and those sampled on land earlier this year. Her research will extend our comprehension of one of the most dramatic Holocene eruptions with consequences for earlier civilisations around the Mediterranean Sea. Acacia actively collaborates with both co-chiefs of the Expedition Dr Steffen

Kutterolf (GEOMAR) and Professor Tim Druitt (Université Clermont Auvergne, France). She is also involved in multiple scientific articles related to the results of the IODP398 Expedition.

Dr Martin Jutzeler led a study to identify coring disturbances in the piston cores of the IODP398 Expedition. Coring disturbances are formed due to technical difficulties while coring soft sediment and can result in partial to full destruction of bed boundaries, and mixing or loss of sediment throughout the cores. Having already published several papers on this topic, Martin was invited to provide an assessment of these disturbances. Successful collaboration with onboard scientists provided a deep understanding of the affected cores, minimising sediment contamination during sampling, and strengthening stratigraphic correlations. This mammoth task consisted of

high-resolution inspection of core photos and physical properties over 1 km of piston cores and has been submitted for publication as an IODP data report.

Powerful basaltic explosive eruption dynamics: Okataina Caldera

Hannah Moore submitted her PhD thesis in 2024 on the 1886 basaltic eruption of Tarawera. Her final projects focused on understanding how powerful large basaltic eruptions initiate, and how multiple high-intensity vents contributed to the formation of a 28-km-high eruption plume. Hannah has demonstrated that the location of the vents across Mt Tarawera during the initial phase of the eruption influenced both eruption intensity and the trajectories of the erupted products, resulting in asymmetrical dispersal footprints of the deposits.

Hannah combined numerical modelling with field-based data on the footprint of the eruption deposit to understand particle transport, in particular how multiple vents across Mt Tarawera delivered material to the 28-km-high eruption column.

Investigating transitions between explosive and effusive volcanism: Okataina Caldera

CODES PhD student Acacia Clark is exploring how large silicic volcanic eruptions shift between explosive and effusive behaviour. Her research focuses on Unit M of the 1315 CE Tarawera eruption, which features one of the world’s best-preserved proximal sequences of changes between explosive and effusive phases. Through detailed mapping, Acacia has revealed a prolonged and complex eruptive Unit M phase – likely lasting several months. Her study of the Kaharoa proximal cone, part of this phase, has uncovered complex transport dynamics of pyroclast fall-out, pyroclastic density current and grain flow transport dynamics. This work addresses a key challenge identified in the 2017 National Academies Report on Volcanic Eruptions: understanding the magmatic and environmental factors that drive transitions in eruption style. Acacia’s findings will provide a foundational framework for future



Associate Professor Rebecca Carey teaching about submarine effusive eruptions in New Zealand at Bethells Beach.

research into eruption mechanisms and triggers, enhancing global assessments of volcanic hazards at silicic volcanoes.

Heard and McDonald Islands, Kerguelen Plateau, Australian Antarctic Territory

Under the leadership of former CODES PhD student Dr Jodi Fox, a team of researchers consisting of Associate Professor Rebecca Carey and Dr Trevor Falloon (UTAS), Professor Robert Duncan (Oregon State University) and Dr Jane Barling (Oxford University), is actively involved in investigating the volcanic history of Heard Island. Jodi has an impressive geochemical data set on these very rare and exceptional rocks resulting in a 2024 publication in *Geochemistry, Geophysics, Geosystems* (Fox et al., 2024). The results established a clear geochemical distinction between MacDonald Island and Heard Island lavas and demonstrated, for the first time, zonation within the Kerguelen mantle plume.

Balleny volcanic chain, offshore Tasmania

A volcanic seamount chain beneath the Tasman Sea and Southern Ocean is thought to be linked to the Balleny Mantle Plume. This chain records the

breakup of Australia, Zealandia and Antarctica between 90 and 35 million years ago, which contributed to the opening of the Southern Ocean and the development of the Antarctic Circumpolar Current.

Geochemical and argon dating data support a connection to the Balleny Plume, showing an age progression and HIMU-type mantle signatures. The timing of this volcanic activity overlaps with Tasmanian volcanism, suggesting the plume may have influenced both. This hypothesis is currently being explored in collaboration with Dr John Everard from Mineral Resources Tasmania.

Amundsen Sea volcanism

Dr Martin Jutzeler is leading a project on tephra identification offshore Western Antarctica. IODP379 Expedition cored the Amundsen Sea in 2019 but almost no tephra was identified by onboard scientists. Characterisation of tephra in glacio-marine intervals can provide critical information on the state of the glacial extents through the Cenozoic and better understanding of volcanism in this very remote area. Martin obtained core samples and is supervising third-year undergraduate student Ellyse Noy on a semester project to create a sampling strategy and identify tephra from glacio-marine unconsolidated muds.

SEDIMENTARY VOLCANOLOGY

Leader: Martin Jutzeler

Team members: Sharon Allen, Rebecca Carey, Jocelyn McPhie, Karin Orth

Students: Shannon Frey, Catherine Lit

Collaborators: Abigail Barker, Cathy Busby, Matthieu Cartigny, Stephen Gallagher, Peter T. Harris, Steffen Kutterolf, Emily Lane, Michael Manga, Janne Scheffler, Tom Trnski, Sally Watson, Suzi Woelz, Ian Wright, Yusuke Yokoyama

The Sedimentary Volcanology project encompasses research on eruption and syn- and inter-eruptive transport and deposition dynamics in modern and ancient volcanic successions. The multidisciplinary project is funded by an ARC Discovery Project started in 2022 and led by Dr Martin Jutzeler with chief investigators Associate Professor Rebecca Carey and Professor Stephen Gallagher (University of Melbourne) and partner investigators Dr Steffen Kutterolf, Professor Yusuke Yokoyama, Professor Michael Manga and Dr Emily Lane.



Depositional ripples and erosional obstacle-and-scour features were captured at about 1 km water depth by the remotely-operated vehicle Jason during the 2015 MESH expedition to Havre volcano. PhD student Shannon Frey is studying deep-ocean sediment remobilisation by ocean currents on seamounts, which raises important questions on the validity of paleocurrent indicators in the rock record.

Targeting Macauley volcano in the Kermadec Arc (Rangitāhua) and its 6.3 ka caldera, this project aims to assess the ability of explosive submarine volcanism to create complex proximal deposits and trans-ocean tsunamis. The team will combine the multiple data sets collected during the 2022 voyage, conduct ¹⁴C dating on foraminifera for chronostratigraphy reconstruction and collect near-vent samples on Macauley Island to numerically model eruption and sediment transport processes. These models will then be used to model tsunami generation and assess their potential impact on coastal populations and infrastructure. This project is very timely, as it targets volcanic processes very similar to those that occurred during the January 2022 eruption of Hunga Tonga, although being an order of magnitude more voluminous, allowing a fantastic opportunity to compare both eruption types. Expected outcomes include an unprecedented reconstruction of the architecture of submarine caldera volcanoes that has direct application for mineral exploration on the Australian continent, and new innovative models applicable globally for a richer understanding of volcanic tsunami and eruptions that shape the seafloor.

PhD student Shannon Frey is conducting research on sediment cores collected on the submarine sediment waves on the slope of the submarine Macauley caldera. These cores recovered exceptional stratigraphy, consisting of a complex succession of planar- and cross-bedded pumiceous units. Together with seismic reflection transects across the sediment waves, these cores allowed Shannon to interpret these pumiceous units as being eruption-fed. Their sedimentary patterns point towards deposition from high-flux subaqueous density currents fed from a large magnitude eruption at Macauley volcano. This research project is at the forefront of research on caldera-forming submarine volcanism with global significance for volcanology and geohazards. Collaborator Matthieu Cartigny (Durham University, UK) is an international expert in sediment waves and visited our research group in 2024 to discuss research outputs and provide numerical modelling of the sediment waves.

Shannon is also working on inter-eruption reworking on volcanic tephra on seamounts, based on video footage during the 2015 and 2022 voyages. She identified a new type of deposit composed of complex and transient fields of sediment ripples that exemplify the deep ocean as a dynamic environment. This project has direct relevance for ocean dynamics and their interaction with the modern seafloor and brings a word of caution for ancient paleocurrent indicator reconstruction and modelling of submarine eruptions. It provides further understanding for post-eruption life recovery.

OLYMPIC DAM FLUID/MELT INCLUSION PROJECT

Leader: Maya Kamenetsky

Collaborators: Kathy Ehrig, Vadim Kamenetsky, Alkis Kontonikas-Charos

This project aims to identify the generations of quartz- and carbonate-hosted fluid inclusions and how they relate to the temperature and

composition of alteration fluids involved in the evolution of Olympic Dam.

The Olympic Dam deposit, a supergiant iron-oxide copper-gold system, is located within the Olympic Dam Breccia Complex (ODBC) and hosted by ~1.6 Ga Roxby Downs Granite. This deposit is recognised as a magmatic-hydrothermal system that formed during the final stages of crystallisation of the Roxby Downs Granite, influenced by nearly simultaneous intrusions of both mafic and felsic magmas from the Gawler Range volcanic series. The extensive volume of altered Roxby Downs Granite surrounding the Olympic Dam deposit, along with potential metal sources (such as Fe, U, REE, W and Sn) within the granite, may provide valuable insights into the mineralisation processes at Olympic Dam.

In the last six months of the project, the team focused on an in-depth study of the Roxby Downs Granite, examining its mineralogy, alteration and quartz-hosted inclusions that may indicate alteration fluids. Preliminary results suggest that the crystallisation or recrystallisation of the Roxby Downs Granite may have

produced deuteric aqueous fluids enriched in fluorine, chlorine and sulfur. The interaction of these fluids with the original granite likely contributed to the formation of oxidised minerals, such as hematite, carbonates and sulfates, as well as reduced minerals like sulfides and uraninite. The discovery of radiogenic and highly radiogenic lead hosted in sulfides within what is deemed ‘fresh’ granite may alter our understanding of uranium potential and the behaviour of uranium within the Roxby Downs Granite.

THE TECTONIC SIGNIFICANCE OF MAFIC/ULTRAMAFIC IGNEOUS ROCKS IN WESTERN TASMANIA

Leader: Ivan Belousov

Team members: Trevor Falloon, Rebecca Carey

Student: Bridie Le'Gallais

Collaborators: Ralph Bottrill, Anthony Brown, Grace Cumming, John Everard, Karsten Goemann, Roland Maas, Andrew McNeill



View of a spectacular pool in the Waimangu Volcanic Rift Valley geothermal system on New Zealand's North Island taken during the 2024 Volcanology and Mineralisation in Volcanic Terrains Masters short course.



Students pictured on Philosophers Ridge while on the western Tasmania leg of the 2024 Volcanology and Mineralisation in Volcanic Terrains Masters short course. The mountains behind them are Mt Lyell (left) and Mt Owen.

This project aims at constraining the number and geographical spread of different magmatic series that exist within western Tasmanian mafic/ultramafic complexes, the nature of parental magma compositions of these complexes, and the possible tectonic settings at which these Tasmanian mafic/ultramafic complexes have formed prior to emplacement into their current position. We also hope to further constrain the age relations between ultramafic rocks and the allochthonous sedimentary units.

Most of 2024 was occupied by a search in the Mineral Resources Tasmania (MRT) and University of Tasmania rock collections for historical regional samples to acquire new whole rock, glass, spinel, olivine and clinopyroxene compositions for a comparison study. To perform all those analyses a new contract with MRT is being arranged. Modelling of magma crystallisation has started to identify parental magma composition and will continue in 2025. One of the crucial parameters needed for the modelling is the water content of the melt, and arrangements are being made for the measurement of melt inclusion compositions using laser

Raman at ISTerre at the Université de Grenoble Alpes in France. Zircon dating of sandstone and in-situ zircon dating of coarse-grained magmatic rocks is also planned to constrain the age relations.

PEGMATITES AND PEGMATITE-RELATED ORES

Leader: Paul Davidson

This initiative examined melt-melt immiscibility in felsic silicate melts, in the formation of pegmatites and pegmatite-related ore deposits. Over the years this project has resulted in the publication of a significant number of papers covering locations around the world.

One final publication will result from this program: chapter 5 in the book *Geography, Earth Science and Environment: Research Highlights Vol. 6*. 'Unveiling of stishovite and coesite in the prismatine-bearing granulite from Waldheim, Germany: A potential role of supercritical fluids of ultrahigh-pressure origin' by Rainer Thomas, Paul Davidson, Adolf Rericha and Ulrich Recknagel will be published by BP International in 2025.

Paul Davidson writes: 'There have been many collaborators over the years, but I must make special mention of Dr Rainer Thomas, without whose excellent analytical work none of these papers would have been possible. With my thanks to all that have been part of the project'.

VHMS RESEARCH – ANCIENT

Leader: Mike Baker

Team members: Matt Cracknell, Charles Makoundi

Student: Zebedee Zivkovic

Collaborators: Shaun Barker, Jonathan Cloutier, David Green, Scott Halley, Andrew McNeill, Dean Tuck

Tasmania

Dr Mike Baker, Dr Matt Cracknell and Dr Shaun Barker (MDRU) are leading a project initially entitled 'Lithogeochemical fertility indicators for VHMS deposits' initiated in June 2019 as a Masters by Research, which was expanded in scope and transferred to a PhD project in 2020, undertaken by

candidate Zebedee Zivkovic. The expanded project was titled, 'Whole rock lithogeochemical methods in magmatic-hydrothermal environments: applications to mineral exploration'.

Zebedee's 2024 efforts were focused on the development of a lithogeochemical method that was impartial to the analytical method and demonstrated different applications in a variety of geological settings. The first case study uses data gathered from the Cambrian Mount Read Volcanics (MRV) of western Tasmania and applies the method to identify prospective mineralised horizons across the MRV by comparing the lithogeochemistry of known mineralised horizons at the Rosebery deposit with MRV samples collected more regionally across the province. This study was published in *Geochemistry: Exploration, Environment, Analysis* in 2024.

A second case study applied the method to samples of Paleoproterozoic intrusions from the western Wunaamin Miliwundi Orogen of the western Kimberley, WA. Lithogeochemical analysis of these rocks identified an intrusion unusually depleted in V which was correlated with similarly V-depleted rocks in the east Kimberley where they are

associated with a large Ti-V resource. Subsequent petrographic and geochronological data confirmed these intrusions to be part of the same Large Igneous Province, thereby significantly extending the exploration search space for similar Ti-V deposits in the west Kimberley. This study was published in the *Australian Journal of Earth Sciences* in 2024. In mid-2024, the project completed with the final version of Zebedee's PhD thesis being accepted.

Dr Charles Makoundi (CODES/MRT) has written a manuscript on downhole hyperspectral mineralogy and multielement analysis to characterise the different types of alteration minerals downhole and their connections to the distribution of precious and base metals for the Mount Julia (Henty) deposit in the Mount Read Volcanic Belt. A complementary section on pyrite chemistry will be added to the manuscript before submission to a journal for peer-review. Drill holes MJ021 and Z15182 were selected for this study. Two mining companies, Catalyst Metals Limited (the new owner) and Diversified Minerals Pty Ltd (the previous owner), are supporting this project.

▶ LOOKING FORWARD

It is exciting times ahead for Program 4. We are looking forward to a research voyage using the RV *Investigator* in the second half of 2025, heading to the site of the powerful 2022 Hunga volcano eruption in Tonga. We are also expecting new research publications from our ARC Discovery Project on Macauley volcano, now in its second year of funding.

We expect the Program 4 team to grow, with at least two new PhD students for 2025, and are also looking forward to the multiple graduations and other achievements of our fantastic student cohort throughout the year. In summary, 2025 is shaping up to be a year of exploration, discovery, and growth.

Program 5: Analytical research

► OBJECTIVES

- Analytical research underpins much of our most innovative research across the fundamental to applied spectrum.
- New developments in analytical research generated by CODES Analytical Laboratories provide the basis for CODES' global leadership in micro-analytical techniques specifically applied to mineral exploration, U/Pb and Lu/Hf geochronology, critical mineral characterisation, mineral processing, ore genesis and waste management, igneous geochemistry and volcanology.
- CODES Analytical Laboratories also provides analytical services to government, academia and industry.

Introduction

Program 5: Analytical research explores and develops novel analytical and data interpretation techniques based on the latest technological and algorithmic developments, such as maintaining a number of high spatial resolution microprobes, developing and testing advanced data-reduction algorithms and applying new techniques to natural samples. This helps in the understanding, exploration and exploitation of deep Earth resources.

Current research projects focus predominantly on expanding the capabilities of laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) for geological applications, analytical data reduction and the development of new, user-friendly software packages. In 2024, a significant proportion of research activities was focused on the development of critical mineral characterisation workflows, improvement of U/Pb geochronology workflows, Lu/Hf dating of garnet and other minerals, as well as using LA-ICP-TOF (Time of Flight (ICP-ToF) imaging for acquiring rapid mineral maps.

The analytical projects using LA-ICP-MS include in-situ multielement analysis and imaging of element distribution within minerals; in-situ isotope analysis, focusing on a range of U/Pb and Lu/Hf dating applications; development of

calibration standards; and technological developments aimed at improving the capabilities of the laser microprobes.

Highlights

The team welcomed a number of new staff members. Dr Valerie Yuleridge joined the team for six months to help with geochronology reporting. Three new full-time staff joined the team in September–October: Dr Carlos Carrasco Godoy as lead analyst, Dr Alice MacDonald as lab analyst and Dr Jack Ward as assistant lab analyst. They bring a wide range of experience to the labs and will be performing analyses, reducing data, writing reports, contributing to R&D, and working with students and other researchers from CODES and Earth Sciences.



In 2024, a significant proportion of research activities was focused on the development of critical mineral characterisation workflows.



The CODES Analytical Laboratories team (L–R): Back row: Alex Cuison (Lapidary Manager), Claire Newland (Administrative Support Officer), Dr Elena Lounejeva (Laboratory Analyst), Dr Jack Ward (Assistant Laboratory Analyst), Dr Ivan Belousov (Senior Research Fellow in Mineralogy and Geochemistry and Leader of Program 5). Front row: Dr Alice MacDonald (Laboratory Analyst), Fanghua Dai (Laboratory Analyst), Dr Carlos Carrasco Godoy (Lead Laboratory Analyst), Michelle Makoundi (Technical Officer) and Dr Jeff Oalman (Manager of the CODES Analytical Laboratories). Michele Chapple-Smith, the Lapidary Technician, was unable to be present.

Dr Paul Olin (Acting Leader of CODES Analytical Laboratories) left UTAS in February and took up a position as an isotope analyst at Adelaide Microscopy, University of Adelaide. Maxwell Morissette also left UTAS later in the year and is now working as an analyst at one of the mine sites in Western Australia.

Another Agilent 8900 QQQ instrument was installed and will increase our capabilities in Lu/Hf, Rb/Sr and Re/Os dating.

Research

CODES Analytical Laboratories participated in the development and characterisation of reference material for garnet Lu/Hf dating by LA-ICP-MS and a paper was published in *Geostandards and Geoanalytical Research* (see Publications section at the back of this report for details). Methods for deconvolution of mixed LA-ICP-MS signals and their use for quantification of inclusions in minerals are being developed.

Publications

As noted above, staff from Program 5 contributed to a paper published in 2024 entitled 'Garnet reference materials for in situ geochronology'



Certificate presented to Dr Ivan Belousov in 2024 for having a top-cited article in the journal *Geostandards and Geoanalytical Research*, for an article published the previous year.

in *Geostandards and Geoanalytical Research*. Dr Ivan Belousov and Dr Jeff Oalman both provided input to this paper.

Conferences

- Dr Ivan Belousov presented at the European Laser Ablation Workshop (EWLA, Ghent) and the International Applied Geochemistry Symposium (IAGS, Adelaide). He presented oral talks at both events on the

deconvolution of mixed LA-ICP-MS signals and quantification of micro-inclusions. He also presented at the Merensky Reef symposium (South Africa) on compositions of sulphides, chromites and silicates from Merensky Reef samples.

- Dr Jeffrey Oalman presented at the European Laser Ablation Workshop (EWLA, Ghent) on comparing ICP-ToF and LA-ICP-MS imaging results.

The program team

LEADER IVAN BELOUSOV
DEPUTY LEADER JEFFREY OALMANN



TEAM MEMBERS:

Sheree Armistead, Matthew Cracknell, Fanghua Dai, Carlos Carrasco Godoy, Alice MacDonald, Sebastien Meffre, Valerie Yuleridge, Jack Ward

PHD STUDENTS:

Axel Cima, Xin Ni Seow

COLLABORATORS:

CENTRAL SCIENCE LABORATORY, UTAS
Karsten Goemann

CURTIN UNIVERSITY
Bruno Vieira Ribeiro

ETH ZURICH, SWITZERLAND
Andrea Giuliani, Marcel Guillong

LAURIN TECHNIC
Michael Shelley

MDRU, CANADA
Shaun Barker

NORRIS SCIENTIFIC

Ashley Norris

UNIVERSITY OF ADELAIDE
Sarah Gilbert, Stijn Glorie, Paul Olin

GEOMAR, GERMANY
Maxim Portnyagin

UNIVERSITY OF MELBOURNE
Roland Maas

UNIVERSITY OF QUEENSLAND
Jeff Chen, Carlos Spier

US GEOLOGICAL SURVEY, USA
Jay Thompson

FUNDAMENTALS OF LASER ABLATION

Leader: Ivan Belousov

Team members: Jeffrey Oalmann, Carlos Carrasco Godoy, Alice MacDonald, Jack Ward, Fanghua Dai

Collaborators: Karsten Goemann, Ashley Norris, Michael Shelley

This project aims to gain a better understanding of laser ablation processes, leading to improved analysis of geological materials, especially sulphide minerals. Imaging and spot analysis methods as well as different matrices are being investigated. For imaging, single vs multi-pulse ablation as well as the ablation of clean vs pre-ablated surfaces are being compared in order to improve imaging results.

CALIBRATION STANDARDS FOR LA-ICP-MS

Leader: Ivan Belousov

Team members: Jeffrey Oalmann, Carlos Carrasco Godoy, Alice MacDonald, Jack Ward, Fanghua Dai

Collaborators: Jeff Chen, Andrea Giuliani, Stijn Glorie, Karsten Goemann, Marcel Guillong, Maxim Portnyagin, Bruno Vieira Ribeiro

This project is aimed at the development and characterisation of new calibration reference materials for LA-ICP-MS analysis of various geological materials.

Calibration standard STDGL3 for sulphide analysis has been distributed to several more analytical laboratories worldwide. Collaboration with Curtin University has progressed and a paper has been published on a new calibration standard for Lu/Hf dating of garnet in *Geostandards and Geoanalytical Research*.



CODES Analytical Laboratories staff in the mix (centre back): this group of scientists includes current and former CODES Analytical Laboratories staff. They are pictured at the European Laser Ablation Workshop, which took place in Ghent, Belgium, in July 2024.



Laboratory Analyst Dr Alice MacDonald, who joined CODES in 2024, in one of the LA-ICP-MS labs setting up laser spots for an analytical session.

Collaboration with ETH Zurich has also been continued on standards for U/Pb dating of calcite. Collaboration with the University of Queensland is addressing reference materials for metallurgical slags. A coltan standard (Coltan 139)

was also tested for U/Pb dating, and the technique is now available for use at CODES. Reference materials for Re/Os and Rb/Sr dating have been acquired, and the method development will begin in 2025.

Projects

Fundamentals of ICP-MS

Fundamentals of laser ablation

Calibration standards for LA-ICP-MS

LA-ICP-MS instrumentation development

U/Pb dating

Lu/Hf dating

LA-ICP-MS data reduction software

Interpretation of LA-ICP-MS time-resolved signals

Project summaries

FUNDAMENTALS OF ICP-MS

Leader: Ivan Belousov

Team members: Jeffrey Oalmann, Carlos Carrasco Godoy, Alice MacDonald, Jack Ward, Fanghua Dai

Student: Xin Ni Seow

This project is aimed at better understanding the physical processes that occur in ICP-MS, in order to improve its performance and the range of applications for laser ablation.

The main focus in 2024 continued to be on improving our understanding of the influence of plasma conditions on quantification of analyses of different minerals. Development of methods for quantitative analyses of trace elements in minerals without using matrix matched reference materials was continued.

A paper describing the method for alunite has been submitted for publication. A study of rates of doubly charged species production for different elements has been continued. One of the focuses has also been improving quantification for the data generated using the ICP-ToF instrument and comparison with data acquired using quadrupole ICP-MS.

LA-ICP-MS INSTRUMENTATION DEVELOPMENT

Leader: Ivan Belousov

Team members: Jeffrey Oalmann, Carlos Carrasco Godoy, Alice MacDonald, Jack Ward

Collaborators: Ashley Norris, Michael Shelley

This project tests, designs and develops new instrumentation to ensure continuing advances in geological LA-ICP-MS applications. Example developments include ablation cells, the interface between the laser and the mass-spectrometer and testing new types of laser microprobes and mass-spectrometers. In 2024 we continued to improve our understanding and capacity of fast imaging using ICP-ToF and testing fast washout setups. Washout of a single laser shot was reduced from ~200 ms to ~30 ms, increasing image collection rates from 10 pixels/second to 30 pixels/second.

U/PB DATING

Leader: Jeffrey Oalmann

Team members: Ivan Belousov, Sheree Armistead, Carlos Carrasco Godoy, Alice MacDonald, Jack Ward, Fanghua Dai

Collaborators: Roland Maas, Carlos Spier

This project investigates the causes of limitations to U/Pb dating of minerals by LA-ICP-MS, with the aim of enhancing laboratory practices and instrumentation parameters to lower systematic errors and improve precision. Investigations for zircon, apatite, garnet, rutile, epidote and titanite are currently underway. Method development for U/Pb dating of wolframite and scheelite continued in 2024. A method for U/Pb dating of coltan (a source of Nb and Ta) has been tested, and a publication comparing results with U/Pb dating from other minerals is being prepared. Data for secondary standards for several minerals is being collated to improve our understanding of uncertainties when comparing U/Pb geochronology results from different minerals.

LU/HF DATING

Leader: Jeffrey Oalmann

Team members: Sheree Armistead, Ivan Belousov, Carlos Carrasco Godoy, Alice MacDonald, Jack Ward

Collaborators: Sarah Gilbert, Stijn Glorie, Jay Thompson, Bruno Vieira Ribeiro

This project is aimed at method development for Lu/Hf dating of minerals using Agilent 8900 QQQ MS. Currently we have established methods for garnet and apatite and are developing methods for calcite and monazite. Fast imaging using ICP-ToF

is being implemented as a precursor to dating to identify zones with high parent-daughter ratios, improving the precision of Lu/Hf dating. A publication on the influence of dislocation networks in deformed garnet on Lu/Hf dating results is being prepared for publication.

LA-ICP-MS DATA REDUCTION SOFTWARE

Leader: Jeffrey Oalmann

Team members: Ivan Belousov, Carlos Carrasco Godoy, Jack Ward

Collaborator: Ashley Norris

This project aims to develop comprehensive, user-friendly LA-ICP-MS data processing software, capable of:

- quantification of trace element and U/Pb dating data acquired using multiple calibration standards and a range of internal standard elements;
- quantification of images depicting distributions of major and trace element concentrations in fine-grained multi-mineral aggregates of sulphides, silicates, phosphates and carbonates;
- identification of mineral phases in, and sizes of, micro-inclusions in minerals.

Activities in 2024 were directed towards imaging elemental distributions in minerals. Work has progressed with processing of ICP-ToF images and as

a result several python scripts were developed. New workflows for plotting and reporting of U/Pb geochronology results were also developed and implemented into an R-based Shiny App. A beta version of the LADR data reduction software with image processing capabilities is being tested in conjunction with Norris Scientific.

INTERPRETATION OF LA-ICP-MS TIME-RESOLVED SIGNALS

Leader: Ivan Belousov

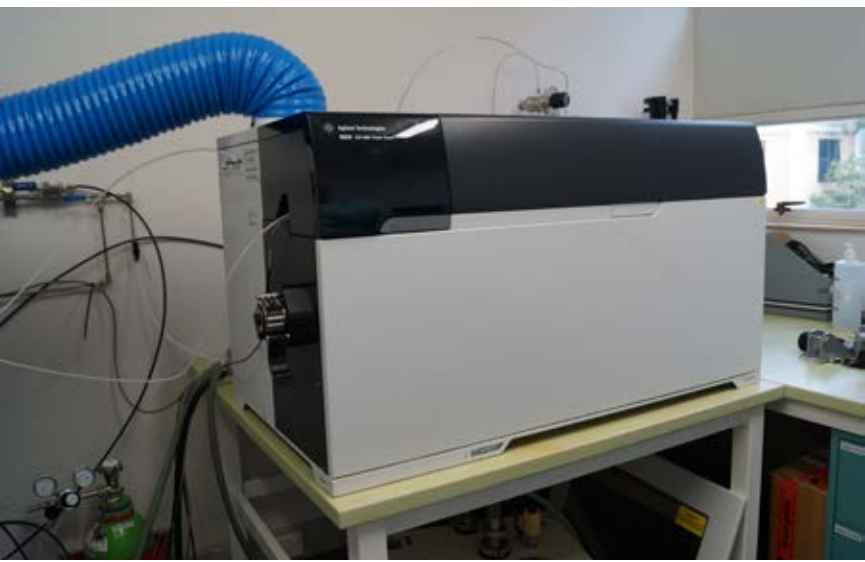
Team members: Matthew Cracknell, Sebastien Meffre, Jack Ward

Student: Axel Cima

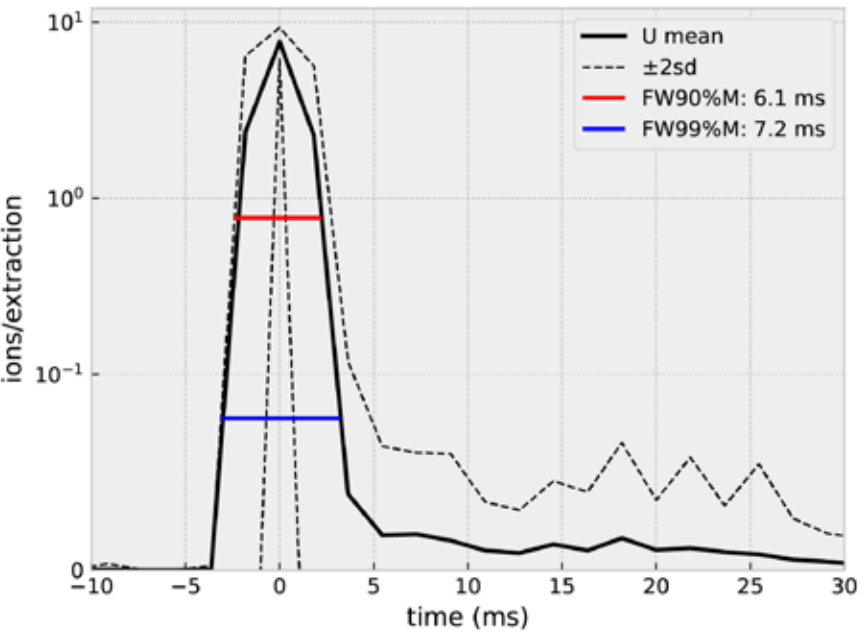
Collaborator: Shaun Barker

This project aims at developing algorithms for the correct identification of mineral inclusion populations in LA-ICP-MS analyses. Such inclusions could significantly improve our understanding of ore deposit formation and could be used in vectoring and fertility studies for a range of deposit styles. Method development for deconvolution of mixed LA-ICP-MS signals and its use for quantification of inclusions is underway.

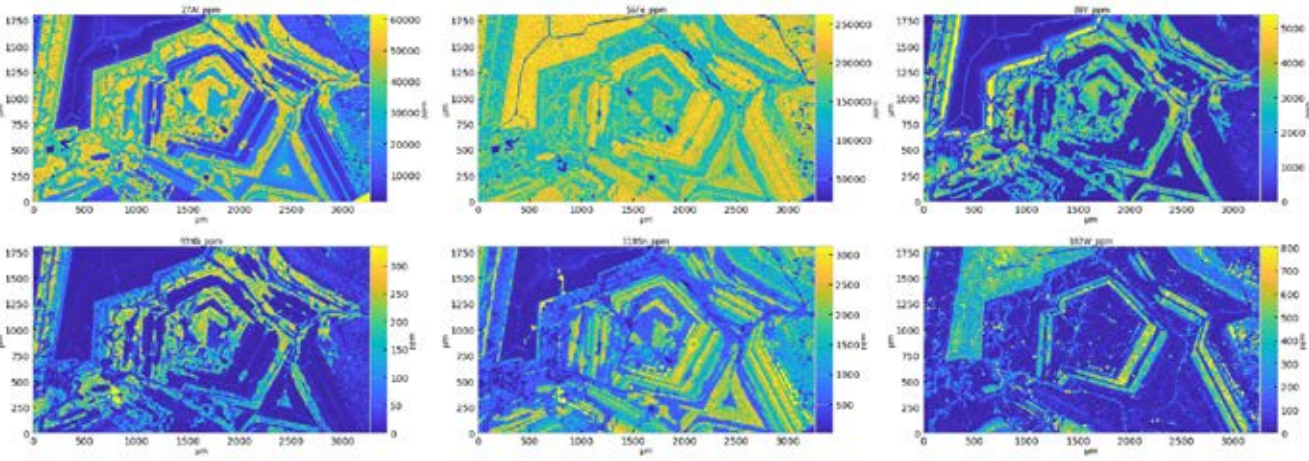
During 2024 we have continued to improve algorithms for identification of micro-inclusions in time-resolved LA-ICP-MS signals from a range of minerals. Work has been started on deconvolution of mixed LA-ICP-MS signals and their use for quantification of micro-inclusions in minerals. A publication on the quantification of mineral inclusions from mixed LA-ICP-MS analyses is being prepared for publication.



This Agilent 8900 triple quadrupole ICP-MS was installed in April 2024. This instrument will be used in conjunction with the existing laser ablation system for geochronology of beta decay systems (e.g., Rb-Sr and Lu-Hf dating) of a wide range of minerals.



Plot showing signal intensity (ions/extraction) vs. time of the average of 50 laser pulses obtained by a LA-ICP-ToF-MS traverse across NIST glass. The full width 99% maximum (FW99%M) metric illustrates that the response of a single laser pulse is less than 10 ms. This advancement is the result of recent upgrades to the aerosol transport system developed in conjunction with Ashley Norris of Norris Scientific. Coupling the updated laser ablation hardware to the time-of-flight mass spectrometer allows for the measurement of high-resolution mass spectra across most of the periodic table (Na-U) from every laser pulse at acquisition rates greater than 100 pixels per second. The near complete decay of the signal between laser pulses eliminates carry-over of particles from pixel to pixel.



Compositional maps obtained by single-pulse LA-ICP-ToF-MS of andradite-grossular garnet from the Kara magnetite deposit in Tasmania. More than 60 elements were processed from this data set, which was collected at 30 pixels per second. The sharpness of the intergrain boundaries is the result of the ultra-fast washout times possible with recent upgrades to the laser ablation system. These maps show that Y, Nb and Sn are enriched in the Al-rich zones and W is enriched in the Fe-rich zones.

▶ LOOKING FORWARD

The team will further develop its analytical research in 2025. Developments using Agilent 8900 QQQ and ICP-ToF are expected to include:

- Use of Agilent 8900 QQQ MS for Re/Os dating of molybdenite, Rb/Sr dating of micas and S isotopic measurements for sulphides and sulphates.
- Continued development of the application of ICP-ToF for imaging elemental distributions in minerals by laser ablation with particular emphasis on increasing imaging speed as well as improving image quantification for different minerals.

Program 6: Geophysics and computational geosciences

► OBJECTIVE

This program addresses the challenges associated with technological advances in automated data acquisition and imaging methods across all aspects of the geosciences. It seeks solutions to managing, processing, analysing, visualising and interpreting minerals industry data sets. This research program contributes to research across all stages of the mining value chain from exploration to mining and mineral processing and to waste management.

Introduction

Program 6: Geophysics and computational geosciences aims to develop and apply novel methods of data collection, analysis and integration for data-driven decision making and visualisation. It includes a diverse range of projects, such as research into three-dimensional geophysical interpretations, near-surface and environmental geophysics, geodata analytics, data visualisation, exploration targeting and geoscience education. One of the unique aspects of Program 6 is that it contributes to all of the other CODES research programs, particularly Programs 1 and 2, via method development, data processing and analysis, and the interpretation and visualisation of results.

Modern minerals industry activities are undertaken in data-rich environments, characterised by a wide range of quantitative and qualitative information. There have been significant recent advances in areas such as geophysical data acquisition, geophysical data processing and inversion, multielement geochemical analyses, and a range of new optical and infrared imaging techniques. The challenge is to be able to effectively integrate these diverse data streams with existing and legacy data using new methods and workflows that can effectively transform data into information and knowledge. The ultimate aim of this data synthesis is to facilitate more informed decision making at all stages of the mining value chain, from mineral exploration to extraction, processing and waste management.



The ultimate aim of...data synthesis is to facilitate more informed decision making at all stages of the mining value chain, from mineral exploration to extraction, processing and waste management.

Highlights

Publications

- Dr Paula Montoya published a paper in *International Geology Review* on the Plomosas deposit in Mexico: 'Oligocene magmato-tectonic events influential in the development of Pb-Zn, Ag, and Au mineralization at the Plomosas deposit, southwestern Sierra Madre Occidental, Mexico'.
- Recent PhD graduate Dr Tom Ostensen published the outcomes of his PhD research in *Exploration Geophysics* into the electrical properties and structure of the Tasmanian crust from magnetotelluric data:
 - 'Resistivity anomalies in the shallow and deep crust beneath West Tasmania from a broadband magnetotelluric 2D transect'.
 - 'Low resistivity anomalies in the upper crust of the Midlands of Tasmania from combined magnetotelluric datasets'.

Conferences

- Dr Matthew Cracknell presented at the 30th International Applied Geochemistry Symposium (IAGS 2024) conference in Adelaide in October 2024, which was also attended by a number of CODES staff and students.
- CODES PhD student Stephen Cooke delivered a poster presentation at the 37th International Geological Congress (IGC 2024) conference in Busan, South Korea, in August 2024.
- Dr Paula Montoya presented at the 37th International Geological Congress (IGC 2024) conference in Busan, South Korea, in August 2024. Her talk was titled: 'Oligocene magmato-tectonic events influential in the development of Pb-Zn, Ag and Au mineralization at the Plomosas deposit, southwestern Sierra Madre Occidental, Mexico'.



Alex Farrar (centre) pictured with his supervisors Dr Matthew Cracknell (left) and Professor David Cooke after his PhD graduation ceremony in December 2024.



In 2024 CODES PhD student Giovana Pimentel spent time in South Africa, where she was looking at Anglo American's Ni-PGE deposits in the Platreef region. Her research is part of the Amira P1249 project, which is being supported by the Program 6 team.

Workshops and activities

Several in-house workshops and training sessions were organised by the Program 6 staff and students including:

- Python for beginners
- ioGAS and Leapfrog for geological data analysis and visualisation
- Mineral texture clustering of drill core imagery
- General discussion and collaboration sessions via the Program 6 working group.

Other highlights

- Alex Farrar graduated in December 2024 after successfully completing his PhD thesis examination process.
- New arrival CODES PhD Francisco Cuadra is working in the Amira P1249 project on an IOCG deposit in northern Sweden.

The program team

LEADER MATTHEW CRACKNELL
DEPUTY LEADER PAULA MONTOYA



TEAM MEMBERS:

Michael Baker, Yamila Cajal, David Cooke, Julie Hunt, Michael Roach, Rob Scott, Lejun Zhang

PHD STUDENTS:

Axel Cima, Stephen Cooke, Francisco Cuadra, Isaac Evinemi, Giovana Pimental, Arka Sahu

HONOURS STUDENT:

William Grant

COLLABORATORS:

BHP

Alejandro Pizarro, Adam Gorecki, Sam Scher

BOLIDEN

Helen Thomas, Tobias Hermansson

CENTRAL SCIENCE LABORATORIES, UTAS

Thomas Rodemann

CODELCO

Felipe Jimenez-Arevalo, Carolina Rodriguez-Soto, Sergio Pichott-Henriquez

UNIVERSIDAD AUSTRAL DE CHILE, CHILE

José Picquer

report on model robustness. Stephen is also preparing new developments for LocatOre that will form the final contribution to his thesis.

HIGH-GRADE CU-MO PORPHYRY MINERALIZING VECTORS THROUGH GEOCHEMICAL, MINERALOGICAL AND TEXTURAL SIGNATURES, OCELOT, ARIZONA, USA

Leader: Paula Montoya

Team members: Matthew Cracknell, David Cooke, Lejun Zhang

Student: Axel Cima

Collaborators: Adam Gorecki, Alejandro Pizarro, Sam Scher

BHP has kindly contributed a study site in Arizona, USA, for the Amira P1249 project. This site, Ocelot, is within the Laramide basin and range belt, a stone's throw from Rio Tinto's Resolution project. BHP has asked the CODES research team to investigate integrating drill core imagery and hyperspectral data with traditional drill core data sets, such as whole-rock geochemistry and core logging observations, to develop new mineral exploration vectors. Fieldwork in early 2024 collected core samples for further analysis, in particular to analyse white mica mineral chemistry.

Throughout 2024, the leader of this project, Dr Paula Montoya, has been generating robust workflows for integrating disparate drill core data with lab observations. This has led to exciting new developments in the combination of mineral texture information (from drill core imagery) and geochemically derived lithogeochemistry and alteration models to identify high-grade Cu vectors. Furthermore, the white mica mineral chemistry data has been instrumental in identifying and separating different styles of alteration throughout the deposit.

The second phase of the project aims to leverage geological domain expertise to construct unsupervised and supervised models of high-grade mineralisation vectors and alteration styles.



Fieldwork in 2024: BHP and CODES staff with the Ocelot study site in Arizona behind them. Adam Goreki (BHP geology manager, white hat) explains the deposit while Grey Small (BHP geologist) holds the map. CODES staff Dr Lejun Zhang (in red) and Dr Paula Montoya (back to camera), and BHP principal geochemist Natalie Caciagli look on.

NAUTANEN IOCG DEPOSIT CHARACTERISATION

Leader: Michael Baker

Team members: Matthew Cracknell, Julie Hunt

Student: Francisco Cuadra

Collaborators: Tobias Hermansson, Helen Thomas

Dr Mike Baker and Dr Matthew Cracknell, along with adjunct Dr Julie Hunt, are supporting new Amira P1249 student Francisco Cuadra to develop and apply orebody characterisation methods for the Nautanen IOCG deposit in northern Sweden. Project sponsors Boliden are keen for Francisco to support the geometallurgy team in predicting rock behaviour, which will aid plant design and waste management. In 2025 Francisco plans

to conduct several weeks of fieldwork in Sweden focusing on sample collection and collaboration with the Boliden staff.

DEEP LEARNING FOR MINERALOGICAL DOMAINING AND PREDICTIVE MODELLING OF ORE DEPOSITS

Leader: Matthew Cracknell

Team members: Michael Baker, Yamila Cajal

Student: Isaac Evinemi

Collaborators: Felipe Jimenez-Arevalo, Carolina Rodriguez-Soto, Sergio Pichott-Henriquez

This project contributes to the large Amira P1249 research project and aims to better understand the applicability of deep learning methods

Projects

Pathways to mineral discoveries through computer-based modelling of geochemical data

High-grade Cu-Mo porphyry mineralizing vectors through geochemical, mineralogical and textural signatures, Ocelot, Arizona, USA

Nautanen IOCG deposit characterisation

Deep learning for mineralogical domaining and predictive modelling of ore deposits

Multi-scale hyperspectral and mineral chemistry data mining

Geological visualisation and virtual education

Project summaries

PATHWAYS TO MINERAL DISCOVERIES THROUGH COMPUTER-BASED MODELLING OF GEOCHEMICAL DATA

Leader: Matthew Cracknell

Team members: Michael Baker, Lejun Zhang

Student: Stephen Cooke

Stephen's project is embedded within the Amira P1249 research project and aims to further develop methods and techniques for ore deposit vectoring using geochemical data such as mineral chemistry and whole-rock analyses. His project focuses on the continued experimentation and development of the LocatOre software platform. LocateOre implements both knowledge-driven and data-driven methods for vectoring towards porphyry copper mineralisation,

via identification of magmatic-hydrothermal heat and fluid sources. The LocatOre knowledge-driven approach uses proximitor equations, first recognised in the Amira P765A research project, to identify the location of intrusive bodies associated with mineralisation. The data-driven approach uses a combined Monte Carlo and regression method to exploit geochemical gradients in mineral chemistry data to highlight the location of intrusive bodies. While both methods are useful for vectoring, Stephen will be addressing problems around communicating model uncertainties resulting from limited numbers of samples and their potentially inadequate spatial distribution.

In 2024 Stephen presented his research at the IGC 2024 conference in South Korea. Stephen has been preparing manuscripts that form the main sections of his thesis, the first of which will summarise LocatOre and highlight its capabilities with two case studies. The second focuses on the impact of sample spatial distribution on output models, which can be used to



This photo of the old mine above Ocelot was taken during fieldwork in early 2024. The mine is a hypogene Cu-Rich system that was in production in the early 1990s. It is in the Old Dominion Historic Park, Arizona, a park open to the public and with miles of hiking trails cutting through the old copper mining facility.



Program 6 Leader, Dr Matthew Cracknell, is seen here presenting a talk at the 30th International Applied Geochemistry Symposium in Adelaide during October.



Dr Paula Montoya at the entrance to the International Geological Congress (IGC) in Busan, South Korea. Five CODES staff and students attended this event, which took place in late August.

to the modelling of ore deposits. PhD student Isaac Evinemi has been working diligently to bring together all of the data provided by CODELCO and integrate these data into a prototype deep learning model for rock type prediction. The predictions are then incorporated into the 3D kriging routine to generate 3D models of the ore deposit. Isaac is currently refining his approach such that it can be used in the context of generating mineralogical models and models rock behaviour. We look forward to the insights gained from this project, which will aid CODELCO mine planning and inform the future use of Artificial Intelligence (AI) for ore deposit modelling.

MULTI-SCALE HYPERSPECTRAL AND MINERAL CHEMISTRY DATA MINING

Leader: Lejun Zhang

Team member: Matthew Cracknell

Student: Arka Sahu

Collaborator: Thomas Rodemann

This PhD project, part of the Amira P1249 program, focuses on using hyperspectral data to predict mineralogy and mineral chemistry. Arka Sahu has developed practical workflows that link spectral data to mineral chemistry, achieving strong results in two case studies: epidote and chlorite from the Batu Hijau Cu–Au porphyry deposit in Indonesia, and the El Teniente Cu–Mo porphyry deposit in Chile. These workflows account for natural mineral variation, making spectral data a reliable tool for predicting changes in mineral chemistry directly in the field. With the analytical stage complete, Arka is now writing his thesis.

GEOLOGICAL VISUALISATION AND VIRTUAL EDUCATION

Leader: Michael Roach

In 2024 the focus of geological visualisation and virtual education was motivated by the generation of learning materials for use in undergraduate and postgraduate teaching programs and also professional education. During 2024, despite the retirement of Dr Michael Roach, we continued to digitise rock samples from our teaching and research collections and these virtual objects have been made freely available through the online Sketchfab portal: <https://sketchfab.com/search?q=Ausgeol&type=models>

OTHER COLLABORATIONS

As always, the Program 6 research group provides technical advice and knowledge across many of the other research themes:

- Dr Matthew Cracknell is working closely with PhD student Axel Cima and the CODES labs in Program 5 to develop methods for detecting and identifying microinclusions.
- Dr Paula Montoya and Dr Matthew Cracknell are providing advice and technical support to the Regional Research Collaboration (RRC) for Critical Metals in Tasmania project embedded within Programs 1 and 2.
- Dr Mike Baker and Dr Matthew Cracknell, with support from Professor Pete Hollings at Lakehead University, Canada, are supervising Amira P1249 PhD student Giovana Pimental's project, which is aligned with Programs 1 and 2. Her project aims to gain insights into ore deposit characterisation that can be gained from a large suite of drill core data at one of Anglo American's Ni-PGE deposits in the Platreef region of South Africa
- Dr Matthew Cracknell is providing technical support for two CODES PhD projects embedded within Dr Jeff Steadman's IOCG³ collaboration. Both Damian Braize and Shouchun Yu aim to use signals within mineral chemistry to answer questions about fertility and mineral exploration in IOCG and related systems.



CODES PhD student Francisco Cuadra pictured at Boliden Aitik's mining and mineral processing operations in northern Sweden while on a field trip related to his Masters degree.

▶ LOOKING FORWARD

In 2025 we look forward to collaborating with Dr Shree Armistead on her new DECRA project based around spatiotemporal mineral exploration in the Central African Copperbelt.

Program 6 researchers plan to continue the CODES internal workshop series that offers training and support for widely used software applications (e.g., LeapFrog, GIS, python etc.). In an ongoing initiative, the Program 6 working group will meet on a regular basis to discuss emerging technologies to aid geoscience research, such as Artificial Intelligence (AI), database management and security, and new advances in geochemical modelling and analysis.

Program 6 deputy leader Dr Paula Montoya is brainstorming new project ideas, one of which is the development of a 3D model that answers geological questions and generates outputs to better understand ore resources, geotechnical and geometallurgy features. This project idea will focus on 3D modelling of veining combined with drillcore data to identify and predict new hydrothermal fluid pathways. These model outputs will offer mining companies information on greenfields exploration targets but may also provide a detailed fracture model for geotechnical or geometallurgical decision making.

We anticipate that 2025 will bring more exciting opportunities to collaborate and celebrate our collective achievements across all the staff and students within the diverse family that is CODES.

Regional Research Collaboration

Project title: ‘Building capacity in regional Australia to enhance Australia’s economy through research, training, and environmentally sustainable production of critical metals’

► OBJECTIVES

The main aims of the Regional Research Collaboration (RRC) project are to:

- Facilitate environmentally sustainable critical metals production in Tasmania.
- Grow UTAS’ research capacity and capability through skills development.
- Improve student retention rates and grow the pool of job-ready graduates for the regions.
- Create sustainable long-term research partnerships.

Introduction

In May 2022 UTAS was granted \$3.5 million from the Australian Government’s RRC Program to fund a novel three-year collaborative partnership between researchers from CODES and the School of Education at the University of Tasmania and the Tasmanian minerals industry. The partnership enables UTAS to work with industry and government to investigate environmentally sustainable critical metals production and improve educational outcomes and regional job opportunities for communities in Tasmania’s West Coast region. Tasmanian industry partners supported the funding application, along with the Tasmanian Minerals, Manufacturing and Energy Council (TMEC) and Mineral Resources Tasmania (MRT). The research project is known by its short title as ‘Environmentally sustainable production of critical metals’.

Critical metals (including tungsten, cobalt, nickel, rare earth elements, indium and magnesium) are vital but scarce resources that society requires for modern technology, infrastructure

and the transition to a renewable energy future. This project aims to provide new methods and approaches to critical metal processing from existing mines, and from legacy mine wastes leading to improved environmental outcomes. The collaboration includes two partner academic institutions – the University of Queensland and the GeMMe research group at the Université de Liège (Belgium). The ten industry partners are: Group 6 Metals (Dolphin mine on King Island), ABx Group (Deep Leads exploration project), Bluestone Mines Tasmania Joint Venture (Renison mine), Tasmania Mines (Kara mine), Avebury Mine, GWR – Tasmanian Magnesium (Prospect Ridge), Copper Mines of Tasmania (Mt Lyell mine), Grange Resources (Savage River mine), MMG (Rosebery mine) and Stellar Resources (Severn and Queen Hill).

The critical metals project is led by four Chief Investigators – three from CODES (Professor David Cooke, Dr Julie Hunt and Dr Ivan Belousov) and one from the UTAS School of Education



The Tasmanian Critical Metals Workshop was held in Tullah, western Tasmania, on 27 November. Here researchers and students from CODES are pictured with other attendees at the Tullah Lakeside Lodge, the venue for the workshop.

(Professor Sharon Fraser). Together they are leading a team of early- to mid-career academic and technical staff, and project-funded postdoctoral researchers in the three elements of the project.

Methodology

Students and postdoctoral researchers have been spending several months on-site with the industry partners to collect samples, characterise critical metal occurrences, test new processes and workflows and help to address the objectives of the project. They are conducting laboratory research at CODES and, where appropriate, at the partner academic institutions. Funding for this project has enabled CODES to take on four new postdocs, and eleven PhDs have joined the project.

The deposits that our researchers are examining in Tasmania for their critical metals potential include Devonian granite-related mineral systems at Renison Bell, Mt Bischoff and Severn; nickel at Avebury; tungsten at Dolphin and Kara; magnesium at Prospect Ridge; and REE at Deep Leads. And also by-product critical metals potential at the Cambrian polymetallic VHMS deposit at Rosebery; and the copper gold deposit at Mt Lyell. Extractable levels of critical metals such as antimony, bismuth, cobalt, gallium, germanium and indium may be found

in these tailings and waste – and in new orebodies as well. Research is focusing first on unearthing western Tasmania’s considerable critical metals potential that lies in its existing mines, mine tailings and waste rocks. Understanding the deportment and reserves of critical metals in existing tailings and waste rock is key to unearthing new finds and helping Australia to become more self-sufficient in these resources, which will be vital for the future as the world transitions to a sustainable green energy future.

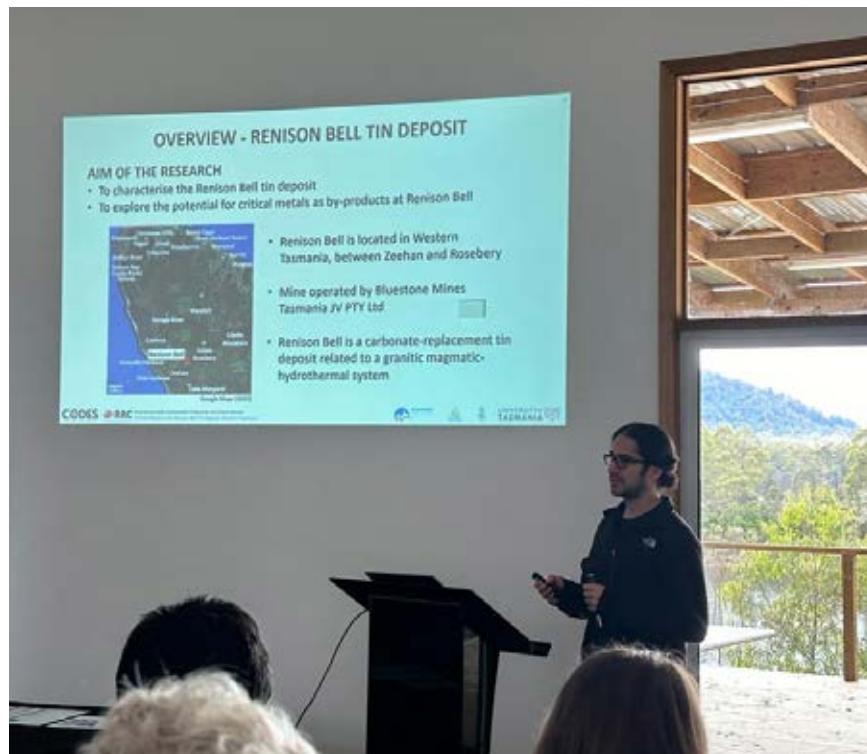
Highlights

2024 was the central year of the Regional Research Collaboration and as such featured a mixture of fieldwork, lab work, conference travel and review meetings. Our team members are expanding knowledge on critical metal resources in Tasmania through the first PhD studies in more than a decade at some of the state’s major mine sites (e.g., Renison Bell) or in the case of some deposits, the first PhD studies ever to be performed are underway (e.g., Prospect Ridge). Data and knowledge are regularly provided to our sponsors and industry partners through field visits and regular meetings.

Data generation was in full swing in 2024, and many manuscripts are under preparation for submission to journals across the economic geology,

geochemistry, metallurgy and education fields. The first research output of the project, a study on computed tomography on scheelite ore from Kara mine co-authored by Dr Julie Hunt, was published but most research papers are expected to be published in 2025 and 2026.

The CODES Critical and Strategic Metals Symposium in July was also a highlight, with several team members showcasing their research at the three-day event. Postdoctoral researchers organised the conference sessions, inviting a range of speakers mainly from government, industry and academia across Australia. The symposium was followed by a three-day field trip to western Tasmania, showcasing our critical metals research to a group of attendees through field visits. In November we held our annual sponsors’ meeting, called the Tasmanian Critical Metals Workshop, with guest speakers Professor David Giles from the University of South Australia and Emeritus Professor Ross Large. The 2025 annual sponsors’ meeting event will be held as part of the Society of Economic Geologists post-conference field trip. While 2025 is the last official year of the project, we will be looking to build on the momentum and data generated within this project to secure future collaborations with the critical metals industry in Tasmania.



CODES PhD student Javier Gil Rodriguez presents at the Tasmanian Critical Metals Workshop. He is carrying out research at Renison Bell in Element 1 of the RRC project.

Key achievements from the three Elements of the project in 2024 were:

Element 1: Unlocking critical metal resources

Element 1's work programs by students and staff at our industry partners' mine sites in 2024 continued with targeted sampling and characterisation of ore, gangue and waste materials. An increased portion of the work program took place at CODES Analytical Laboratories and the Central Science Laboratories at UTAS. Over the course of 2024, students and staff continued to spend time at each of the partners' industrial sites in regional Tasmania to undertake field characterisation of the ores and host rocks as the basis for laboratory work on critical metal deportment. The project's laboratory work demonstrated that specific critical metals are present in ores, gangue minerals and mine wastes at all study sites (Renison Bell, Rosebery, Avebury, Mt Lyell, Heemskirk, Dolphin, Deep Leads, Aberfoyle) with considerable detail emerging on the distribution of critical metals through different minerals at each of the sites. The expertise of CODES Analytical Laboratories in ICP-MS continues to be a major boon for the project.

Element 2: Pathways to production

Element 2 student research began at Savage River and continued at Prospect Ridge and Kara mine, as well as expanding to Mt Lyell mine through staff research. Element 2 is addressing industry's barriers to cost-effective critical metal production that include issues with crushing and grinding, separation of critical metals from gangue, and efficient energy use. Further significant progress was made in 2024 with regards to characterisation of critical metal ores and gangue. Student and staff research on different aspects of scheelite metallurgy has led to initial trials on tungsten processing options at Kara mine. These trials are delivering new information on workflows for separating critical metals (even with a low starting scheelite grade) and testing regimes for workflow implementation. Progress was also made at the Prospect Ridge magnesite deposit regarding developing the workflow for carbonate-hosted critical metal characterisation and processing. Ore at Prospect Ridge has now been classified into three types, each of

which requires their own processing pathway. Significant progress was made on the pathway for processing the purest ore type, designated as type 1 magnesite. At Savage River, student research has focused on tracing critical metal behaviour in magnetic (magnetite-rich) and non-magnetic parts of the ore that are fed through the processing plant at Savage River with an eye to increased geoenvironmental and metallurgical testing in 2025. All these activities have contributed significantly with regards to progress towards achieving Element 2's planned outcome of cost-effective critical metal production.

Element 3: Education and engagement

Element 3 has the objective of devising innovative solutions to community-based barriers that affect engagement in STEM and limit growth of the STEM-capable workforce needed by regional industries for critical metals production. Community engagement/outreach activities (e.g., presentation at forums, museum open days, school visits to the West Coast Study Hub) have formed the basis of our data generation activities with stakeholders responding to survey, interview and/or interactive activities communicating their perceptions of the mining industry and their understandings and experiences with the education system. Regular attendance at community events has proven important to build trust before engaging in longer discussions with community members which have proven very fruitful for the project. We are also developing activities to share with families and the wider community linking young people and the geosciences industry. These activities were informed by the Element 3 sub-committee which included the project team, and members of the West Coast community and industry representatives. From the data generated from these activities, the project has identified key community-based barriers and/or concerns that affect their engagement with mining industries.

The program team

LEADERS DAVID COOKE, JULIE HUNT, IVAN BELOUSOV, SHARON FRASER (SCHOOL OF EDUCATION)



PROJECT MANAGER:

Helen Scott

TEAM MEMBERS:

CODES: Sheree Armistead, Mike Baker, Yamila Cajal, Rebecca Carey, Matthew Cracknell, Mohammad Fathi, Wei Hong, Sebastien Meffre, Clare Miller, Owen Missen, Rob Scott, Jeff Steadman, Lejun Zhang

CENTRAL SCIENCE LABORATORY:

Thomas Rodemann

SCHOOL OF EDUCATION:

Kim Beasy, Connie Cirkony

WEST COAST STUDY HUB:

Belinda Martin

PHD STUDENTS:

CODES: Chris Allen, Alfredtina Appiah, Angela Costa, Vinicius da Cruz, José Barillas Díaz, Emmanuel Dogara Musa, Javier Gil Rodriguez, Pratiche Mondal, Nelao Natukondje Naimbale, Emrekan Yurdakul

SCHOOL OF EDUCATION:

Jane Hall-Dadson

COLLABORATORS:

ABx GROUP LTD

Mark Cooksey

AVEBURY MINE

Tony Chisnall, Josh Denholm, Rebecca Lockley

BLUESTONE MINES TASMANIA JOINT VENTURE PTY LTD

Mark Aheimer, Colin Carter, Brian Dalton, Esther Little

COPPER MINES OF TASMANIA PTY LTD

Geoff Cordery

GRANGE RESOURCES

Kathleen Bowron, Roger Hill, Alexey Lygin

GROUP 6 METALS LTD

Tim Callaghan, Keith McKnight, Rowena Murcott

GWR GROUP LTD (TASMANIAN MAGNESIUM PTY LTD)

Mick Wilson

MINERAL RESOURCES TASMANIA

Mark Duffett, David Green, Verity Kameniar-Sandery, Andrew McNeill, Clint Siggins, Carol Steyn

MMG AUSTRALIA LTD

Corey Jago, Don Macansh, Kevin Robinson

NAGROM

Rain Lewis

STELLAR RESOURCES LTD

Gary Fietz, Adam Frankcombe, Rebecca Lockley

TASMANIA MINES PTY LTD

Greg Doherty, Marcus Mollison

TASMANIAN MINERALS, MANUFACTURING AND ENERGY COUNCIL (TMEC)

Ray Mostogl, Vanessa Skipworth

UNIVERSITÉ DE LIÈGE, BELGIUM

Eric Pirard

UNIVERSITY OF SOUTH AUSTRALIA

George Abaka-Wood

UNIVERSITY OF QUEENSLAND

Rick Valenta

The project comprises three elements:

ELEMENT 1:

Unlocking critical metal resources – developing characterisation and deportment toolboxes and workflows for effective resource evaluation and improvements to waste management.

ELEMENT 2:

Pathways to production – address barriers to cost-effective critical metal production including issues with crushing and grinding, separation of critical metals from gangue, and efficient energy use.

ELEMENT 3:

Education and engagement – devise innovative solutions to community-based barriers that affect engagement in STEM and limit the growth of the STEM-capable workforce needed for critical metals production in regional areas.

Project summaries

ELEMENT 1:
UNLOCKING CRITICAL METAL RESOURCES – DEVELOPING CHARACTERISATION AND DEPARTMENT TOOLBOXES AND WORKFLOWS FOR EFFECTIVE RESOURCE EVALUATION AND IMPROVEMENTS TO WASTE MANAGEMENT

CHARACTERISATION OF W MINERALISATION AT GRASSY, KING ISLAND, TASMANIA – IMPLICATIONS FOR ORE GENESIS, EXPLORATION, AND PATHWAYS TO PRODUCTION

Leader: David Cooke

Team members: Julie Hunt, Lejun Zhang, Yamila Cajal

PhD student: Angela Costa

Collaborators: Tim Callaghan, Keith McKnight, Rowena Murcott (Group 6 Metals Ltd)

This PhD study investigates the geology, alteration and mineralisation of the Dolphin W deposit in Grassy, King Island. Key objectives include determining mineralogy using petrographic, SWIR, SEM and MLA analyses, and assessing critical and valuable metal deportment with LA-ICP-MS to optimise mineral processing. The study is also working on a refined genetic and exploration model for W mineralisation on King Island using regional samples from outcrops around the island.

In the second year of her candidature, Angela Costa completed further advanced analytical work including SEM, microprobe, LA-ICP-MS, TerraSpec, HyLogger and XRF. Angela successfully completed her mid-term review. Angela’s microanalytical work helped her to constrain the paragenetic sequences of alteration and mineralisation, including a granite fertility study. She also conducted U-Pb dating on different hydrothermal



The AusIMM Critical Minerals Conference 2024 took place in Brisbane during August and was attended by (L–R) Dr Mohammad Fathi along with PhD students Alfredtina Appiah and Emmanuel Musa Dogara. Both students are working in Element 2 of the RRC project.

gangue and ore minerals to determine the age of the deposits. She successfully applied for beamtime at the X-ray fluorescence microscopy beamline of the Australian Synchrotron, which will be undertaken in 2025, as well as progressing her writing up of some of her research results.

CHARACTERISATION OF COMPLEX OREBODIES IN THE SOUTHERN PART OF THE ROSEBERY–HERCULES DISTRICT, WESTERN TASMANIA

Leader: David Cooke

Team members: Lejun Zhang, Rebecca Carey, Wei Hong, Yamila Cajal

PhD student: Vinicius da Cruz

Collaborators: Don Macansh, Corey Jago, Kevin Robinson (MMG Australia Ltd))

This PhD project is characterising the complex orebodies and volcano-sedimentary succession at the southern end of the Rosebery mine, focusing on the potential for critical metals exploration, in particular indium and germanium. The specific goals are to understand the stratigraphy and alteration of the Cambrian primary mineralisation and Devonian overprint mineralisation, characterise the Devonian mineralisation in terms of ore and gangue minerals, develop geological and geochemical constraints and vectors for the orebodies at southern Rosebery mine, and assess the potential for critical metals in these complex orebodies.

Vinicius completed further fieldwork, undertook detailed SEM and LA-ICP-MS analyses particularly of sulfides, and collected geochronology data in 2024 to better constrain mineralisation events. Preliminary results indicate that Devonian granite-related hydrothermal events overprinted primary Cambrian VHMS massive sulfide mineralisation.

Critical elements indium and germanium have been identified in high concentrations within sphalerite and chalcopyrite, and were compared with other deposits globally. Vinicius completed his confirmation of candidature in early 2024 and presented a talk at the CODES Critical and Strategic Metals Symposium. In 2025 Vinicius will work on finalising his geochronological sequence and focus on writing up his research.

CHARACTERISATION OF THE HEEMSKIRK TIN PROJECT, ZEEHAN, WESTERN TASMANIA

Leader: David Cooke

Team members: Wei Hong, Robert Scott

PhD student: Nelao Natukondje Naimbale

Collaborators: Gary Fietz, Adam Frankcombe, Rebecca Lockley (Stellar Resources Ltd)

The Heemskirk tin project in Zeehan, western Tasmania, hosts Australia’s largest undeveloped tin resource, owned by Stellar Resources Ltd. This PhD project focuses on characterising the stratigraphy and complex structure of the Heemskirk project to aid near-mine exploration and improve orebody knowledge. The objectives include conducting detailed core logging to understand stratigraphy and structurally controlled Sn mineralisation, mapping alteration assemblages during field core logging and using hyperspectral techniques, and using LA-ICP-MS to determine critical metal deportment in sulfides and cassiterite for optimising mineral processing. Additionally, the project is testing LA-ICP-MS trace element analyses of accessory sulfides and gangue minerals to aid mineral exploration.

Nelao completed further fieldwork, collected Hylogger data and worked on her cross-sections in 2024 to enhance and refine the cross-section and paragenetic sequences. She has now refined her paragenetic scheme and built an updated cross-section based on detailed graphic logging and further microanalytical work. Nelao completed her confirmation of candidature in

2024. Selected gangue and ore minerals were analysed using SEM and LA-ICP-MS to investigate the occurrences and deportment of critical metals in the Heemskirk tin project. In 2025 Nelao will work on finalising her fieldwork and continue with her analytical work with the aim of better constraining critical metal deportment.

CHARACTERISATION OF THE AVEBURY NICKEL DEPOSITS, ZEEHAN, WESTERN TASMANIA

Leader: David Cooke

Team members: Lejun Zhang, Yamila Cajal, Wei Hong

PhD student: José Barillas Diaz

Collaborators: Tony Chisnall, Josh Denholm (Avebury Mine)

This PhD research project aims to characterise the geology, alteration, mineralisation, paragenesis, geochemistry and geochronology of the Avebury Ni deposit in western Tasmania. This will be achieved through drill core logging, surface and underground mapping, and advanced analytical laboratory techniques.

In 2024, José completed further fieldwork, and conducted further analytical work using TerraSpec, HyLogger, pXRF, SEM including automated mineralogy, and detailed LA-ICP-MS techniques to investigate the concentration and deportment of critical metals at Avebury. His results revealed the complexity of Ni sulfide minerals at Avebury including complex trace element zonation. A detailed geological cross-section has been built based on detailed graphic logging. Initial results on the deportment of PGEs have been presented at project review meetings and José also presented his findings focusing on Ni and Co at the CODES Critical and Strategic Metals Symposium. José completed his confirmation of candidature and fieldwork, and focused on petrographic and SEM work to unlock the paragenetic sequence of the alteration and mineralisation at Avebury. In 2025, as well as writing up his research, he will apply for Synchrotron beamtime to further explore PGE deportment at Avebury.

CHARACTERISATION OF RENISON BELL TIN DEPOSIT, WESTERN TASMANIA

Leader: David Cooke

Team members: Wei Hong, Owen Missen

PhD student: Javier Gil Rodriguez

Collaborators: Colin Carter, Mark Aheimer, Esther Little (Bluestone Mines Tasmania Joint Venture Pty Ltd.)

Renison Bell in western Tasmania is Australia’s largest Sn producer, with potential for by-product Cu production. However, the potential for recovery of other critical metals such as In, Co or Ni from ores, gangue and/or waste, or the discovery of other granite-related critical metal resources such as W, Nb or Ta in the district, has not been explored prior to the commencement of this project. This characterisation-based PhD research project aims to aid near-mine exploration and improve orebody knowledge at Renison, assisting in the discovery of additional Sn resources and evaluating the potential for the discovery and/or recovery of critical metals in sulfide and oxide minerals

Javier completed further fieldwork and finalised his first detailed geological cross-section in 2024 based on graphic logging and further petrographic and microanalytical work. He also collected a further suite of data to develop a second detailed cross-section meaning that his results are highly geologically constrained, focusing on central fault architecture. His results show the existence of critical metal-bearing minerals such as scheelite but the major source of critical metals such as Co, Ni, Sb, Bi, In, Sc, Te, and V is as trace elements in various sulfides (e.g., pyrrhotite and chalcopyrite) and oxides (e.g., cassiterite and magnetite). In 2025 Javier will finalise his fieldwork and lab work, send samples to Canada for further isotope analysis, and work on writing up his research, focusing first on his granite fertility results.

OREBODY KNOWLEDGE OF THE WESTERN THARSIS CU-AU DEPOSIT, TASMANIA

Leader: Lejun Zhang

Team members: Mike Baker, Rob Scott

PhD student: Emrecan Yurdakul

Collaborator: Geoff Cordery (Copper Mines of Tasmania Pty Ltd)

The Western Tharsis Cu-Au deposit (12.4 Mt indicated and inferred resource, averaging 1.3% Cu and 0.3 g/t Au) is one of the major unmined deposits in the Mt Lyell district, hosted by the Central Volcanic Complex of the Mt Read Volcanics. The main research objectives of this PhD study are to characterise the alteration and mineralisation features and geochronology, and to provide a

detailed geological, exploration and geometallurgical model of the deposit. This will help optimise mine planning, develop deposit-specific exploration tools, and understand the relationships between Western Tharsis and regional tectonic and magmatic evolution processes.

Emrecan Yurdakul conducted several field campaigns and completed 2.5 km² of detailed anaconda-style bench mapping, 5 km² of regional structural and geological surface mapping, and over 5,000 metres of graphic drill core logging, including reinterpretation of historical logs. A total of 519 outcrop and drill core samples were collected for detailed analysis, including whole geochemistry, XRD, SWIR, FT-NIR, FTIR, SEM and LA-ICP-MS. Preliminary results were presented at project review meetings, and Emrecan has also presented on the Mt Read Volcanics in general and delivered guest lectures for third-year environmental geology

students. He has now completed all analytical work and will focus on thesis writing in 2025. Emrecan is also planning a sponsors' update meeting to bring together industry, government, consultants and academia.

ELEMENT 2: PATHWAYS TO PRODUCTION – ADDRESS BARRIERS TO COST-EFFECTIVE CRITICAL METAL PRODUCTION INCLUDING ISSUES WITH CRUSHING AND GRINDING, SEPARATION OF CRITICAL METALS FROM GANGUE, AND EFFICIENT ENERGY USE

The Environmentally Sustainable Production of Critical Metals project (known as the Regional Research Collaboration or RRC) ramped up in 2023 and continued in 2024 as all three PhD student projects in Element 2, as well as research staff, gathered pace. CODES Research Program 2 is currently particularly focused on Element 2 of the RRC, which seeks to develop innovative ways to produce critical metals from both ores and wastes, focusing on the Tasmanian context. Multiple field trips to a number of sites on the west coast of Tasmania were undertaken for sample collection, as well as a visit to Perth to visit geometallurgy laboratories there. Further work on 3D visualisations for education and outreach was undertaken at Kara mine.

PATHWAYS TO PRODUCTION – MAGNESITE DEPOSITS AT PROSPECT RIDGE, NORTHWEST TASMANIA

Leader: Julie Hunt

Team members: Ivan Belousov, Mohammad Fathi, Wei Hong, Owen Missen

PhD student: Alfredtina Appiah

Collaborators: George Abaka-Wood (Uni South Australia), Mick Wilson (GWR Group Ltd (Tasmanian Magnesium Pty Ltd)), Verity Kameniar-Sandery (MRT), Rain Lewis (Nagrom)



CODES PhD student Pratichee Mondal core logging at the Savage River magnetite deposit, northwest Tasmania, while carrying out research for her project in Element 2.

The Prospect Ridge exploration tenement encompasses the Arthur River and Lyons River magnesite deposits in the Arthur Lineament of NW Tasmania, a high strain zone that is 5–10 km wide and 110 km long, comprised of Cambrian metamorphosed rocks. The magnesite deposits within the Arthur Lineament are yet to be mined and have not been fully defined. This PhD thesis will evaluate pathways to produce magnesite concentrates from Prospect Ridge, focusing on the Arthur River Mg deposit in the northern part of the Arthur Lineament. The local geology,

alteration and mineralisation are being characterised through drill core logging and laboratory investigations. Ore and gangue mineralogy are being determined using petrographic, short-wave infrared (SWIR), SEM-based automated mineralogy and geochemical analyses. Magnesium and trace element deportment are being constrained through detailed LA-ICP-MS to help optimise mineral processing options.

Simple field- and/or laboratory-based tools are being tested and applied to assist with domaining high-grade

magnesite ore and discriminating it from visually similar dolomite and calcite, resulting in the description of different magnesite ore types. Opportunities for blending wastes from Prospect Ridge with other mine wastes in western Tasmania will be evaluated to establish whether there are opportunities to improve environmental management of acid drainage at other mine or legacy sites. Alfredtina has also visited Nagrom's laboratories in Perth to see metallurgy test work on her samples in action. The first publication from this PhD project is almost complete and will be submitted in early 2025. Alfredtina's research was also featured in a *West Australian* newspaper article entitled 'Magnesium hunt kicks off for GWR, Dynamic in Tasmania'.

RECOVERY OF CRITICAL METALS FROM TAILINGS STREAMS, LEGACY MINE WASTE AND WATERS: SAVAGE RIVER MAGNETITE DEPOSIT, NORTHWEST TASMANIA

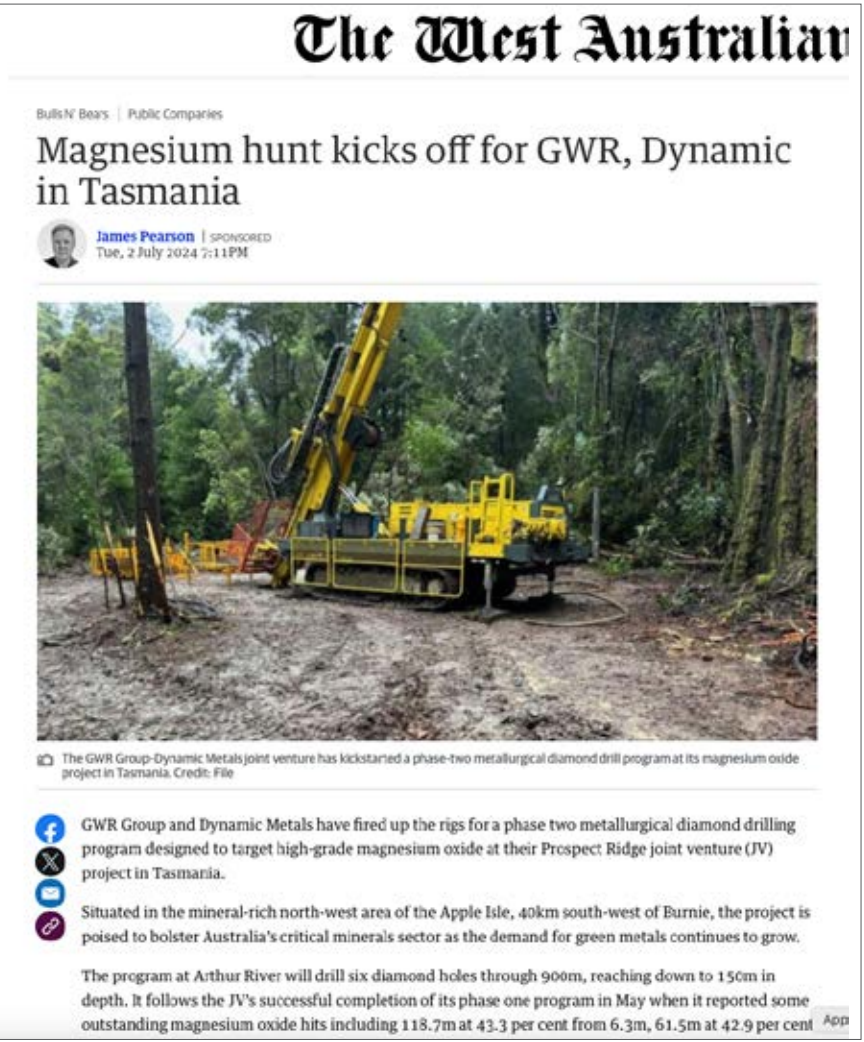
Leader: Owen Missen

Team members: Mohammad Fathi, Julie Hunt, Lejun Zhang

PhD student: Pratichee Mondal

Collaborators: Kathleen Bowron, Roger Hill, Alexey Lygin (Grange Resources)

This PhD research project, which commenced in 2023, is focused on the mining value chain at Savage River. The project begins with ore mineralogy to characterise the mineral assemblages in both economic and neighbouring non-economic zones. This is followed by geoenvironmental and geometallurgical characterisation of material that reports to waste streams to aid opportunity recognition for by-product metal recoveries while reducing the volume of potentially deleterious wastes on-site. Tailings material collected for this study has been accurately geo-located within the orebody to improve the accuracy of the research results. The project aims to assist in recovery of critical metals from ores and wastes at Savage River while,



A *West Australian* newspaper article about PhD student Alfredtina Appiah's RRC project within in Element 2, 'Pathways to production – magnetite deposits at Prospect Ridge, northwest Tasmania'.

in turn, also reducing the environmental impacts of legacy wastes by improving characterisation to inform mineral processing and waste management. The project will assess whether critical metals such as Ti, V, Co and/or other critical metals can be recovered from the Savage River ores and/or wastes.

PATHWAYS TO PRODUCTION – KARA W-FE MINE, NW TASMANIA

- Leader:** Julie Hunt
- Team members:** Mohammad Fathi, Owen Missen
- PhD student:** Emmanuel Dogara Musa
- Collaborators:** Greg Doherty, Marcus Mollison (Tasmania Mines Pty Ltd)

Kara, a Fe-W skarn-type deposit in northwestern Tasmania, has substantial critical metal resources

such as tungsten (W) found as scheelite, with the potential to contribute significantly to growth in Tasmania’s critical metals inventory. Extraction of critical metals from ores and waste materials can be challenging and pose potential barriers to cost-effective recovery that need to be addressed. These include potential issues with crushing and grinding, separation of critical metals from gangue, and efficient energy use.

The aim of this research is to develop sustainable pathways for scheelite production at Kara mine and in skarn deposits more generally. The objectives include: (1) Rock characterisation of representative samples to identify lithology, alteration and mineralisation; (2) Detailed petrographic and geochemical characterisation of ore and gangue minerals; (3) Evaluation of processing methods currently used on-site for W-bearing ore; (4) Assessment of the feasibility of using other techniques, not currently used on site, to help improve extraction,

concentration and saleability of products; and (5) creation of characterisation and testing workflows based on the outcomes of the research to optimise critical metals recovery and sustainable/optimal use of the orebody. The first publication from this PhD project is in preparation.

OPTIMISING REMEDIATION OF LEGACY MINES – MINERALOGICAL CONTROLS ON LONG-TERM WASTE ROCK WEATHERING AND MINE DRAINAGE

- Leader:** Sebastien Meffre
- Team members:** Matthew Cracknell, Owen Missen, Clare Miller
- PhD student:** Chris Allen
- Collaborators:** Mark Duffett, Clint Siggins, Carol Steyn (all MRT); Brian Dalton (Bluestone Mines)

Characterisation of mine wastes through lab- and field-based tests is now standard practice in the initial stages of mine closure. However, there is insufficient knowledge about how exposure and weathering may influence mine wastes in the medium term (i.e., ~10 years). Previous studies have indicated the importance of secondary mineral formation on leachate chemistry. However, most studies typically consider only the weathering of recently extracted rocks or deeply weathered waste rocks rather than investigating both fresh and weathered materials to understand how weathering and exposure affects mineralogy, surface area and texture, grain size and metal(loid) deportment. The Happy Valley Waste Rock dump at Mt Bischoff has been exposed to the effects of weathering over a 10–12-year period. This provides an excellent opportunity to study the progression of weathering and changes in mineralogy, surface area and texture, grain size and metal deportment on rocks exposed to weathering for a known amount of time without requiring long-term column or barrel tests in addition to having the ability to study relatively fresh materials of the same lithology. This PhD study commenced in early 2022 and is integrating geophysical studies of the waste rock pile with geochemical studies of waste products and benchtop testing to evaluate the evolution of mine wastes at Happy Valley, and to evaluate options for future waste management.

Activity in 2024 consisted of ongoing column testing, SEM analysis of samples, processing and interpreting geophysical data, and an oral presentation on geophysical results at the International Conference on Acid Rock Drainage (ICARD) in Halifax, Nova Scotia.



Community consultation has helped to highlight...the ways in which social attitudes shape pathways to STEM careers.



Professor Sharon Fraser from the School of Education speaking about regional barriers to engagement in STEM at the Tasmanian Critical Metals Workshop at Tullah, November 2024. Her research is within Element 3 of the RRC project.

ELEMENT 3: EDUCATION AND ENGAGEMENT – DEVISE INNOVATIVE SOLUTIONS TO COMMUNITY-BASED BARRIERS THAT AFFECT ENGAGEMENT IN STEM AND LIMIT THE GROWTH OF THE STEM-CAPABLE WORKFORCE NEEDED FOR CRITICAL METALS PRODUCTION IN REGIONAL AREAS

ADDRESSING REGIONAL BARRIERS TO ENGAGEMENT IN STEM – EDUCATION AND OUTREACH STRATEGIES RELATING TO CRITICAL METALS PRODUCTION

- Leader:** Sharon Fraser
- Team members:** Kim Beasy, Connie Cirkony, David Cooke
- PhD student:** Jane Hall-Dadson

This PhD research project continues its focus on addressing regional barriers to STEM engagement, particularly within critical metals production, by exploring familial influences on STEM aspirations on the West Coast of Tasmania. Since April 2024, extensive community engagement has been conducted through 66 meetings, events and outreach sessions, involving schools, neighbourhood houses, community organisations, mining

groups and local government representatives. These activities aim to understand regional challenges and identify opportunities for increasing STEM participation.

The research has incorporated five school holiday activities, seven community events, 57 completed surveys and 10 completed interviews, as well as planned focus groups. Engagement efforts have spanned 49 days of fieldwork, strengthening relationships with key stakeholders and ensuring diverse perspectives are considered. Community consultation has helped to highlight the role of parental influences, local workforce needs and the ways in which social attitudes shape pathways to STEM careers.

The next stages will involve analysing the findings from data collected so far, with a particular focus on understanding the barriers and motivators affecting STEM engagement in regional communities. Focus groups with key stakeholders will be conducted to explore how community strengths – such as existing networks, local expertise and education initiatives – can be leveraged to support STEM education and career pathways. By working collaboratively with educators, policymakers and industry representatives, the project aims to develop practical strategies that will enhance long-term STEM participation, strengthen workforce development, and contribute to broader regional sustainability efforts.



The Iron Blow, where mining began at Mt Lyell. PhD student Emrecan Yurdakul is working on one of the underexplored and unmined orebodies in the Mt Lyell field, Western Tharsis, within Element 1 of the RRC project.

Training and education



LEADERS REBECCA CAREY, MATTHEW CRACKNELL, ROBERT SCOTT AND MARTIN JUTZELER

► OBJECTIVES

- To develop exceptional geoscience graduates to lead innovation and discovery across academia, government and industry.
- To deliver a range of professional development short courses and workshops tailored to the needs of the minerals industry.
- To prepare highly skilled geoscience professionals ready to tackle real-world challenges through advanced postgraduate education.
- To support the physical and mental wellbeing of students across all aspects of their education and training.

Introduction

CODES is internationally recognised for excellence in postgraduate geoscience education, offering students a strong foundation in the Earth Sciences. Attracting students from around the world, CODES has a proud track record of graduates advancing to senior roles in the minerals industry, government and academia.

Education and training are integral to CODES' research, spanning our six core programs (see page 8 for a description of these programs). Offerings include Higher Degrees by Research (PhD and Masters by Research), the Master of Economic Geology, the Graduate Certificate in Economic Geology and Honours programs. In addition, CODES delivers a range of short courses and workshops – both online and in-person – designed to equip students with essential research skills to meet the challenges of today's society.

Highlights

New students

This year, we welcomed a dynamic group of new PhD students across a range of research themes, contributing to our academic community.

- **Amira P1249:** Poliana Vidal Salgado, Fransisco Cuadra Amaro
- **IOCG³:** Damian Braize, Shouchun Yu
- **Volcanology:** Catherine Brown, Cat Lit

Graduates

We have celebrated the achievements of our 2024 PhD graduates, many of whom have already gone on to roles in industry, government and academia. Congratulations to the following:

- **Alex Farrar** – Principal Geologist, Predictive Exploration, First Quantum Minerals
- **Colin Jones** – Retired and living the dream



Participants on the Advanced Field Skills in Economic Geology short course take a break at Donaghys Hill Lookout on their way to Tasmania's West Coast in February 2024.

- **Rhiannon Jones** – Geologist, Geological Survey of Queensland
- **Xin Ni Seow** – Exploration Geologist, AngloGold Ashanti
- **Emily Smyk** – Geologist, Bayside Geoscience
- **Yi Sun** – Mine Geologist, Gold Fields
- **Zebedee Zivkovic** – Postdoctoral Researcher, CODES/Geoscience Australia

Grants and awards

Several students were successful with competitive travel grants and other awards, enabling them to further their research and/or present their research to an international community.

- **Billy Beas** – Student bursary from IAGS 2024.
- **Damian Braize** – SEG travel grant to SEG Conference 2024, Namibia; Travel funds for the NVCL-ANU Hyperspectral Mineralogy Workshop, Canberra.
- **Angela Costa** – Shared in an Australian Synchrotron in-kind grant of \$131,136; SEG Student Research Grant; CSIRO Mineral Resources Internship including conference support bursary; SEG Conference Presenter Student Support for SEG Conference 2024, Namibia.

- **José Barillas Diaz** – Travel grant to the International Ni-Cu Symposium 2024, Canada.
- **Javier Gil Rodriguez** – SEG Student Research Grant, US\$5,000; Student bursary from IAGS 2024.
- **Nelao Natukondje Naimbale** – Travel grant to SEG Conference 2024, Namibia; travel funds for NVCL-ANU Hyperspectral Mineralogy Workshop, Canberra.
- **Jaime Osorio** – SEG Student Research Grant, \$2,500.
- **Giovana Oliveira Pimental** – Travel grant to the International Ni-Cu Symposium 2024, Canada; SEG Graduate Student Fellowship 2024; Student bursary from IAGS 2024; Travel funds for NVCL-ANU Hyperspectral Mineralogy Workshop, Canberra.
- **Emrecan Yurdakul** – Travel grant to the Discoveries in the Tasmanides 2024 Conference, Albury, from NSW AIG and AMEC.
- **Axel Cima** – Travel grant to the SEG Conference 2024, Namibia.

Other highlights

In addition to research and academic achievements, our students played key roles in organising and participating in major events and field experiences.

Our HDR students co-organised the **CODES Critical and Strategic Metals Symposium** (July 2024), and the **CODES SEG Student Chapter trip to Japan** (September 2024).

Postgraduate programs

PHD AND MASTERS BY RESEARCH PROGRAM

Postgraduate students are at the heart of research at CODES, contributing significantly to the centre's scientific output across the fundamental to applied spectrum. Their projects span all of CODES' research themes and frequently involve collaboration with partners in Tasmania, across Australia, and internationally. These partnerships include industry, government agencies, geological surveys and academic institutions around the world.

Project locations

Our HDR research activities spanned a wide geographic area in 2024, reflecting the global relevance and reach of our work.

- **Australia (mainland):** 8 projects
- **Tasmania:** 11 projects
- **International:** 17 projects



Bluestone Bay on the Freycinet Peninsula on Tasmania's east coast was the location for the last day of the 2024 Advanced Field Skills in Economic Geology short course.

These projects are supported by industry and government sponsors and involve national and international academic collaborations, providing our graduates with real-world training and experience. This ensures that project outcomes align closely with stakeholder needs, resulting in meaningful and lasting research impact.

MASTER OF ECONOMIC GEOLOGY PROGRAM

The coursework-based Master of Economic Geology degree at CODES forms part of the national Minerals Geoscience Masters (MGM) program – a collaboration between UWA, UTAS and Curtin University. The MGM remains the course of choice for industry-based geoscientists, attracted by the opportunity of studying for an internationally recognised degree, while still being able to pursue full-time careers in the minerals industry. Dr Robert Scott is the program coordinator of the Master of Economic Geology and Graduate Certificate in Economic Geology programs at CODES.

2024 was another good year for degree completions and new admissions for the

MEconGeol and GCertEconGeol degree programs, with the net result being a small increase in total student numbers. Congratulations are due to the nine MEconGeol students who graduated in 2024 (Roseanna Dale, Michael Adams, David Portocarrero Ccaccya, Steven Rennick, Joel Blake, Jessica Askew, Brianna Clark, Lucy Jones, Paul Edmonds) and also Nick Poznik and Dom Murphy who both completed their degrees in late 2024, and will graduate in 2025. Six students graduated, and a further two completed, the GCertEconGeol. These departures from the program were more than offset by a healthy number of new admissions, with eight students commencing the GCert and 18 students either commencing or restarting the MEconGeol in 2024. Pleasingly, two new starters in the MEconGeol are recent graduates of the GCert, highlighting the role of the GCert as an alternative entry pathway to the Masters degree. There were 85 active students in the MEconGeol/GCertEconGeol program for 2024; a 7% increase on the previous year.

In 2024, CODES decided to reduce the annual coursework unit offering in the MEconGeol from six to five. GeoData Analytics and Advanced Field Skills (offered annually since 2020/21) will now to be offered in alternate years. Despite this, the total number of unit enrolments for 2024 was only slightly down on 2023 enrolments, when seven coursework units were delivered, due to Ores in Magmatic Arcs being offered twice.

Summaries of the five UTAS-based Masters short courses held during 2024 follow:

ADVANCED FIELD SKILLS IN ECONOMIC GEOLOGY 4–17 FEBRUARY 2024

This unit provides training in fundamental and advanced mapping and field skills for minerals industry geologists. Techniques covered include field-based rock and mineral identification, fact and form surface mapping, Anaconda-style mapping, structural measurement and graphic logging techniques for drill core, and the use of spectral, geochemical and remote sensing data sets in making and interpreting geological maps. The

unit was delivered by CODES teaching staff Robert Scott, Lejun Zhang and Francisco Testa, with CODES PhD student Emrekan Yurdakul assisting as demonstrator. The first week of the unit is delivered concurrently with the CODES/Victorian Institute of Earth and Planetary Sciences (VIEPS) Exploration Field Skills mapping camp and involved nine participants. The first mapping area is located ~20 km north of Queenstown (where participants stay until early in the second week of the intensive delivery), but the first day is spent in Hobart at Mineral Resources Tasmania's core storage facility in Mornington, with participants logging three drill cores from the mapping area. After travelling to Queenstown, and a series of introductory lectures on day two, participants spend four days mapping a ~3 km² area centred on the Hall Rivulet Canal. The mapping area is 13 km south (along strike) from the poly-metallic Rosebery volcanic-hosted massive sulfide (VHMS) deposit. Participants use information obtained during the field mapping and core logging exercises to interpret the structure and stratigraphy of the mapping area and based on this, identify untested areas with potential for hosting significant VHMS-style deposits at less than 500 m depth.

The second week of the field trip began with a 2.5-day Anaconda mapping and core logging exercise on the Mt Lyell mine lease in Queenstown. CODES is very grateful to Geoff Cordery and CMT for again facilitating this exercise. Participants then travelled to George Town (northeast Tasmania) for three days of structural mapping exercises in the multiply deformed Lower Palaeozoic turbidites exposed in wave-cut rock platforms on the NE coast. The field trip concluded with a daytrip to the Freycinet Peninsula on the east coast of Tasmania, where participants examined and mapped magmatic–hydrothermal transition features developed in the granites exposed at Bluestone Bay.

VOLCANOLOGY AND MINERALISATION IN VOLCANIC TERRAINS 1–14 MARCH 2024

The 2024 delivery of this unit took place in March, taking advantage of the typically favourable weather on New Zealand's North Island to access key alpine volcanic regions. The course aimed to familiarise students with volcanic facies types and their architectural relationships in modern volcanic environments – information essential for reconstructing ancient

volcanic terrains, particularly in the context of vent proximity and mineralisation potential.

Field visits included the Auckland monogenetic volcanic field, the Taupō Volcanic Zone with its caldera systems, and the andesitic volcanoes of the central North Island. A highlight was the Tongariro Alpine Crossing and Mt Doom (Ngauruhoe volcano) from Lord of the Rings, which was completed under perfect conditions. We also explored active geothermal parks including mud boiling pits, and the world-famous Champagne Pool. This year's standout experience was at Waihi gold mine, where we examined some epithermal veins in outcrop. We are always treated to an update of Waihi epithermal gold mine exploration targets and discoveries, and we sincerely thank Shannon Richards, and our OceanaGold hosts, for their preparation and sharing their time on the day.

This year a particularly memorable stop was Tauhara Quarry, where students encountered a rare dacite containing both quartz and olivine phenocrysts – an excellent opportunity to test students' mineral ID! The site also features world-class exposures of cryptolava from a 60-ka andesite dome complex on the northern Taupō



Students and industry participants on the Volcanology and Mineralisation in Volcanic Terrains short course pictured in the 1886 fissure, Mt Tarawera, New Zealand in March 2024.



Terry Hoschke addresses a large group of participants in the first week of the Ore Deposit Models and Exploration Strategies Masters short course at CODES in June 2024.

Caldera. The variability in adjacent volcanic and sedimentary facies and their contact relationships provided exceptional learning opportunities. We thank Craig from Tauhara Quarry and GNS volcanologist Michael Rosenberg for facilitating access and sharing his expertise.

FUNDAMENTALS OF ECONOMIC GEOLOGY 8–13 APRIL AND 6–10 MAY 2024

This unit introduces the fundamental skills and theory needed by all economic geologists, and covers topics including ore deposit classes, environments of ore formation, mineralogy and textures, paragenesis, zoning, geochemical and geophysical characteristics of ore deposits, supergene features and the economics of economic geology. First delivered in 2021, Fundamentals of Economic Geology is now delivered annually in April/May and is one of two compulsory units in the current structure of the MEconGeol degree.

In 2024, Fundamentals was presented by CODES staff David Cooke (unit coordinator), Michael Baker, Francisco Testa, Michael Roach, Robert Scott and Lejun Zhang along with guest presenters Tim Callaghan, Karsten Goemann, Scott Halley, Jeff Hedenquist, Thomas Rodemann, Sam Scher and Noel White, and was attended by 36 people (19 Masters students, four industry participants, and 13 other CODES students who sat in on part or all of the unit). A virtual geological tour and sample set

for the Dolphin scheelite deposit on King Island forms the centrepiece of this unit. The virtual tour, which was prepared by Michael Roach, Lejun Zhang and Francisco Testa, contains interactive 3D imagery of the entire open pit, with close-ups of key exposures in the pit walls, and high-resolution 3D imagery, mineralogical and geochemical data for a representative suite of ore and host rock samples collected from the pit. Participants use the Dolphin deposit sample set to reinforce many of the key concepts (e.g., paragenesis, mineral and metal zonation) and analytical techniques introduced in this unit. CODES is grateful to King Island Scheelite for enabling the pit access and sampling required to develop this exercise.

ORE DEPOSIT MODELS AND EXPLORATION STRATEGIES 3–8 JUNE AND 8–12 JULY 2024

Ore Deposit Models and Exploration Strategies is delivered biennially, in even-numbered years, and is the second compulsory unit in the MEconGeol degree. In 2024, the unit was again delivered in blended mode (live-streamed from Hobart) in two week-long intensive blocks. The unit provides an up-to-date synopsis of key ore deposit types (e.g., characteristics, location, genesis and exploration strategies) including porphyry, epithermal, skarn, IOCG, magmatic sulfide, VHMS, orogenic gold, Carlin, sediment-hosted-Cu and Zn-Pb, and Broken Hill-type Pb-Zn-Ag deposits.

Twenty-three Masters students, seven industry participants and 13 CODES PhD students attended the entire short course. However, a highlight of the second intensive week was the inclusion of the very successful three-day Critical and Strategic Metals Symposium. Critical and strategic minerals are an emerging national and global priority area, as they essential for many modern technologies, including those underpinning the transition to net zero emissions. The three-day symposium provided participants with both global perspectives and the outcomes of some exciting new research into lithium, tin-tungsten, rare earth elements, cobalt-copper and nickel-PGE resources. The symposium was organised by Paula Montoya, Yamila Cajal, Owen Missen and the UTAS Society of Economic Geology Student Chapter. It was attended by 97 on-campus participants and 37 online participants from five continents.

EXPLORATION IN BROWNFIELD TERRAINS 28 OCTOBER–2 NOVEMBER 2024 AND 18–22 NOVEMBER 2024

Exploration in data-rich environments, close to existing mines, has become a preferred and successful method of increasing company resources. The Brownfields short course is designed to bring participants up to date with the latest approaches, tools and software needed for navigating, integrating and interpreting extensive multi-faceted,

multi-generational geoscience data sets. The unit was delivered in late 2024 in two, week-long, live-online intensive teaching blocks. It was attended by 23 Masters students and six other students (mostly CODES PhDs), and six industry participants also attended all or part of the unit. The unit was taught by CODES staff Matt Cracknell, Michael Roach, Robert Scott and Zeb Zivkovic, with guest lectures from government and minerals industry professionals Tony Webster, Ned Howard, Chris Muller, Andrew McNeill, Terry Hoschke, Kate Hine, Kim Frankcombe, Dave Isles, Lesley Wyborn, Wess Edgar and Jo Whelan. The major assessment task for the unit is a real-world brownfields exploration exercise using data from the Pine Creek Orogen in the Northern Territory provided by Agnico Eagle Mines Limited. CODES are indebted to Meg Ellis and Wess Edgar (Agnico Eagle) for compiling and providing the data used for this exercise.

The Master of Economic Geology short course program for 2025:

- 9–22 March: Ores in Magmatic Arcs – Indonesia
- 7–12 April and 5–9 May: Fundamentals of Economic Geology
- 2–7 June and 7–11 July: Ore Deposit Geochemistry, Hydrology and Geochronology
- 4 August–12 September; 15–19 September and 22 September–31 October: Geodata Analytics
- 11–25 October: Ores in Magmatic Arcs – Chile and Peru
- 27 October–1 November and 24–28 November: Geometallurgy

HONOURS PROGRAM

The Honours degree in Earth Sciences is designed to train our students for both industry and academia. The program is coordinated by Dr Martin Jutzeler and consists of thesis-based research balanced with a literature review and four weeks of short course units that take place in Tasmania or at universities in Victoria. The Honours year also includes in-house one-day workshops to improve the students'



CODES PhD student Axel Cima presenting a talk about his research at the 2024 SEG Conference in Windhoek, Namibia, in late September.

writing skills, introduce them to our laboratories, library services, and to the specific software they will need for their projects. The Honours program has two intakes a year (February and July) and consists of around 38 weeks of study, with graduations in December and August. Our Honours program allows full- or part-time enrolment and has been proven as an efficient segue for our graduate students to access competitive industry employment.

The 2024 academic year saw the graduation of two Honours students. Sarah Purdom's Honours project was on the characterisation of the White Rabbit Diorite in the Lachlan orogen near Stawell, Victoria. Her project was funded by Battery Minerals. William Grant's Honours thesis was a geophysical analysis of the geometry of the dolerite intrusions on Bruny Island for hydrogen reservoir characterisation. His project was funded by Hobart-based MRT and the Institute for Mining Seismology (IMS).

Honours coursework program – VIEPS

In 2024, CODES offered two short courses as part of the Victorian Institute of Earth and Planetary Sciences (VIEPS) Honours coursework program. This program is attended by CODES and Victorian Honours students.

EXPLORATION FIELD SKILLS MAPPING CAMP **Course leaders: Rob Scott, Sebastien Meffre, Sheree Armistead**

This course was followed by seven of our Honours students and 15 VIEPS students from Victoria. It provides participants with the opportunity to develop or enhance existing skills in geological mapping, core logging and structural analysis, within a mineral exploration context. Students map and interpret a ca. 5 km² area in the mineralised Cambrian Mount Read Volcanics. Prior to travelling to Tasmania's West Coast participants spent a day examining drill cores from the mapping area at MRT's core storage facility in Hobart. HyLogger data for the drill cores provides important insights into the nature and extent of hydrothermal alteration affecting the rock sequence exposed in the study area. Insights from drill core coupled with an analysis of data collected during the fieldwork, provide the basis for the students' assessment of the future exploration potential of the study area.

ENVIRONMENTAL GEOLOGY
FIELD TECHNIQUES

Course leaders: Matthew Cracknell, Owen Missen

Twenty-one Honours, Masters and PhD students from Victoria participated in a four-day environmental geology field course that ran in early September 2024. The course started with one day of lectures and field practicals at CODES. Students then conducted three days of fieldwork at various sites of environmental geology interest in the Queenstown–Strahan area in western Tasmania. The trip included a site visit to the Mount Lyell mine to discuss the past and current environmental management strategies. Students were given the chance to investigate tailings-rich sediments on the King River. This was followed by collection of water samples and in-field water chemistry measurements (pH, conductivity) along the Queen River system across Queenstown to examine a system heavily impacted by mine drainage. Once back at CODES, the water samples were analysed by ICP-MS to determine their metal concentrations. These data contribute to a longitudinal study of Queen River water quality that has been running for almost 25 years, with the results published in Nascimento et al. (2023) in *Mine Water and the Environment*, 42: p. 399–417. Students were assessed based on several assignments related to the visits to the mine site, sediment banks, King River delta and water chemistry.

Honours skills workshops

As in previous years, Honours students attended a number of workshops covering software programs and communication skills.



CODES PhD student Poliana Vidal Salgado (right) and Luis Miguel Cuadri, from Sandfire-MATSA, checking rhyolite outcrops in the Magdalena VHMS deposit area, Spain – Poliana’s study site.

► **LOOKING FORWARD**

2025 should be a wonderful year for postgraduate student training and fieldwork opportunities with the postgraduate SEG trip to China in July 2025, and the SEG conference being held in September 2025 in Brisbane. Jessica Askew will join us to undertake her PhD in 2025, and the successful outcomes of an ARC Future Fellowship to Associate Professor Rebecca Carey and ARC DECRA to Dr Sheree Armistead will recruit at least three further postgraduate students.

Through our world-class research training programs, CODES is committed to equipping the next generation of geoscientists with the skills, knowledge and experience needed to address the pressing challenges of our time. Our students are being prepared to lead in both research and industry – advancing responsible mineral exploration and ensuring that geoscience continues to play a vital role in building a more sustainable and equitable future. As the global demand for critical minerals grows, these future geoscientists will be at the forefront of discovery, processing and environmental remediation – driving innovation for the resources essential to clean energy technologies, computing infrastructure and sustainable development. Their work will directly support Australia’s and the world’s efforts to meet ambitious sustainability targets, while also helping to close the significant skills gap in the geoscience workforce.

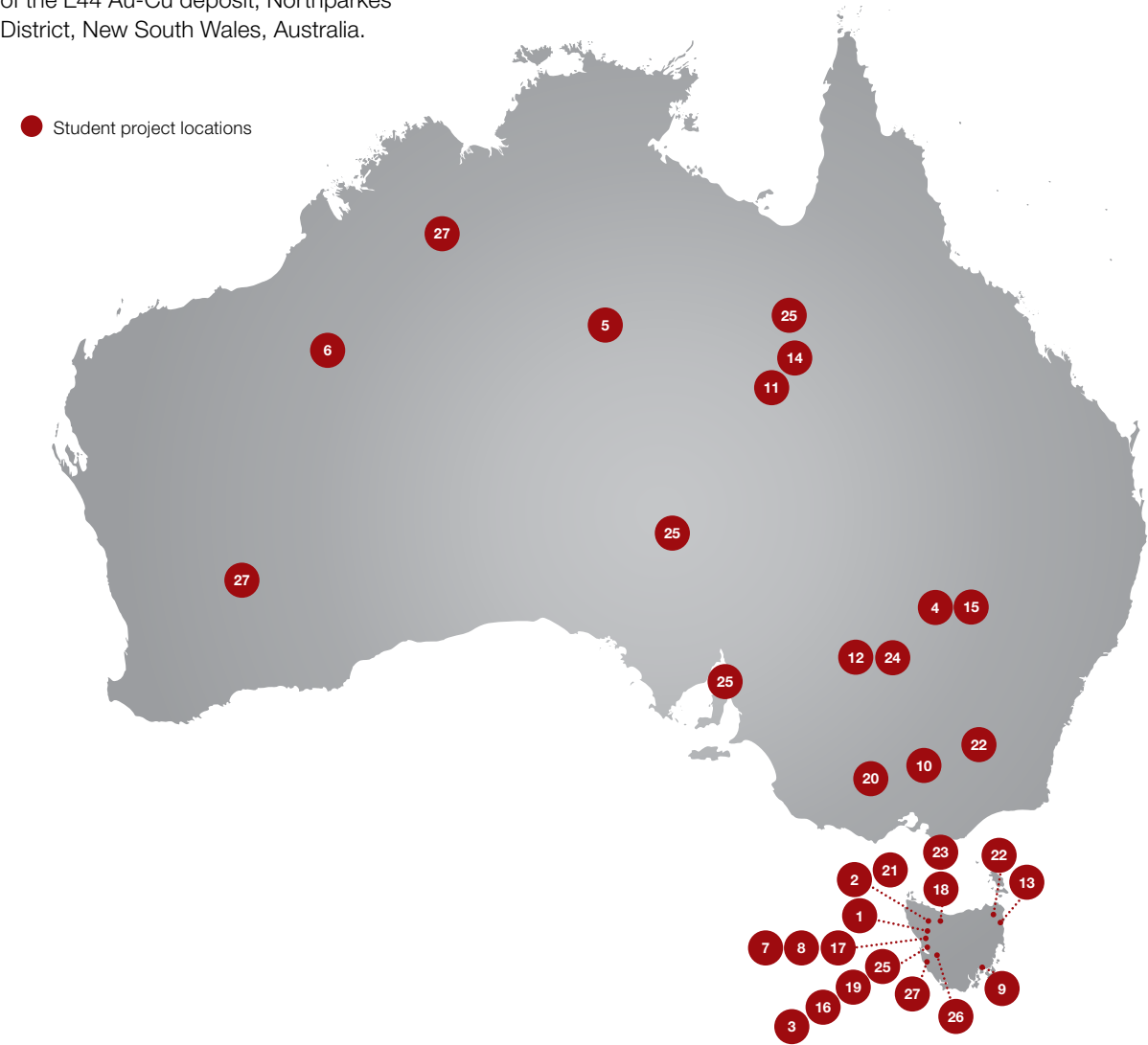
Student projects

IN AUSTRALIA

Project locations are shown in capitals. Unless marked otherwise, student projects shown here are PhDs.

- 1. Allen, Christopher. TAS**
Optimising remediation of legacy mines – mineralogical controls on long-term waste rock weathering and mine drainage.
- 2. Appiah, Alfredtina. TAS**
Pathways to production: Magnesite deposits at Prospect Ridge, northwestern Tasmania.
- 3. Barillas Diaz, José. TAS**
Atypical nickel mineralization in metasomatic rocks – The Avebury Ni deposit, Western Tasmania.
- 4. Beas, Billy. NSW**
Orebody knowledge, halogen deportment and vectoring implications of the E44 Au-Cu deposit, Northparkes District, New South Wales, Australia.
- 5. Braize, Damian. NT**
Mineral chemistry and geochronology of the Tennant Creek IOCG deposits.
- 6. Brown, Isaac. WA**
Geology, geochemistry and genesis of the Haverton gold-copper deposit, Paterson Province, Western Australia.
- 7. da Cruz, Vinicius. TAS**
Characterisation of the complex orebodies in the Rosebery Middle Mine: implications for ore processing and mineral exploration.
- 8. Gil Rodriguez, Javier. TAS**
Characterisation of skarn-type deposits: Renison Bell Sn deposit.
- 9. Grant, William. TAS (Honours)**
Geophysical investigation into the geometry of dolerite intrusions of North Bruny Island, Tasmania.

- 10. Greene, Joshua. VIC (Masters)**
The geological and geochemical fingerprinting of high-grade gold mineralisation in the Shepherd deposit, Costerfield, Victoria.
- 11. Hohl, Max. QLD**
Defining the mineral chemistry footprints of the Starra iron oxide-copper gold deposits in northwest Queensland.
- 12. Ila’ava, Malai. NSW**
Cambro-Ordovician volcanic facies, stratigraphy, and geochemistry of the Cowal Igneous Complex, New South Wales, Australia.
- 13. Jones, Colin. TAS**
The petrogenesis of the Devonian granites of the East Tasmania Terrane.



14. **Jones, Lucy.**
QLD (Masters)

Characterisation of ore textures at Cannington Mine by Automated Mineral Analysis and implications for processing.

15. **Jones, Rhiannon.** NSW

The significance of phyllic alteration at the E26 porphyry Cu-Au deposit, NSW, Australia.

16. **Le’Gallais, Bridie.** TAS

The tectonic significance of mafic/ultra mafic igneous rocks in western Tasmania.

17. **Mondal, Pratichee.** TAS

Critical metal potential in the Savage River magnetite deposit, northwest Tasmania.

18. **Musa, Emmanuel Dogara.**
TAS

Pathways to production for critical metals: Kara W deposit, western Tasmania.

19. **Naimbale, Nelao**
Natukondje. TAS

Characterisation of the Heemskirk tin project.

20. **Purdom, Sarah.**
VIC (Honours)

Genesis of a possible IRGS deposit near Stawell, Victoria.

21. **Santos Costa, Angela**
Isaura. TAS

Characterisation of tungsten mineralisation at Grassy, King Island, Tasmania: Implications for magmatic-hydrothermal sources, ore genesis, and exploration.

22. **Schaap, Thomas.**
TAS, NSW, VIC

Tectonic evolution of the early Palaeozoic Lachlan Orogen.

23. **Schaumburg, Henry.**
TAS (Masters)

The Kara Fe-W skarn: A mineral chemistry and age dating study to better determine controls on skarn formation.

24. **Staubmann, Markus.** NSW

Geology, geochemistry, and geometallurgy of the GRE46 epithermal gold deposit, Cowal District, NSW.

25. **Yu, Shouchun.**
QLD, SA, TAS

Mineral geochemistry of IOCG deposits.

26. **Yurdakul, Emrecan.** TAS

Orebody knowledge of the Western Tharsis Cu-Au deposit, Tasmania: implications for ore processing and mineral exploration.

27. **Zivkovic, Zebedee.**
TAS, WA

Trace element systematics in whole rock analysis of magmatic-hydrothermal ore deposits.

OUTSIDE AUSTRALIA

Project locations are shown in capitals. Unless marked otherwise, student projects shown here are PhDs.

1. **Atanga, Fuseini.** GHANA

Deposit characterisation and exploration vectors for the Akyem orogenic gold deposit, Ghana.

2. **Ball, Ashleigh.**
CHILE (Masters)

Geology, structural control and exploration implications of Au mineralized Fenix gold project, Maricunga Belt, Chile.

3. **Brown, Catherine.**
ICELAND

Volcano rock properties.

4. **Cima, Axel.**
INDONESIA, USA

Microinclusions in porphyry Cu deposits.

5. **Clark, Acacia.**
NEW ZEALAND, GREECE

Dynamics of subaerial silicic explosive volcanism: The 1315 CE Kaharoa eruption and the Late Bronze Age eruption of Santorini.

6. **Coaquira, Takeshy.** USA

Mineral chemistry tools for targeting copper porphyry deposits a case study of the supergiant high-grade Resolution Cu-Mo deposit, Arizona.

7. **Cuadra Amaro, Francisco.**
SWEDEN

Nautanen IOCG Deposit: Geometallurgical program.

8. **Evinemi, Isaac.** CHILE

Mineralogical domaining and predictive modelling of porphyry copper deposits using deep learning approach.

9. **Farrar, Alex.**
PERU, CHILE, ARGENTINA

Tectonic and structural controls on the spatio-temporal distribution of giant porphyry copper deposits in the Central Andes.

10. **Frey, Shannon.**
NEW ZEALAND

Behaviour of submarine caldera-forming silicic eruptions in the Kermadec arc, New Zealand.



11. **Lit, Catherine.**
NEW ZEALAND

Tephra geochemical fingerprinting.

12. **Merrill, Javier.** CHILE

Quantification of mineral texture for geometallurgical predictive modelling.

13. **Moore, Hannah.**
NEW ZEALAND

Reconstructing eruption and transport processes of the 1886 basaltic Plinian eruption at Tarawera volcano, New Zealand.

14. **Osorio, Jaime.** CHILE

Anatomy of the porphyry-epithermal transition in the Valeriano Cu-Au deposit, Chile.

15. **Pimentel, Giovana.**
SOUTH AFRICA

Rock characterisation of Platreef Style PGE mineralisation.

16. **Ponyalou, Olive.** PNG

Geology, genesis, and exploration significance of Cu-Au veins and altered rocks in the Kainantu Cu-Au district, PNG.

17. **Seow, Xin Ni.**
SOUTH KOREA, USA

Genesis, geochemistry and spectral characteristics of alunite supergroup minerals: Implications in lithocap and porphyry explorations.

18. **Smyk, Emily.** USA

Geology, geochemistry, geochronology and exploration footprints of the Christmas porphyry Cu-Mo deposit, Arizona.

19. **Sritangsirikul, Peerapong.**
MAINLAND SE ASIA

Tectonic evolution and related mineral deposits of mainland SE Asia: Insights from geochemistry and geochronology of zircons.

20. **Sun, Yi.** PHILIPPINES

Geology of the Quartz – Pyrite – Gold (QPG) mineralization and the new model of the Mankayan District, Northern Luzon, Philippines.

21. **Torres Pacheco, Victor.**
PERU

Geology, genesis, and geometallurgy of Cu-Au-Ag mineralized tourmaline breccia pipes at Soledad, central Peru.

22. **Vidal Salgado, Poliana.**
SPAIN

Characterization and paragenesis of the Magdalena VHMS Deposit, Iberian Pyrite Belt, Spain.



CODES PhD student Nelao Natukondje Naimbale (far left) runs an Early Career Researcher Day session at the SEG 2024 Conference in Windhoek, Namibia.

Lab-based projects

Cooke, Stephen.

Pathways to mineral discoveries through computer-based modelling of geochemical data.

Lounejeva, Elena.

Trace element geochemistry of pyrite in sediments across the Permian Triassic boundary.

Sahu, Arka.

Method development for quantitative prediction of mineralogy, mineral chemistry, and proximity to orebody in porphyry deposits from near-infrared spectral data: Case studies from El Teniente (Chile), and Batu Hijau (Indonesia).

Society of Economic Geologists (SEG) Student Chapter

The CODES SEG Student Chapter at the University of Tasmania is a branch of the Society of Economic Geologists. We are dedicated to fostering an inclusive and collaborative social fabric within the geosciences research community, with a focus on engagement between students and industry. We pride ourselves on making significant contributions to the social and professional lives of students from a diverse range of backgrounds and cultures.

In 2024, CODES welcomed PhD students from several countries, including Brazil and France. Many of these students joined the SEG Student

Chapter as a way to integrate into the CODES community and expand their professional and social networks.

The newly elected committee for 2024 included PhD students Fuseini Atanga (Secretary) and Giovana Oliveira (Treasurer). Axel Cima was re-elected as President, and Arka Sahu as Vice President. The outgoing committee members, Bryce de Hahn (Secretary), and Yvette Chan (Treasurer), are thanked for their tremendous efforts over the previous year.

Field trip

Report by CODES SEG Student Chapter 2024 President, Axel Cima

The highlight of 2024 was the international field trip to Japan, organised by the CODES SEG Student Chapter. This trip was an unforgettable experience that significantly enriched our understanding of geology, exploration and Japanese culture. A group of 11 students, led by Professor David Cooke, alongside

seven industry participants from Newmont, Gold Road, AngloGold Ashanti and Lakeside Minerals, explored the diverse geological wonders of Kyushu Island and the Akita region in northern Honshu.

In Kyushu, Dr Mizuki Ishida from the Natural History Museum (UK), along with Dr Akane Ito and Professor Kotaro Yonezu from Kyushu University, helped organise this leg of the trip. We began our trip at Kyushu University, meeting the local SEG Student Chapter and participating in introductory talks and lectures. Highlights included visits to Kagoshima volcano, Kirishima geothermal pools, the Aso Caldera and associated limonite deposits. We also explored a low-sulfidation epithermal target in the Hishikari district and visited two high-sulfidation epithermal mines in southern Kyushu. We toured a geothermal power plant and an earthquake museum, gaining insights into Japan's natural hazards and the use of geothermal energy.

A unique cultural experience was our visit to a shochu and sake brewery in an historic underground gold mine, as well as sandbathing in geothermally heated sands.

The Akita leg of the trip, hosted by Professor Andrea Agangi from Akita University, provided further geological insights. We attended a lecture by Professor Yasushi Watanabe and interacted with students from the SEG Akita Student Chapter. This part of the trip focused on the geological successions where Kuroko deposits were first described, with visits to abandoned deposits and active geothermal fields featuring fumaroles and mud pools. Professor David Cooke's participation throughout the trip was invaluable, offering critical insights into the geothermal and epithermal environments we encountered.

This exceptional experience was made possible through the support of the SEG Student Chapter committee and co-organisers Vinicius da Cruz, Arka Sahu and Jaime Osorio. We are deeply grateful to our Platinum Sponsor, Newmont Australia Ltd, the SEG Wallace Fund, and all industry participants for their financial backing.

Networking and social events

The Chapter actively co-hosted multiple BBQs, serving the dual purpose of generating funds to support SEG activities and providing opportunities for students to socialise. We continued our tradition of hosting BBQs during Amira Sponsors' Review Meetings in July and December, which facilitated interactions with industry representatives from some of the world's most prominent mining companies.

We also hosted recruitment sessions featuring Evolution Mining's Manager of Geoscience, Ned Howard, followed by networking BBQs.



Members of the CODES SEG Student Chapter pictured during the Critical and Strategic Metals Symposium held at CODES in July 2024. They are (L-R): PhD students Alfredina Appiah, Vinicius da Cruz and Pratichee Mondal.

Talks and workshops

Given that most of our efforts in 2024 were focused on organising the Japan field trip, our participation in additional events was limited. As mentioned, we actively contributed to CODES events, such as the Amira Sponsors' Review Meetings, where we facilitated student engagement with industry experts. Additionally, we played a role in organising the CODES Critical and Strategic Metals Symposium in July, which brought together over 100 researchers and industry professionals from Australia, New Zealand and North America.

Throughout the year, the SEG Student Chapter was also responsible for coordinating the weekly CODES seminars, featuring renowned speakers in economic geology and geochemistry, as well as presentations from our own research team.

Finances and fundraising

The Chapter continued to operate using accumulated funds from previous fundraising efforts. We successfully secured a grant from the SEG Stewart R. Wallace Fund in 2024, which significantly contributed to the funding of the Japan field trip. Additionally, we maintained our fundraising activities by selling geological field equipment, such as hammers and hand lenses, introducing new students to the Chapter in the process.

Future plans

Following the success of the Japan field trip, the Student Chapter set its objectives for 2025 at our AGM in October 2024, when a new committee was elected, as both the President and Vice President concluded their two-year terms. The new elected President (Damian Braize) and Vice President (Poliana Vidal Salgado) will keep working alongside Fuseini Atanga and Giovana Oliveira with the aim of organising another international trip, in conjunction with Colorado School of Mines SEG Student Chapter, where staff from both universities in addition to Hefei University will have us visiting China in mid-2025. Most of the efforts and fundraising activities will be directed to the organisation of this field trip.



The CODES SEG Student Chapter ran a successful study trip to Japan in September 2024 visiting many areas of geological interest, interacting with students from the universities of Kyushu and Akita, and experiencing some of Japan's cultural traditions.

▼

Professor David Cooke's participation throughout the trip was invaluable, offering critical insights into the geothermal and epithermal environments we encountered.

Outreach and media

Outreach was once again an important activity for the team at CODES/Earth Sciences, and 2024 included more visits to schools and community events as well as visits by students to the geology facilities at the Sandy Bay campus.

Below is just a selection of the many educational outreach events that took place during the year. Once again, we extend our thanks to the students and staff who took time out of their weekends and study time to talk to groups ranging from Year 1 primary school students to the silver-haired senior members of the community.

Agfest

Four CODES PhD students hosted the CODES/Earth Sciences booth at Agfest 2024 at Carrick in northern Tasmania. Chris Allen, Markus Staubmann, Axel Cima and Pratiche Mondal did a great job in engaging with around 1,000 attendees over the three days of the event (2–4 May). The sandpit was a great drawcard, and many young people were keen to find the trilobites hidden within it.

Beer Aquatic

This series of talks at the Hobart Brewing Company is proving very popular. On 27 February Associate



Digging for trilobites was a popular choice at the Earth Sciences/CODES booth during the 2024 Agfest event, held at Carrick, northern Tasmania, from 2 to 4 April.

Professor Rebecca Carey gave a presentation titled 'The peaks and troughs of submarine volcanoes' with a very healthy turnout of 150 attendees.

Festival of Bright Ideas

This now-annual science festival was held on 16 and 17 of August down on the Princes Wharf in Hobart with two CODES PhD students (Damian Braize

and Poliana Vidal Salgado) and two Earth Sciences students assisting with the UTAS Earth Sciences stall. A large turnout saw around 1,000 people pass by the stall keeping the stallholders busy on both days.

Galley Museum Open Day

The Galley Museum in Queenstown on Tasmania's West Coast held an Open Day in April. Dr Owen Missen from



The Galley Museum Open Day was held in Queenstown during April 2024 and attracted a large number of families to the event; Dr Owen Missen oversaw the CODES/ES stall.

CODES/ES and Belinda Martin along with Jane Hall-Dadson and Jesse Brennan looked after the Earth Sciences stall. They were pleased to welcome around 150 visitors, who were mainly school students. CODES Rock Curator Izzy von Lichten assisted by loaning the impressive Tasmanian rock samples on display for the day. Owen's enthusiastic stewardship of the stall enabled visitors to gain an insight into the research work that CODES and Earth Sciences do, and why it is important.

It Takes a Spark! STEM Conference

The 2024 iteration of this event took place in November at Launceston Church Grammar School and CODES was represented by Dr Francisco Testa and PhD student Damian Braize. The idea is to bring together students, teachers and inspiring industry role models to engender an interest in STEM-based careers. Francisco said: 'We spoke to students on various topics, including what minerals are and how rocks are formed. We also explained the rock cycle and introduced them to basic tools for identifying different minerals using hand lenses and even microscopes. They were very excited about it! I also showed them some Darwin glass samples from northwest Tasmania and explained what tektites are and how they form.' The students ranged in age from as young as six to about 17.



The Festival of Bright Ideas, held down on the Hobart waterfront at Princes Wharf in mid-August, was well-attended by people of all ages. Here CODES PhD students Damian Braize and Poliana Vidal Salgado show off some of the important rock specimens loaned by CODES Rock Curator Izzy von Lichten for the event.



CODES PhD student Damian Braize (left) and staff member Dr Francisco Testa explain to students the many types of precious stones during the It Takes a Spark! STEM Conference held at the Launceston Church Grammar School in November 2024.

Mini MakerX

Professor Sebastien Meffre took part in this National Science Week event run by UTAS at Burnie on the Cradle Coast campus on 25 August. Mini MakerX is a one-day expo which aimed to raise awareness of STEM activities in the community and promote interest in UTAS’s strong STEM offerings. There were plenty of hands-on events for all ages and around 550 visitors attended.

School visit and trips

In 2024 CODES/Earth Sciences continued its program of educational visits with staff and PhD students travelling to schools and colleges across the state. CODES/Earth Sciences also hosted a number of school groups for tours of the geology facilities on the Sandy Bay campus. In an online UTAS news article, Professor Sebastien Meffre said this type of outreach is important to ‘provide visibility for the BSc and to encourage high school students into taking science, technology and maths subjects at school by highlighting the current demand for university-trained science graduates in the workforce’.

Among the many educational visits to schools and colleges across Tasmania that took place were:

- 22 February: Professor Sebastien Meffre visited the Zeehan Primary School and gave a presentation titled ‘What are the Earth Sciences?’ to students from years 1–6.
- 7 June: Professor Sebastien Meffre, Angelica Matusiewicz and George Hamaty took students from The Friends School in Year 3 on an expedition to Lower Sandy Bay to look at fossils and also to look at rocks under the microscope back at the UTAS Sandy Bay campus.



The UTAS Sandy Bay campus Open Day in mid-September provided budding young geologists with the opportunity to try their hand at gold panning. Here Professor Sebastien Meffre shows two of them the correct technique for using the panning sieves.

- 12 June: Professor Sebastien Meffre took part in the Hobart College Careers Expo, which had around 500 attendees.
- 24–26 June: PhD student Zeb Zivkovic led a geology excursion to Sandy Bay with a total of 75 students from Mt Carmel School.

Science in the Pub

To celebrate the beginning of what the organisers call ‘the dark season’ in Tasmania a trio of talks were held at the Deep South Brewing Co in North Hobart on 13 June 2024. These talks showcased research that ‘happens in deep places’. Dr Mohammad Fathi from CODES gave a talk entitled ‘Beneficiation of Critical Minerals: Pathways and Challenges’ to a gathered audience of around 50 people.

Science Meets Parliament

In August 2024 Dr Sheree Armistead was a guest speaker at this dinner event, which has been part of National Science Week in Tasmania since 2006 at Tasmania’s Parliament House.

Sheree talked briefly about her research in Madagascar, India and Canada prior to joining CODES/Earth Sciences at UTAS, and then went on to discuss her current research into ore deposits in central Africa, which are the second largest source of Cu and the largest source of Co in the world. She also talked about her research into the mineral potential of northwest Tasmania and collaborative work with Mineral Resources Tasmania and Geoscience Australia.

Society of Economic Geologists (SEG)

Staff and students at CODES play a big role in the SEG activities within Tasmania, and often give talks locally. In 2024 CODES PhD student Poliana Vidal Salgado and former CODES PhD student Dr Victor Torres took part in a national webinar discussion titled: ‘Developing a career in economic geology: how to begin, enjoy, and succeed in the economic geology journey’. The session was moderated by CODES PhD student Angela Costa, and can be viewed on the SEG YouTube channel: <https://youtu.be/xE-BdoctUVU>

Strahan Primary School Field Excursion

CODES Lecturer in Environmental Geology, Dr Owen Misssen, and PhD student Pratiche Mondal braved the elements on Tasmania’s West Coast during August to demonstrate water quality testing to a class of Strahan Primary School students. This event was organised by Belinda Martin, the UTAS Regional Learning Officer (West Coast), in conjunction with the Cradle Coast Authority (CCA). The students learnt a lot and, according to Jason Cullen from CCA: ‘It was wonderful to see all the primary school students so engaged with the water quality testing and similarly how knowledgeable and enthusiastic they are about the aquatic life in the local waterways.’

The Royal Society of Tasmania

In September 2024 Dr Matthew Cracknell gave a talk to the Royal Society on the topic of ‘Artificial Intelligence for society and science – why should you care?’; see <https://rst.org.au/view-recording-dr-matthew-cracknell-sep-2024/>

UTAS Open Day 2024

Professor Sebastien Meffre was one of the movers and shakers for the UTAS Open Day, which took place on 15 September in 2024. A gold panning activity was held for younger members of the community and a stall was hosted by students.

Zeehan Mineral Fair

This year’s event was held on 10–11 November and was facilitated by Professor Sebastien Meffre.

Media

A selection of media involving CODES/Earth Sciences staff and students in 2024:

RADIO/PODCASTS

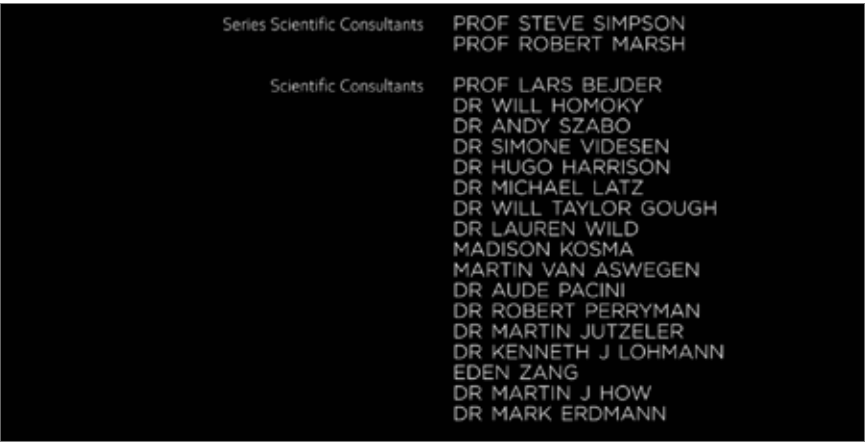
- In February, Associate Professor Rebecca Carey gave an interview with ABC Radio Hobart about her talk on submarine volcanoes at the Beer Aquatic event.
- In March 2024, CODES PhD student Hannah Moore interviewed staff members from CODES for a ‘Geoscience Miniseries’ on *That’s What I Call Science!*, a volunteer-run radio show and podcast that Hannah co-produces. She chatted with Izzy Von Lichten, Owen Misssen, Sheree Armistead and Indrani Mukherjee (formerly CODES). Hannah adds: ‘In these episodes, we chat about how they got into their field, take a deep dive into the work they’re doing now, and hear about their hopes for the future. The podcast episodes can be found on podcast streaming services. The episodes were also each played twice on Edge radio, Hobart’s premium youth station’.
- On 16 July 2024, Dr Francisco Testa did an interview with Leon Delaney on the program *Talking Canberra*, broadcast nationally by 2CC Radio Canberra. He talked to Leon about what has been learned about Earth from meteorites and comets.

ONLINE

Dr Francisco Testa wrote several articles for the online news/discussion forum called *The Conversation*, and these were also released online in Spanish. See, for example: ‘Interactive: What Earth’s 4.54 billion-year history would look like in a single year’ at <https://theconversation.com/interactive-what-earths-4-54-billion-year-history-would-look-like-in-a-single-year-245373>

TELEVISION

Dr Martin Jutzeler was a Scientific Consultant for *Pacific Ocean*, the first in a series of five episodes of the Netflix documentary called *Our Oceans*, narrated by Barack Obama. The episode for which Martin was a consultant was released on 24 November 2024. See: <https://www.netflix.com/au/title/81139969>



Dr Martin Jutzeler was a Scientific Consultant for the Netflix series called *Our Oceans*, which started screening in December 2024, and was narrated by Barack Obama.



CODES PhD student Hannah Moore co-produces a podcast called *That’s What I Call Science!* and in March 2024 interviewed several CODES staff to get their take on why they love geology. Hannah has since graduated from CODES and has gone on to great things in WA.



Panellists in the SEG webinar discussion about starting out in a career in geology that took place in June 2024 included CODES PhD students Poliana Vidal Salgado and Victor Torres Pacheco. The event was hosted by another CODES PhD student, Angela Costa.



Dr Francisco Testa regularly writes articles for the online news/research forum The Conversation and this screenshot shows one of his 2024 pieces.

Industry links



Professor David Cooke running a workshop for staff from Rio Tinto – one of CODES' longstanding Industry Partners – in December 2024 at the CODES facilities on the UTAS Sandy Bay campus.

► OBJECTIVES

- To be a research focus for the national and international minerals industry.
- Strategically collaborate with other top-level national and international research groups in the field of ore deposits, mineral exploration technologies and mineral processing.

CODES is recognised as a world leader in industry-linked, collaborative ore deposit research. Strong relationships have been developed with a range of industry partners and researchers who invest in, support and contribute to research projects. Fostering and growing these national and international collaborations is a key strategic focus.

Industry links and synergies

CODES has strong, enduring and mutually beneficial links with a group of major Australian and international mining companies. These links have been and continue to be critical for

funding CODES' research, and for technology transfer to the mining and mineral exploration community. In 2024, the group of CODES' Industry Partners comprised of six Australian and international mining companies: Anglo American, AngloGold Ashanti, First Quantum Minerals, Mount Isa Mines (Glencore), Newcrest Mining and Rio Tinto.

Partner companies have been providing support of up to \$60,000 in cash per year to the core research budget of the Centre. Gold and Platinum Partners are also offered a seat on the CODES Advisory Board, which meets at least annually to discuss the strategic direction of the Centre.

Representatives of these companies are invited to the CODES Annual Review, along with other government and university researchers. The Annual Review showcases the breadth of research undertaken at the Centre through a day of oral and poster presentations for our stakeholders and offers the opportunity to influence future research directions. In 2024 there was again no Annual Review in order to mitigate ongoing workload issues.

Industry partnership opportunities

CODES offers partnership opportunities aligned to the evolving needs of mining companies. The minerals industry is cyclical by nature, and operating conditions can vary greatly from one year to the next, often through unforeseen circumstances. For this reason, our partnership opportunities are offered on an annual basis, giving partners the flexibility to adjust their involvement in line with their current operating conditions and research requirements.

Funding levels are tailored to suit all levels of operation, from junior explorers through to the large multinationals. Companies may sign up at the Silver (\$20K), Gold (\$40K) or Platinum (\$60K) level, depending on their planned level of involvement with the Centre. Benefits of a partnership agreement vary depending on the level of investment, but include enhanced prospects of discoveries, optimisation of existing reserves, first call on geoscience graduates, and access to a world-class research team and state-of-the-art facilities. Further details can be found at: <https://www.utas.edu.au/codes/about-us/industry-partnership-program>



Three of the speakers at the CODES Critical and Strategic Metals Symposium, which was held in July 2024 on the Sandy Bay campus. Pictured in the CODES offices, they are (L-R): Dr Ignacio Gonzalez-Alvarez (CSIRO), Dr Carmen Krapf (Geological Survey of South Australia) and Dr Simon Jowitt (University of Nevada, Reno).

Role of Amira Global

Amira Global plays a vital role in facilitating the funding of collaborative research involving university research groups and the minerals industry. Amira funds projects within the Centre, which run over a period of one to five years. In 2024 it continued to fund the five-year project – Amira P1249 'Exploring, characterising, and optimising complex orebodies – upscaling orebody knowledge to add value across the mining value chain'.

Research collaborations

In 2024, CODES continued its reputation for cultivating research collaborations with other Australian and international research organisations. Throughout the year, collaborative research was conducted with 56 international and 17 national organisations.

Our partnership opportunities are offered on an annual basis, giving partners the flexibility to adjust their involvement in line with their current operating conditions and research requirements.

CODES Industry Partners 2024

PLATINUM



GOLD



SILVER



Technology transfer

► OBJECTIVES

- Involve end-users (exploration and mining companies) in research planning, research evaluation and research adoption.
- Promote technology transfer so that innovative research outcomes are accessible to end-users.
- Comply with the national principles of intellectual property management for publicly funded research.



Dr David Selley gives a history lesson: One of the more light-hearted moments from the Critical and Strategic Metals Symposium organised by CODES and held in July 2024.

Technology transfer activities

CODES undertakes strategic and applied research into ore deposits (characterisation and context) and geometalurgy, and the development of innovative enabling technologies to support these research endeavours.

These initiatives create knowledge, processes, methods and solutions for the minerals industry and ore deposit researchers – locally, nationally and internationally. Research results and technical developments in the applied research programs are transferred to end-users via regular research meetings, research reports, monographs, books, digital presentations and software packages, where appropriate. In 2024, a total of 194 research reports were presented

to industry clients. Meetings were also held to present and discuss progress and adoption of research results.

Projects that delivered significant technology transfer objectives during 2024 included:

- The Amira P1249 research project conducted a series of technology transfer workshops in conjunction with its biannual sponsors review meetings. In 2024 the P1249 project hosted workshops at CODES on the application of the mineral co-occurrence probability field (MCOPF) workflow, and navigating telescoped porphyry – HS epithermal systems using the Resolution porphyry Cu-Mo deposit as a case study.
- Dr Matt Cracknell delivered a mineral texture clustering technology transfer workshop for Amira P1249 sponsors

attending the SRM 5 in June 2024. The workshop was attended by ~12 industry sponsors and CODES researchers. It provided participants with a workflow and python code to run and evaluate the mineral texture clustering algorithm initially developed as part of the Amira P1202 project.

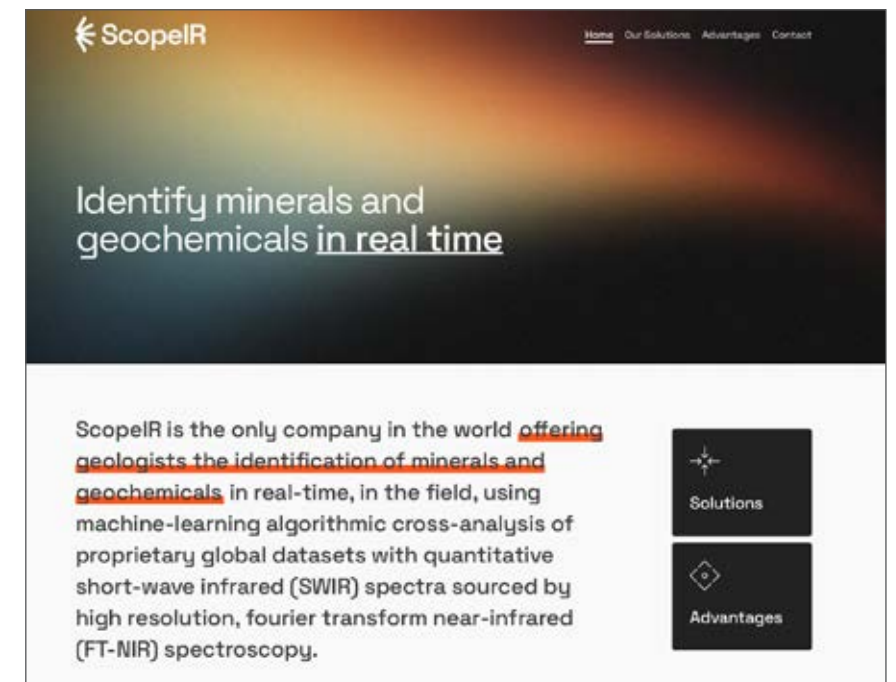
- A project update workshop for Amira P1249 sponsors was held in conjunction with the IAGS 2024 conference in Adelaide in October. This was attended by ~10 industry people, mostly from Newmont. The workshop covered the overall aims and recent achievements of the Amira P1249 project, specifically highlighting significant PhD research outcomes.
- CODES and the CSL, with support from the UTAS InVent team, launched ScopelIR, a cutting-edge spectral interpretation platform that combines high-resolution FT-NIR and FT-IR data with machine learning to deliver quantitative mineralogical and geochemical results for the minerals industry.

Publications targeted at end-users

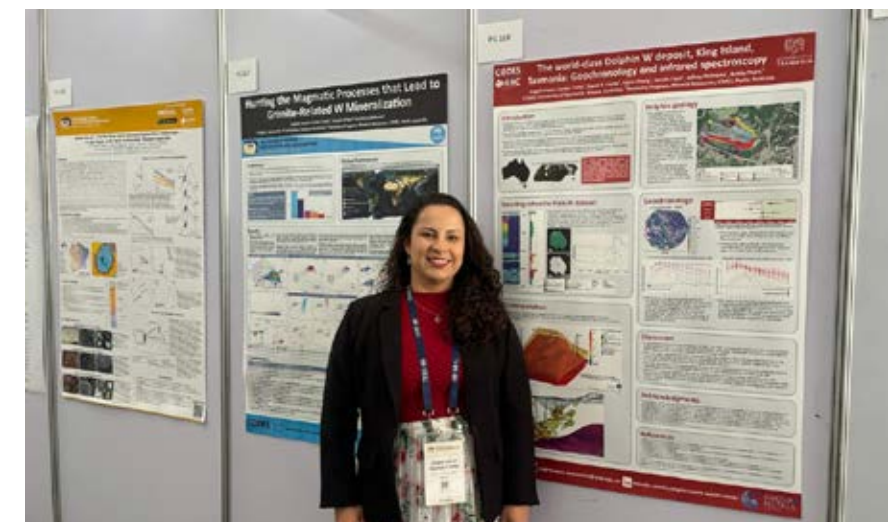
CODES also delivers knowledge and applications to end-users and the wider scientific community through a selection of special publications that represent the culmination of major research efforts by the Centre's staff.

The following publications were sold during 2024:

- *Altered volcanic rocks: A guide to description and interpretation (2005)*. Authors: C. Gifkins, W. Herrmann and R. Large (24 copies).
- *Basins, fluids and Zn-Pb ores (1998)*. Editors: O. Holm, J. Pongratz, P. McGoldrick (3 copies).
- *Geophysical signatures of copper-gold porphyry and epithermal gold deposits, and implications for exploration (2011)*. Author: T. Hoschke (14 copies).
- *Giant ore deposits: Characteristics, genesis and exploration (2002)*. Editors: D.R. Cooke and J. Pongratz (1 copy – now out of stock).
- *The geology and origins of Australia's mineral deposits (2000)*. Authors: M. Solomon and D.I. Groves (2 copies).



Associate Professor Lejun Zhang and Associate Professor Thomas Rodemann (CSL) are the driving force behind a cutting-edge spectral interpretation platform called ScopelIR developed at CODES, which is now available for use by the minerals industry. This is the opening page of the ScopelIR website.



CODES PhD student Angela Costa at the 2024 SEG conference in Windhoek, Namibia, with her poster about her research into the Dolphin W deposit on King Island.

- *The geology of the Broken Hill Pb-Zn-Ag deposit, NSW, Australia (2006)*. Author: A. Webster (6 copies).
- *Volcanic textures: A guide to the interpretation of textures in volcanic rocks (1993)*. Authors: J. McPhie, M. Doyle and R. Allen (33 copies).

CODES-led short courses, workshops, conferences and field trips for end-users

In 2024 workshops and conferences, including the important and well-attended Critical and Strategic Metals Symposium organised by CODES in

July, continued to play a key role in the Centre's technology transfer activities. One continuing legacy of the COVID pandemic has been the preference for some participants to teach and learn online, meaning that online courses are now a permanent feature of CODES' offerings. During 2024 CODES organised a total of 21 technology transfer events.

Total attendance by industry geologists, academic researchers and postgraduate students was approximately 780 with 52 presenters, including PhD students and honoraries, from CODES involved in delivering the courses or leading the conferences or field trips.

2024 SHORT COURSES, WORKSHOPS, CONFERENCES AND FIELD TRIPS LED BY CODES

TITLE	PRESENTERS	NO.	LOCATION	DATE
Gold-rich porphyries and related deposits – characteristics and exploration strategies: short course, AME Roundup conference	David Cooke	200	Vancouver, Canada	25 January
Advanced Field Skills in Economic Geology (MEconGeol short course)	Mike Baker, Robert Scott, Emrecan Yurdakul, Lejun Zhang	7	Western, eastern and northeastern Tasmania	4–17 February
Exploration Field Skills Mapping Camp (VIEPS)	Robert Scott, Emrecan Yurdakul	4	Hobart/western Tasmania	4–11 February
Tasmanian tectonics, volcanology and ore deposits: short course for China University of Geosciences Beijing	Sheree Armistead, David Cooke, Wei Hong, Sebastien Meffre, Rob Scott, Lejun Zhang	9	Hobart and western Tasmania	16 February–1 March
Volcanology and Mineralisation in Volcanic Terrains (MEconGeol short course)	Rebecca Carey, David Cooke, Martin Jutzeler, Lejun Zhang	10	New Zealand and Tasmania	1–14 March
Tasmanides – Macquarie Arc workshop for Anglo Gold Ashanti	Tony Crawford, Dick Glen, Sebastien Meffre	15	Perth	25–26 March
Fundamentals of Economic Geology (MEconGeol short course)	Mike Baker, Tim Callaghan, David Cooke, Karsten Goemann, Scott Halley, Michael Roach, Thomas Rodemann, Sam Scher, Robert Scott, Francisco Testa, Noel White, Lejun Zhang	39	Online	8–13 April AND 6–10 May
Ore Deposit Models and Exploration Strategies (MEconGeol short course)	Mike Baker, Stuart Bull, Jonathan Cloutier, David Cooke, Kathy Ehrig, Alex Farrar, Scott Halley, Terry Hoschke, Ned Howard, Tim Ireland, Corey Jago, Ross Large, Adi Maryono, Cam McCuaig, Andrew McNeill, Jaime Osorio, Maria Rodriguez-Mustafa, Robert Scott, David Selley, Penny Sinclair, Jeff Steadman, Jeneta Wellard, Noel White, Lejun Zhang	61	CODES, online and in-person	3–8 June AND 8–12 July
Amira P1249 Sponsors’ Review Meeting 5	Mike Baker, Ivan Belousov, Damian Braize, Yamila Cajal, David Cooke, Stephen Cooke, Matthew Cracknell, Jason Dyer, Bright Foli, Scott Halley, Malai Ila’ava, Andrew Jenkins, Bridie Le’Gallais, Owen Missen, Paula Montoya, Jaime Osorio, Adam Pacey, Jose Piquer, Markus Staubmann, Nafiu Sulyman, Yi Sun, Chase Turner, Emrecan Yurdakul, Lejun Zhang	50	CODES	12–13 June
CODES Critical and Strategic Metals Symposium	Michael Anenburg, Sheree Armistead, Mike Baker, José Barillas, Stephen Barnes, Evgeniy Bastrakov, Steve Beresford, John Bishop, Phil Blevin, Yamila Cajal, Yanbo Cheng, David Cooke, Vinicius da Cruz, Kathy Ehrig, Arianne Ford, Denis Fougrouse, Ignacio González-Álvarez, Wei Hong, Simon Jowitt, Carmen Krapf, Ryan Manton, Adi Maryono, Owen Missen, Paula Montoya, Rachael Morgan, Indrani Mukherjee, Josh Phillips, Anthony Schofield, David Selley, Jeff Steadman, Lejun Zhang	134	CODES	10–12 July
Field trip to western Tasmania (post-symposium)	Sheree Armistead, David Cooke, Owen Missen, Paula Montoya, Emrecan Yurdakul	17	Western Tasmania	13–15 July
Environmental Geology Field Techniques (VIEPS)	Matthew Cracknell, Owen Missen	4	CODES, Hobart and western Tasmania	4–5 September

TITLE	PRESENTERS	NO.	LOCATION	DATE
CODES SEG Student Chapter Field Trip to Japan	Andrea Agangi, David Cooke, Mizuki Ishida, Akane Ito, Kotaro Yonezu	18	Japan	September
IAGS pre-conference workshop on IOCG deposits	Jeff Steadman	~40	Adelaide, SA	10–11 October
Porphyries, high sulfidation epithermal, lithocaps and related deposits – characteristics and explorations strategies: workshop for AGA	David Cooke, Jamie Osorio, Lejun Zhang	11	Nevada	21–25 October
Exploration in Brownfield Terrains (MEconGeol short course)	Matthew Cracknell, Wessley Edgar, Kim Frankcombe, Kate Hine, Terry Hoschke, Ned Howard, David Isles, Andrew McNeill, Chris Muller, Michael Roach, Robert Scott, Tony Webster, Jo Whelan, Lesley Wyborn, Zebedee Zivkovic	36	CODES (online)	28 October–2 November AND 18–22 November
Tasmanian Critical Metals Workshop & Research Update	Christopher Allen, Alfredtina Appiah, Sheree Armistead, José Barillas, Kim Beasy, Ivan Belousov, David Cooke, Angela Costa, Vinicius da Cruz, Musa Emmanuel Dogara, Mohammad Fathi, Sharon Fraser, Javier Gil Rodriguez, David Giles, Jane Hall-Dadson, Wei Hong, Julie Hunt, Ross Large, Owen Missen, Pratichee Mondal, Nelao Natukondje Naimbale, Thomas Rodemann, Jack Ward, Emrecan Yurdakul, Lejun Zhang	40	Tullah, western Tasmania	27 November
Volcanic Processes, Deposits, and Resources: Modern and Ancient	Rebecca Carey, Pat Hayman	18	Merimbula, NSW	1–7 December
Amira P1249 Sponsors’ Review Meeting 5	Fuseini Atanga, Mike Baker, Ivan Belousov, Yamila Cajal, Carlos Carrasco Godoy, Axel Cima, David Cooke, Stephen Cooke, Angela Costa, Matthew Cracknell, Jason Dyer, Isaac Evinemi, Mohammad Fathi, Wei Hong, Elena Lounejeva, Hayley McGilvray, Giovana Oliviera Pimentel, José Piquer, Thomas Rodemann, Arka Sahu, Chase Turner, Jack Ward, Lejun Zhang	53	CODES	6–7 December
Navigating porphyry mineral districts: workshop for Rio Tinto Exploration	David Cooke, Jaime Osorio, Lejun Zhang	9	CODES, Hobart	December
Porphyry Cu, Au and Mo deposits – characteristics and explorations strategies: workshop for Fortescue	David Cooke	12	Online	9 December

Performance indicators

PERFORMANCE MEASURES

	TARGET	2024
Research findings (CODES and Earth Sciences)		
Publications in international journals	50pa	41
Percentage of publications in high-quality international journals	70%	66%
Reports to industry collaborators	80pa	194
Special issues and/or research monographs	1 per 2 years	1
Invitations to give keynote conference presentations	10pa	4
Papers at national/international meetings	70pa	61
Research training and professional education		
Percentage of HDR students attracted from interstate	25%	13%
Percentage of HDR students attracted from overseas	65%	72%
Number of Honours students in CODES' programs	15	2
Number of HDR students in CODES' programs	50	47
Percentage of students in projects linking with industry	80%	76%
Professional short courses/workshops for industry	4pa	21
International, national and regional links and networks		
CODES' national or international conferences/workshops	1 per 2 years	2
Registrants at CODES' conferences/workshops	600pa	~780
End-user links		
Frequency of meetings with industry representatives	15pa	35+
National benefit		
CODES' research has input into a major mineral discovery	1 per 5 years	10 in 35 years

Opposite: Looking east from the Wetar mine camp at sunrise along the northern Wetar coastline, Indonesia (Photo: Owen Missen).

Finances

2024 income

Total CODES income was \$8.6 million (see Table 1). This was derived principally from UTAS (27%), Contracts/Consultancies/Revenue Raising (23%), and the combined income sources of the Regional Research Collaboration Project (22%) (see Figure 1). The main income streams over time are compared in Figure 2, showing an increase in overall income to CODES in 2024 when compared to 2023. This increase occurred across most categories including the Regional Research Collaboration, UTAS in the tuition fee waiver space, ARC funding via Discovery program projects and Fellowships, and increases in both the support of student projects, and the use of the CODES Analytical Laboratories.

Summary of the main income streams to CODES in 2024:

- **Host institution support:** Funding from UTAS in 2024 was \$2.3 million, up from \$2.2 million in 2023, attributable to an increase in PhD tuition fee scholarship funding from central sources. UTAS funding relates primarily to research salaries, PhD scholarships and income earned by the Centre from research output.
- **Contracts/consultancies/revenue raising:** Combined funding of \$2 million comprises funding related to Short Courses (\$144k), Analytical Services (\$1.8 million) and Book Sales (\$12k).

- **Regional Research Collaboration Project:** The combined income sources for the RRC amounted to \$1.9 million in 2024, comprising of funding from the Department of Education (\$1.8 million) and interest (\$78k).



TABLE 1: CASH INCOME FINANCIAL STATEMENT 2024

ARC Grants

Discovery Grants (incl Fellowships)	311,804
	311,804

Regional Research Collaboration – Critical Metals

Department of Education	1,837,047
Miscellaneous (incl interest)	78,044
	1,915,091

Other Commonwealth Government

Specific Projects	153,042
Student Projects	500
	153,542

State Government

Specific Projects	12,000
Student Projects	5,361
	17,361

Industry/private

Amira Global Projects	794,736
CODES Industry Partners	200,000
Directly Funded Research Projects	402,213
Directly Funded Student Projects	309,907
Miscellaneous	23,988
	1,730,844

Contracts/consultancies/revenue raising

Short Courses	143,827
Book Sales	11,796
Miscellaneous (incl. Analytical Services)	1,804,571
	1,960,195

University of Tasmania – host institution support

Operating Grant	866,846
Scholarships and Tuition Fee Waivers	1,473,905
Strategic Projects	4,500
	2,345,251

Other income sources/interest

Society of Economic Geologists – Student Scholarships	33,659
Student Support	50,699
Specific Projects	68,401
Miscellaneous	3,291
	156,050

Total annual income	8,590,137
----------------------------	------------------

FIGURE 1:
Total Cash Income 2024

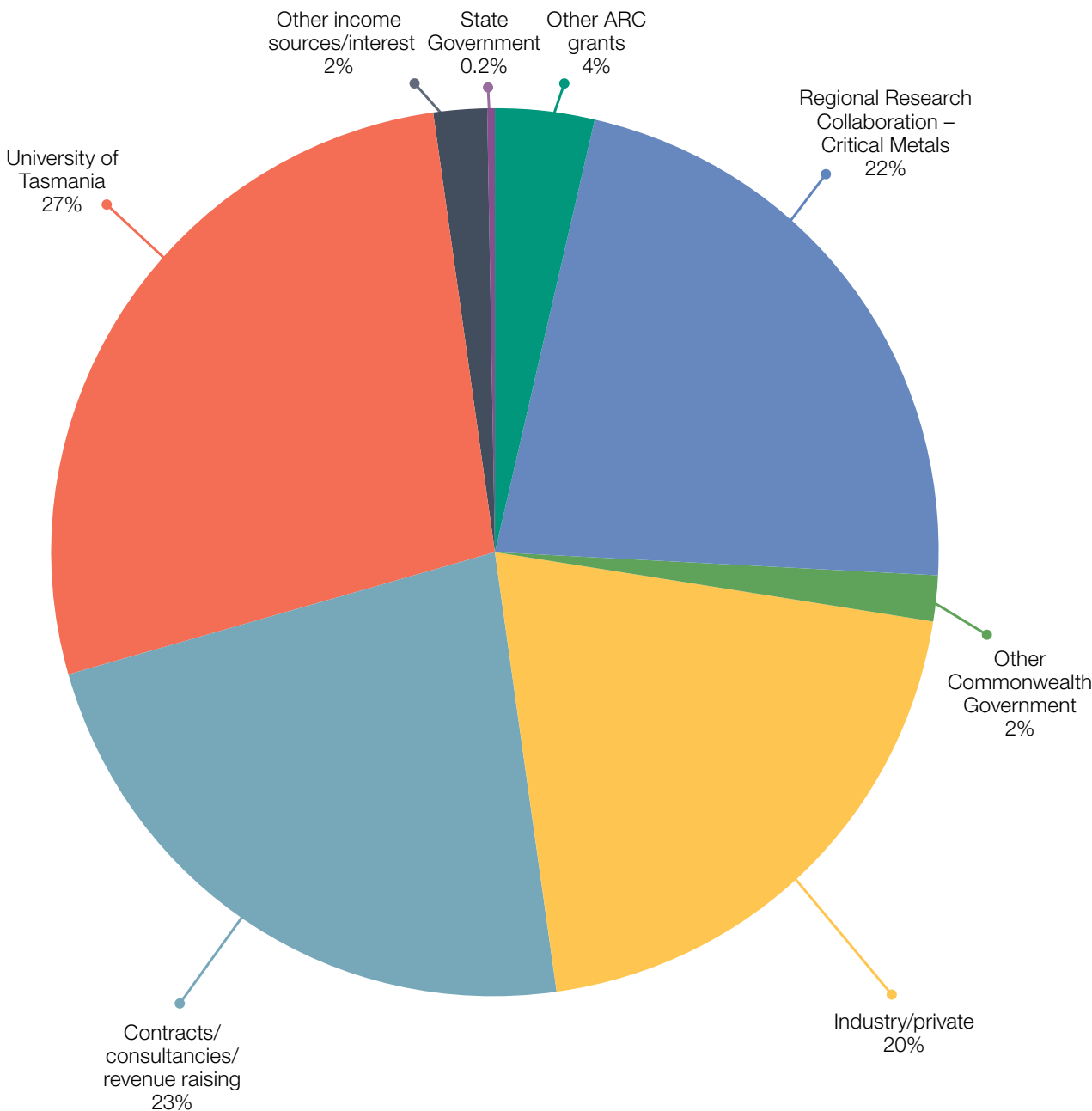
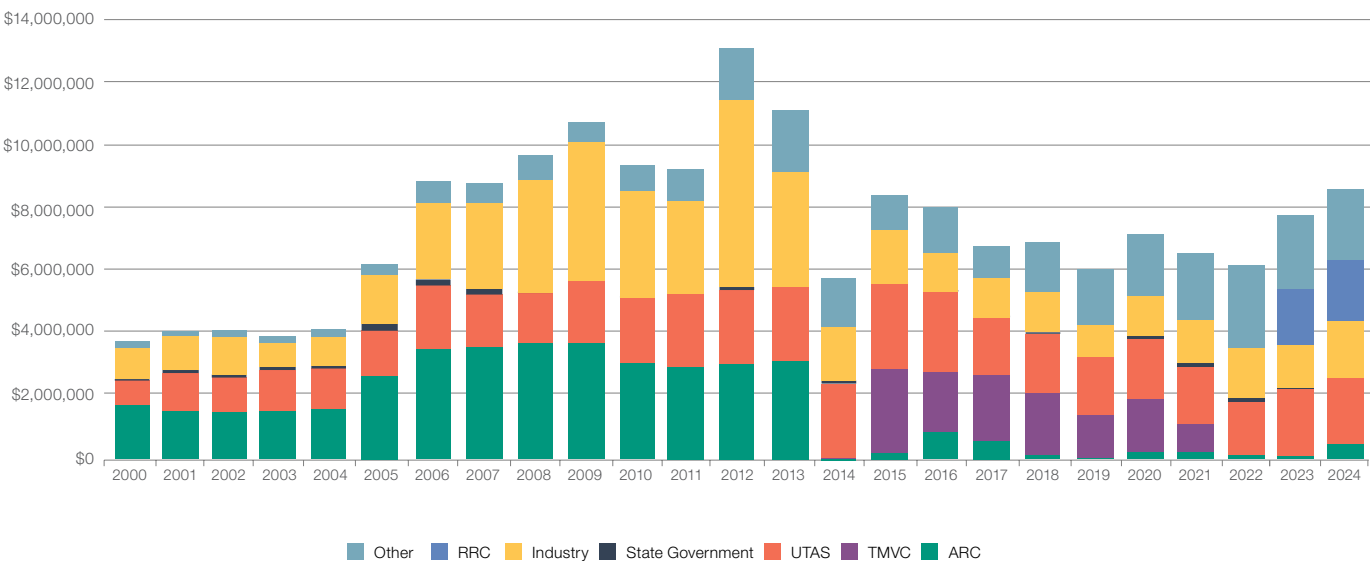


FIGURE 2:
Comparison of CODES
main income streams 2000–2024



2025 income estimates
Funding to CODES in 2025 is expected to be at a similar level when compared to 2024. Primary streams will continue to be represented by UTAS, in the form of scholarships and tuition fee waivers, external funding of predominately existing research projects, and sustained external use of the CODES Analytical Laboratories.

Notes to, and forming part of, the financial statements for 2024
The financial pages of this Annual Report were prepared by Helen Scott (Project Administration Manager). Data for the financial statements was extracted from UTAS systems, particularly its Finance System.

Income statement explanations
The income figures in Table 1 represent actual income recorded in the University's finance system, transferred internally from UTAS to CODES during 2024, or centrally administered for CODES RHD students (as in the case of scholarships and tuition fee waivers).



Publications 2024

Refereed journal articles (41)

Abersteiner, A., Beier, C., Genske, F., Berndt, J., **Kamenetsky, M.**, Goemann, K., Nekrylov, N. and Kamenetsky, V.S., 2024, Multi-stage evolution of the oceanic lithosphere beneath Heard Island, Southern Indian Ocean: *Journal of Petrology*, v. 65(10), Article egae106.

Adnan, N., Endut, Z., Ariffin, K.S., **Makoundi, C.** and Jimoh, O.A., 2024, Mineralogy and geochemistry of the tin-tungsten deposit in Sintok, Kedah, Malaysia: *Malaysian Journal of Microscopy*, v. 20(1), p. 110-122.

Armistead, S., Meffre, S., Bottrill, R., Cross, A., Huston, D. and Cumming, G., 2024, Multi-mineral geochronology reveals a protracted Mesoproterozoic tectonic and metallogenic link between southeastern Australia and Laurentia: *Precambrian Research*, v. 415, Article 107619.

Asimus, J.L., Daczko, N.R., Gazi, J.A., Ezad, I.S., **Belousov, I.**, Rodemann, T., Halpin, J.A. and Piazzolo, S., 2024, Experimental replacement of zircon by melt-mediated coupled dissolution-precipitation causes dispersion in U–Pb ages: *Journal of Metamorphic Geology*, v. 42(9), p. 1179-1195. DOI: 10.1111/jmg.12795

Berry, R., Goemann, K., **Danyushevsky, L.** and **Lounejeva, E.**, 2024, Geology of the Mutis Complex, Miomaffo, West Timor: *Australian Journal of Earth Sciences*, v. 71(2), p. 231-250.

Carrasco-Godoy, C., Campbell, I.H. and **Cajal, Y.**, 2024, Quantifying the criteria used to identify zircons from ore-bearing and barren systems in porphyry copper exploration: *Economic Geology*, v. 119(5), p. 1035-1058.

Cluzel, D., Montanini, A., Secchiari, A., Ferrari, E., Heizler, M., Jourdan, F., **Meffre, S.**, Zhou, R. and Teyssier, C., 2024, New geochemical and age constraints (40Ar/39Ar and U-Pb) on forearc intrusive rocks from the New Caledonia Ophiolite (SW Pacific): diversity of melts generated at hot subduction inception: *Journal of the Geological Society*, V. 181(1), Article jgs2023-145.

Cumming, G.V., **Berry, R.F.**, Bottrill, R.S., **Armistead, S.E.**, Everard, J.L., Bombardieri, D.J., Goemann, K. and **Meffre, S.**, 2024, Mesoproterozoic age for andalusite in the lower Rocky Cape Group, northwest Tasmania: *Australian Journal of Earth Sciences*, v. 71(3), p. 338-360.

Direen, N.G. and Kroll, A., 2024, Suppression of surficial maghaemite magnetic noise using an Unmanned Aerial Vehicle deployed magnetometer: *Exploration Geophysics*, v. 55(3), p. 336-350.

Druitt, T., Kutterolf, S., Ronge, T. A., Hübscher, C., Nomikou, P., Preine, J., Gertisser, R., Karstens, J., Keller, J., Koukousioura, O., Manga, M., Metcalfe, A., McCanta, M., McIntosh, I., Pank, K., Woodhouse, A., Beethe, S., Berthod, C., Chiyonobu, S., Chen, H., **Clark, A.**, DeBari, S., Johnston, R., Peccia, A.,

Yamamoto, Y., Bernard, A., Perez, T. F., Jones, C., Joshi, K. B., Kletetschka, G., Li, X., Morris, A., Polymenakou, P., Tominaga, M., Papanikolaou, D., Wang, K.-L. and Lee, H.-Y., 2024, Giant offshore pumice deposit records a shallow submarine explosive eruption of ancestral Santorini: *Communications Earth & Environment*, v. 5, Article 24.

Etschmann, B., **Missen, O.P.**, Conradson, S.D., Mills, S., Liu, Y. and Brugger, J., 2024, Environmental stability of a uranium-plutonium-carbide phase: *Scientific Reports*, v. 14(1), Article 6413.

Fathi, M., Mahmoudian, M., Diaz Alorro, R. and Chegini, M., 2024, Crosslinked polydiallyldimethylammonium chloride adsorbent for the selective separation of rhenium ions from pregnant leach solutions: *Materials*, v. 174(11), Article 2737.

Forni, F., Phua, M., Bernard, O., Giuditta Fellin, M., **Oalmann, J.**, Maden, C., Rifai, H. and Bouvet de Maisonneuve, C., 2024, Remobilization and eruption of an upper crustal cumulate mush at the Singkut caldera (North Sumatra, Indonesia): *Journal of Volcanology and Geothermal Research*, v. 445, Article 107971.

Fox, J.M., **Falloon, T.J.**, Carey, R.J., Watson, S.J., Duncan, R.A., Olin, P.H., Arculus, R.J. and Coffin, M.F., 2024, McDonald Islands phonolitic lavas: evidence for zonation of the Kerguelen Plume: *Geochemistry, Geophysics, Geosystems*, v. 25(11), Article e2024GC011854.



Sierra Nevada mountain range, view of Yerington porphyry Cu district, Nevada, taken by David Cooke during fieldwork to the area in early 2024.

Gao, Y., Zu, B., Zhao, X., Sui, Q., **Zhang, L.**, Seltmann, R., Weng, K., Chen, B., Song, W. and Xie, X., 2024, Genesis of the Kateba'asu gold deposit, Western Tianshan, China: Constraints from pyrite trace element, sulfur isotope, and quartz H-O isotopes: *Ore Geology Reviews*, v. 174, Article 106299.

Hohl, M., Steadman, J.A., Cloutier, J., Barker, S.L.L., **Belousov, I.**, Goemann, K. and **Cooke, D.R.**, 2024, Trace element systematics of magnetite from the Starra iron oxide-copper gold deposits reveals early fluid conditions characteristic for Cu mineralization: *Chemical Geology*, v. 648, Article 121960.

Hohl, M., Steadman, J.A., Cloutier, J. and **Cooke, D.R.**, 2024, Paragenetic and geological setting of the Starra iron oxide copper-gold deposits, Mount Isa Inlier, Queensland, Australia: constraints on IOCG deposit models: *Australian Journal of Earth Sciences*, v. 71(4), p. 513-537.

Hong, W., Fabris, A., Gilbert, S., Wade, B.P., Collins, A.S., Wise, T. and Reid, A.J., 2024, Using zircon and apatite chemistry to fingerprint porphyry Cu – Mo ± Au mineralization in the Delamerian Orogen, South Australia: *Mineralium Deposita*, v. 59, p. 1619-1640.

Ila'ava, M., Jutzeler, M., Cas, R. and **Carey, R.**, 2024, 3D modelling of subsurface ancient volcanic successions: a workflow developed during regional reconstructions of the Cowal Igneous Complex in the Ordovician Macquarie Arc of NSW, Australia: *Australian Journal of Earth Sciences*, v. 71(5), p. 699-720.

Jutzeler, M., Carey, R.J., Dagasan, Y., McNeill, A. and **Cas, R.A.F.**, 2024, Machine-learning crystal size distribution for volcanic stratigraphy correlation: *Scientific Reports*, v. 14, Article 31793.

Kang, J., Gregory, D.D., Gill, B., Huang, S., Lai, C., Chang, Z., Cui, H., **Belousov, I.** and Xiao, S., 2024, Trace element evidence for diverse origins of superheavy pyrite in Neoproterozoic sedimentary strata: *Geochimica et Cosmochimica Acta*, v. 364, p. 1-9.

Krebbbers, L.T., **Hunt, J.A.** and Lottermoser, B.G., 2024, Computed tomography of scheelite ore, Kara, Australia: morphological characterisation and modal mineralogy: *Minerals*, v. 14(4), Article 345.

Liu, M., Zhao, P., **Hong, W.** and Yuan, S., 2024, Assessing the W-Sn ore formation potential of large granite batholiths: Insights from zircon U-Pb and muscovite Ar-Ar geochronology of

the Tianmuchong W-Sn deposit in the Nanling region, South China: *Ore Geology Reviews*, v. 174, Article 106311.

Marcelissen, M., Hollings, P., **Cooke, D.R., Baker, M.J., Belousov, I., Orovan, E.** and Friedman, R., 2024, Geochronology on the Mines Gaspé porphyry deposit, Québec, Canada: *Canadian Journal of Earth Sciences*, v. 61, p. 876-893.

Mather, B., Seton, M., Williams, S., Whittaker, J., **Carey, R.**, Arnould, M., Coltice, N. and Duncan, R., 2024, Spreading ridge migration enabled by plume-ride de-anchoring: *Nature Communications*, v. 15, Article 8934.

Missen, O.P., Mills, S.J., Moro, T.T., Villalobos-Portillo, E.E., Castillo-Michel, H., Lockwood, T.E., Gonzalez de Vega, R. and Clases, D., 2024, Natural cobalt-manganese oxide nanoparticles: speciation, detection and implications for cobalt cycling: *Environmental Chemistry*, v. 21, Article EN23093.

Montoya-Lopera, P., Levresse, G., Ferrari, L., Catchpole, H., Coto, L., Mar, F. and Cárdenas-Castro, A., 2024, Oligocene magmato-tectonic events influential in the development of Pb-Zn, Ag, and Au mineralization at the Plomosas deposit, southwestern Sierra Madre Occidental, Mexico: *International Geology Review*, doi: 10.1080/00206814.2024.2372607

Murch, A.P., White, J.D.L., During, T., Nichols, A.R.L. and **Carey, R.J.**, 2024, Reconstructing the timing and conditions of fragmentation from water speciation in ash during a deep submarine eruption: 2012 eruption of Havre, Kermadec Arc: Lithos, v. 464-465, Article 107432.

O'Neill, H.S.C., Berry, A.J., Danyushevsky, L.V., **Falloon, T.J.**, Mass, R. and Feig, S.T., 2024, The relationship between iron redox states and H₂O contents in back-arc basin basaltic glasses from the North Fiji Basin: Chemical Geology, v. 655, Article 122062.

Ostersen, T.C.H., Reading, A.M., **Cracknell, M.J., Roach, M.**, Duffett, M.L., Bombardieri, D.J., McNeill, A., Fomin, T., Brand, K.E., Thiel, S., Boren, G. and Heinson, G., 2024, Resistivity anomalies in the shallow and deep crust beneath West Tasmania from a broadband magnetotelluric 2D transect: Exploration Geophysics, v. 55(5), p. 562-574.

Ostersen, T.C.H., Reading, A.M., **Cracknell, M.J., Roach, M.**, Duffett, M.L., McNeill, A., Bishop, J.R., Brand, K.E., Thiel, S. and Heinson, G., 2024, Low resistivity anomalies in the upper crust of the Midlands of Tasmania from combined magnetotelluric datasets: Exploration Geophysics, v. 55(5), p. 545-561.

Preine, J., Karstens, J., Hübscher, C., Druitt, T., Kutterolf, S., Nomikou, P., Manga, M., Gertisser, R., Pank, K., Beethe, S., Berthod, C., Crutchley, G., McIntosh, I., Ronge, T., Tominaga, M., **Clark, A.**, DeBari, S., Johnston, R., Mateo, Z., Peccia, A., Jones, C., Kletetschka, G., Metcalfe, A., Bernard, A., Chen, H., Chiyonobu, S., Fernandez-Perez, T., Joshi, K. B., Koukousioura, O., McCanta, M., Morris, A., Polymenakou, P., Woodhouse, A., Yamamoto, Y., Wang, K.-L., Lee, H.-Y., Li, X. and Papanikolaou, D., 2024, Hazardous explosive eruptions of a recharging multi-cyclic island arc caldera: Nature Geoscience, v. 17, p. 323-331.

Ribeiro, B.V., Kirkland, C.L., Smit, M., Musiyachenko, K., Korhonen, F.J., Evans, N.J., Rankenburg, K., McDonald, B.J., Glorie, S., Gilbert, S.E., Goemann, K., **Belousov, I., Oalmann, J.**, Clark, C. and Makin, S., 2024, Garnet reference materials for in situ Lu-Hf geochronology: Geostandards and Geoanalytical Research, doi: 10.1111/ggr.12579

Sritangsirikul, P., Meffre, S., Khin Zaw, Belousov, I., Lai, Y.-J., Richards, A. and Charusiri, P., 2024, Using compositions of zircon to reveal fertile magmas for the formation of porphyry deposits in the Loei and Truong Son fold belts, northern Laos: Journal of Asian Earth Sciences, v. 272, Article 106244.

Terry, J.P., Goff, J., Jankaew, K., Lhosupasirirat, K., Li, T., **Oalmann, J.**, Oliver, G.J.H. and Parham, P.R., 2024, Elevation and age of a raised beach in the upper Gulf of Thailand, as evidence for regional sea level during the Late Holocene: Journal of Asian Earth Sciences, v. 273, Article 106259.

Viola, B., Puskic, P., Corney, S., Barrett, N., Davies, B., Clausius, E., **Jutzeler, M.** and Lea, M-A., 2024, A quantitative assessment of continuous versus structured methods for the detection of marine mammals and seabirds via opportunistic shipboard surveys: Scientific Reports, v. 14, Article 18796.

Wu, C., **Cooke, D.R., Baker, M.J., Zhang, L.**, Liang, P., Fang, P., **Olin, P.**, Danyushevsky, L.V. and Chen, H., 2024, Using pyrite composition to track the multi-stage fluids superimposed on a porphyry Cu system: American Mineralogist, v. 109(5), p. 827-845.

Xu, X., Bain, W.M., Tornos, F., Hanchar, J.M., Lamadrid, H.M., Lehmann, B., Xu, X., **Steadman, J.A.**, Bottrill, R.S., Soleymani, M., Rajabi, A., Li, P., Tan, X., Xu, S., Locock, A.J. and Steele-MacInnis, M., 2024, Magnetite-apatite ores record widespread involvement of molten salts: Geology, v. 52(6), p. 417-422.

Zhang, P., Jiang, S-Y., **Khin Zaw, Li, R.**, Mei, L. and Li, Q., 2024, Development of major unconformities in the forearc regions: A signal of west Myanmar-Asia assemblage before the late Paleocene: Journal of Structural Geology, v. 185, Article 105174.

Zivkovic, Z., Halley, S., Vicary, M., **Baker, M., Cracknell, M.J.** and **Barker, S.**, 2024, Whole rock lithogeochemical analysis of the Mount Read Volcanics: a new tool for geochemical exploration: Geochemistry: Exploration, Environment, Analysis, doi: 10.1144/geochem2024-008

Zivkovic, Z., Orth, K., Chapman, N., **Oalmann, J., Baker, M., Cracknell, M.J.** and **Barker, S.**, 2024, Yampi Peninsula felsic Hart Dolerite: re-evaluating the Nellie Tonalite using evidence from whole rock, petrography and geochronology: Australian Journal of Earth Sciences, doi: 10.1080/08120099.2024.2379839

Book (1)

Cas, R., Giordano, G. and Wright, J.V., 2024, Volcanology – Processes, deposits, geology and resources: Springer Nature, Switzerland, 1833p.

Invited keynote addresses (4)

Cooke, D.R., 2024, Gold rich porphyries and related deposits – characteristics and explorations strategies: RoundUp 2024, Vancouver, Canada.

Cooke, D.R., Cracknell, M., Smyk, E., Farrar, A., Belousov, I., Cooke, S., Baker, M., Zhang, L., Hollings, P., White, N., Wilkinson, J. and Chang, Z., 2024, The copper challenge – facilitating society’s transition to a low carbon-energy future through new discoveries: CET Members Day Symposium, University of Western Australia, Perth.

Khin Zaw, 2024, U-Pb geochronology and trace elements of ruby and sapphire deposits, Mogok Metamorphic Belt (MMB): Implications for gemstone genesis: MUIGC 2024, Kanchanaburi, Thailand.

Zhang, L.J., Cooke, D.R.C., White, N.C. et al., 2024, The journey of using mineral chemistry to aid exploration: Mineral Exploration Conference, Guangzhou, China.

Conference abstracts (61)

Allen, C., 2024, Electrical Geophysical Methods for Characterisation of a Valley Infill Waste Rock Dump: CODES Critical and Strategic Metals Symposium, Hobart, Australia. Poster presentation.

Allen, C., 2024, Electrical Geophysical Methods for Characterisation of a Valley Infill Waste Rock Dump: ICARD 2024, Halifax, Canada. Oral presentation.

Appiah, A.A.A., Hunt, J., Fathi, M. and Missen, O.P., 2024, Processing challenges in magnesite beneficiation: Arthur River magnesite deposit: MetFest 2024, Burnie, Australia. Oral presentation.

Appiah, A.A.A., Hunt, J., Fathi, M. and Missen, O.P., 2024, Selectivity of magnesite from dolomite during flotation with sodium hexametaphosphate and citric acid: Critical Minerals Conference 2024, Brisbane, Australia. Poster presentation.



Participants in the Volcanology and Mineralisation in Volcanic Terrains Masters short course on Mount Ngauruhoe, New Zealand, in March 2024.

Armistead, S., 2024, Proterozoic sediment-hosted mineralisation in southeastern Australia and links to the Belt-Purcell basin of North America: SEG 2024, Windhoek, Namibia. Oral presentation.

Armistead, S.E., 2024, Mesoproterozoic tectonic and metallogenic link between Tasmania and Laurentia revealed by multi-mineral geochronology: SGTSG, Armidale, Australia.

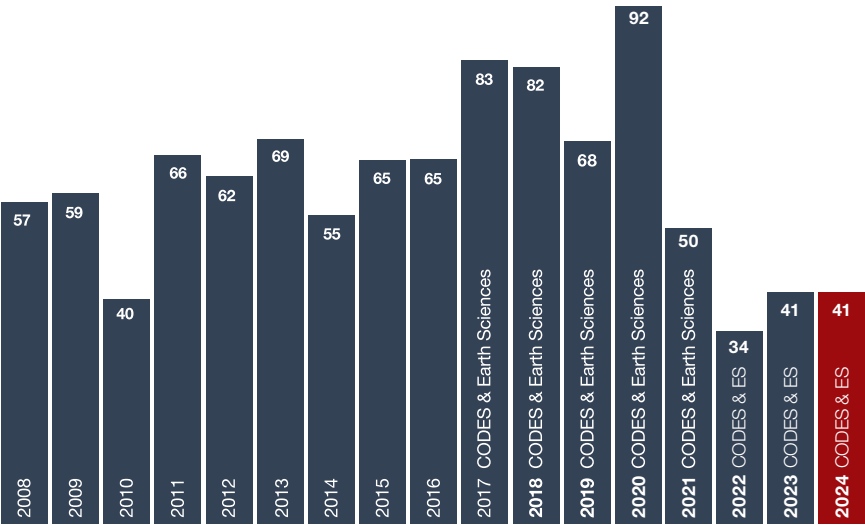
Armistead, S.E., 2024, The oldest Cu in Tasmania: new geochronology from sediment-hosted deposits in the Rocky Cape Group: Tasmanian Geoscience Forum, Tullah, Australia.

Barillas-Diaz, J.L., Cooke, D.R., Zhang, L., Hong, W., Cajal, Y., Chisnall, T. and Denholm, J., 2024, The Avebury Ni deposit, western Tasmania: CODES Critical and Strategic Metals Symposium, Hobart, Australia. Oral presentation.

Barillas-Diaz, J.L., Cooke, D.R., Zhang, L., Hong, W., Cajal, Y., Denholm, J. and Chisnall, T., 2024, Mineral geochemistry and textural relations of Ni sulfides and Co arsenides ores from the atypical Avebury nickel deposit, western Tasmania, Australia: International Nickel Symposium, Thunder Bay, Canada. Oral presentation.

Barillas-Diaz, J.L., Cooke, D.R., Zhang, L., Hong, W., Cajal, Y., Denholm, J. and Chisnall, T., 2024, Mineral compositions and evolution of hydrothermal Ni-Co mineralization from the Avebury metasomatic Ni sulfide deposit, Western Tasmania, Australia: International Geological Congress, Busan, South Korea. Oral presentation.

Belousov, I., Cima, A. and Danyushevsky, L., 2024, Deconvolution of mixed LA ICPMS signals and quantification of trace



REFEREED JOURNAL ARTICLES



Sunset over the Superior district, Arizona, home to the super giant Resolution porphyry Cu-Mo deposit.

element compositions of microinclusions in minerals: European Workshop on Laser Ablation, Ghent, Belgium. Oral presentation.

Belousov, I., Cima, A. and Danyushevsky, L., 2024, Trace element compositions of micro inclusions extracted from mixed LA ICPMS signals: International Applied Geochemistry Symposium, Adelaide, Australia. Oral presentation.

Belousov, I.A., Kamenetsky, V.S., Feig, S., Chayka, I.F. and Zhitova, L.M., 2024, PGE enrichment in the Merensky Reef: a 'missing link' to sulfide melts: 100 years of the Merensky Reef – Minerals Metals and Mining Conference, Rustenburg, South Africa. Oral presentation.

Braize, D., Steadman, J., Meffre, S. and Cuisson, A.L., 2024, Is the Tennant Creek mineral field an IOCG province? Insights from chlorite chemistry: SEG 2024, Windhoek, Namibia. Poster presentation.

Chayka, I.F., Kamenetsky, V.S., Belousov, I.A. and Zhitova, L.M., 2024, Chromite-hosted multiphase silicate inclusions from the Merensky reef of the Bushveld complex (Driekop area): phase composition and heating experiments: 100 years of the

Merensky Reef – Minerals Metals and Mining Conference, Rustenburg, South Africa. Oral presentation.

Cima, A., Belousov, I., Cooke, D. and Cracknell, M., 2024, Influence of titanite and apatite microinclusions on vectoring and fertility assessment tools in the green rock environment: A case study from Batu Hijau Cu-Au porphyry deposit, Indonesia: SEG 2024, Windhoek, Namibia. Oral presentation.

Coaquira, T.X., Cooke, D.R. and Zhang, L., 2024, Geological evolution of the supergiant Resolution Cu-Mo porphyry deposit, Arizona, USA: SEG 2024, Windhoek, Namibia. Oral presentation.

Cooke, D.R., Testa, F., Zhang, L., Torres, V. and Escolme, A., 2024, Breccias in magmatic-hydrothermal environments: SEG 2024, Windhoek, Namibia. Oral presentation.

Cooke, S.A., Cracknell, M.J., Baker, M.J., Zhang, L., Cooke, D.R., Belousov, I., 2024, LocatOre: Mineral exploration and vectoring software: International Geological Congress, Busan, South Korea. Poster presentation.

da Cruz, V.G.P., Cooke, D.R., Carey, R., Belousov, I. and Jago, C.M., 2024, Critical metals potential in volcanic-

hosted massive sulfide deposits: The Rosebery case, western Tasmania: CODES Critical and Strategic Metals Symposium, Hobart, Australia. Oral presentation.

Fathi, M., 2024, Exploring anisotropic effects of grinding media for selective separation of scheelite and fluorite: Critical Minerals Conference 2024, Brisbane, Australia. Poster presentation.

Fathi, M., 2024, Slimes generation in Critical Mineral Processing, challenges, processing issues, and potential remedies: MetFest 2024, Burnie, Australia. Oral presentation.

Frey, S.E., Jutzeler, M., Carey, R.J. and Harris, P.T., 2024, Active deepwater multidirectional tractional sands at Havre Submarine Volcano; a new facies model for deep marine deposition: International Association for Sedimentologists Conference, Aberdeen, UK. Oral Presentation.

Frey, S.E., Jutzeler, M., Cartigney, M.J.B. and Carey, R.J., 2024, Large-scale single-event sediment-waves; Insights into cyclic step/antidune deposition and eruption-fed density currents: International Association for Sedimentologists Conference, Aberdeen, UK. Poster Presentation.

Frey, S.E., Jutzeler, M., Kutterolf, S. and Scheffler, J., 2024, Ship-based epoxy impregnation of unconsolidated marine sediment cores: a detailed methodology: International Association for Sedimentologists Conference, Aberdeen, UK. Poster Presentation.

Gil Rodriguez, J., 2024, Critical metals in the Renison Bell tin deposit: CODES Critical and Strategic Metals Symposium, Hobart, Australia. Poster presentation.

Hollings, P., Hamilton, P., Jedemann, A., Zhang L. and Cooke, D.R., 2024, Geology, alteration and mineralization of the Pemberton Hills porphyry system, Canada: anatomy of a lithocap: International Geological Congress, Busan, South Korea. Oral presentation.

Hong, W., 2024, Tourmaline chemistry: A fertility assessment and vectoring tool for magmatic-hydrothermal ore systems: CODES Critical and Strategic Metals Symposium, Hobart, Australia. Poster presentation.

Hong, W. and Cooke, D., 2024, Greisen-hosted Li mineralisation in eastern Tasmania – a pilot study: CODES Critical and Strategic Metals Symposium, Hobart, Australia. Oral presentation.

Hong, W., Cooke, D.R., Zhang, L. and Oalmann, J., 2024, Preliminary characterisation of greisen-hosted Li mineralisation in eastern Tasmania: IAGS 2024, Adelaide, Australia. Poster presentation.

Hong, W., Zhang, L., Cooke, D., Fox, N. and Chang, Z., 2024, Alunite and pyrite mineral chemistry vectoring to high-grade Au-Ag orebodies associated with the Martabe lithocap in Sumatra arc, Indonesia: IGC 2024, Busan, Korea. Oral presentation.

Hoschke, T. and Frankcombe, K., 2024, Geophysical response of alteration and mineralisation in the Wafi-Golpu porphyry system, Papua New Guinea: ASEG 2024, Hobart, Australia. Extended Abstract, 4p.

Ila'ava, M., Jutzeler, M., Cas, R. and Carey R., 2024, 3D Modelling of ancient volcanic successions: A workflow developed from the Cowal Igneous Complex (CIC), New South Wales: CODES Critical and Strategic Metals Symposium, Hobart, Australia. Poster presentation.



Supergene Fe-oxides replacing pyrite-cemented breccia in white mica-altered monzodiorite, Yerington porphyry Cu district, Nevada.

Khin Zaw and Makoundi, C., 2024, Pegmatite deposits in Myanmar: Insight into exploration potential of lithium for battery metals: CODES Critical and Strategic Metals Symposium, Hobart, Australia. Poster presentation.

Le'Gallais, B., Belousov, I., Falloon, T., Danyushevsky, L., Cumming, G. and Everard, J.L., 2024, Geochemistry of an ultra-depleted melt from the Whyte River Complex: A potential parental melt to the Cambrian Ultramafic Complexes of Western Lutruwita (Tasmania)? CODES Critical and Strategic Metals Symposium, Hobart, Australia. Poster presentation.

Missen, O.P., 2024, Could harnessing natural processes be a potentially viable method to extract critical elements from mine wastes? Responsible Raw Materials, online. Oral presentation.

Missen, O., 2024, Introduction to the Regional Research Collaboration (RRC) project: a holistic approach to critical metal research: CODES Critical and Strategic Metals Symposium, Hobart, Australia. Oral presentation.

Missen, O., 2024, Regolith cobalt in the weathering environment: from nano to macro scale: CODES Critical and Strategic Metals Symposium, Hobart, Australia. Oral presentation.

Missen, O., 2024, Unlocking Critical Metals in mine wastes: Potential for bismuth, indium, cobalt and more in Tasmania: CODES Critical and Strategic Metals Symposium, Hobart, Australia. Poster presentation.

Missen, O.P., Hunt, J., Fathi, M. and Cooke, D.R., 2024, Unlocking Critical Metals in mine wastes: Potential for bismuth, indium, cobalt and more in



Moody skies above Rangitoto volcano in New Zealand seen during the Volcanology and Mineralisation in Volcanic Terrains short course that ran during March 2024.

Tasmania: Australian Mine Waste Symposium, Brisbane, Australia. Poster presentation.

Montoya-Lopera, P., Levresse, G., Ferrari, L., Catchpole, H., Coto, L., Mar, F. and Cárdenas-Castro, A., 2024, Oligocene magmato-tectonic events influential in the development of Pb-Zn, Ag and Au mineralization at the Plomosas deposit, southwestern Sierra Madre Occidental, Mexico: IGC 2024, Busan, Korea. Oral presentation.

Musa, E., Hunt, J., Fathi, M., Missen, O.P, Doherty, G. and Mollison, M., 2024, Scheelite Processing Challenges and Opportunities: A case study of coarse froth flotation: MetFest 2024, Burnie, Australia. Oral presentation.

Musa, E., Hunt, J., Fathi, M., Missen, O.P, Doherty, G. and Mollison, M., 2024, Scheelite Processing Challenges and Opportunities: An example from Kara magnetite-scheelite mine, Tasmania: Critical Minerals Conference 2024, Brisbane, Australia. Poster presentation.

Naimbale, N.N., 2024, Heemskirk tin project, Western Tasmania, Australia: Characterization of Severn-Queen Hill tin deposits: SEG 2024, Windhoek, Namibia. Poster presentation.

Naimbale, N.N., 2024, The ore genesis of Okanjande graphite deposit, Central Zone, Damara Belt, Namibia: SEG 2024, Windhoek, Namibia. Poster presentation.

Oalmann, J., Belousov, I., Morissette, M. and Ribeiro, B., 2024, Comparing methods for quantifying elemental images obtained by quadrupole and time-of-flight LA-ICP-MS: European workshop on Laser Ablation, Ghent, Belgium. Poster presentation.

Portocarrero, D.G., Cooke, D.R., Zhang, L., 2024, Magmatic-hydrothermal history at the Antakori Cu-Au-Ag project, northern Peru: new ages from U-Pb and Re-Os geochronology: SEG 2024, Windhoek, Namibia. Poster presentation.

Santos Costa, A.I, 2024, Hunting the magmatic processes that lead to granite-related w mineralization: SEG 2024, Windhoek, Namibia. Poster presentation.

Santos Costa, A.I, 2024, The world-class Dolphin W deposit, King Island, Tasmania – Exploration tools and infrared spectroscopy: SEG 2024, Windhoek, Namibia. Poster presentation.

Santos, A.I.C., Cooke, D., Zhang, L. and Cajal, Y., 2024, The W skarn system at Grassy, King Island, Tasmania: From Dolphin to the West targets: Gordon Research Conference and Seminar, Maine, USA. Poster presentation.

Santos Costa, A.I., Cooke, D.R., Zhang, L., Cajal, Y. and Oalmann, J., 2024, The W skarn system at Grassy, King Island, Tasmania: From Dolphin to the West targets: CODES Critical and Strategic Metals Symposium, Hobart, Australia. Poster presentation.

Steadman, J., 2024, Cobalt: An IOCG perspective: CODES Critical and Strategic Metals Symposium, Hobart, Australia. Oral presentation.

Steadman, J., 2024, Mineral chemistry in IOCG systems: IAGS IOCG Workshop, Adelaide, Australia. Oral presentation.

Steadman, J., Baker, M., Cracknell, M.J. and Belousov, I., 2024, Epidote as a tracer of Cu-Au-REE mineralization in Iron Oxide Copper-Gold systems: Examples from the Mt Isa Inlier and Gawler Craton: Goldschmidt 2024, Chicago, USA. Oral presentation.

Staubmann, M., Rodemann, T., Hunt, J., Cooke, D., Cracknell, M., Gardner, K. and Howard, N., 2024, FT-IR spectroscopy for geometallurgy modelling: Proof-of-concept study from the GRE46 epithermal gold deposit (NSW): CODES Critical and Strategic Metals Symposium, Hobart, Australia. Poster presentation.

Vidal Salgado, P., 2024, Analysis of visual grading of the hydrothermal alteration of the Vazante Zn-Pb Deposit, Minas Gerais, Brazil: A new vector for exploration?: SEG 2024, Windhoek, Namibia. Poster presentation.

Yurdakul, E., Zhang, L., Baker, M. and Scott, R., 2024, The Western Tharsis Cu – Au Deposit: recognition of a high sulfidation epithermal – porphyry system in the Mount Lyell District, Tasmania: Gordon Research Conference and Seminar, Maine, USA. Poster presentation.

Yurdakul, E., Zhang, L., Baker, M. and Scott, R., 2024, Critical metal by-products of Cu – Au in the Western Tharsis high sulfidation epithermal deposit, Tasmania: CODES Critical and Strategic Metals Symposium, Hobart, Australia. Poster presentation.

Yurdakul, E., Zhang, L., Baker, M. and Scott, R., 2024, Critical metal by-products of Cu – Au in the Western Tharsis high sulfidation epithermal deposit, Tasmania: Mines and Wines, Albury, Australia. Poster presentation.

Zhang, L.J., Cooke, D.R.C., White, N.C., Harrison, R., Escolme, A. and Eastman, K., 2024, Lithocaps and associated high-grade porphyry – high sulfidation deposits: IGC 2024, Busan, Korea. Oral presentation.

Zhang, L., Hong, W., Cooke, D.R., Roach, M., Testa, F. and Santos Costa, A.I., 2024, Introduction to granite related Sn, W deposits in Tasmania, Australia: CODES Critical and Strategic Metals Symposium, Hobart, Australia. Oral presentation.

Research reports to industry/government agencies (194)

Allen, C.C., 2024, Electrical geophysical methods for characterising a valley infill waste rock dump [Poster Speed Talk]: RRC SRM #3, 27 November 2024, p. 217-219.

AMIRA P1249 research team, 2024, Amira P1249 SRM5 Poster session introduction: Amira P1249 SRM #5, 12 & 13 June 2024, p. 117-144.

AMIRA P1249 research team, 2024, Poster session highlights Amira P1249 SRM 6: AMIRA P1249 SRM #6, 4 & 5 December 2024, p. 131-151.

Atanga, F., Baker, M., Armistead, S. and Zhang, L., 2024, The geology and paragenesis of the Akyem orogenic Au deposit, Ghana: AMIRA P1249 SRM #6, p. 40-74.

Baker, M. and the AMIRA P1249 research team, 2024, Introduction: Amira P1249 SRM #5, 12 & 13 June 2024, p. 1-21.

Baker, M. and the AMIRA P1249 research team, 2024, Introduction: AMIRA P1249 SRM #6, 4 & 5 December 2024, p. 1-20.

Baker, M., Cracknell, M., Halley, S., Osorio, J. and Cima, A., 2024, Ventana porphyry Au-Cu prospect, Argentina; Mineral texture clustering progress report: Amira P1249 SRM #5, 12 & 13 June 2024, p. 69-94.

Baker, M., Cracknell, M., Halley, S., Osorio, J. and Cima, A., 2024, Ventana porphyry Au-Cu prospect, Argentina; Mineralogical domaining and clustering progress report – December 2024: AMIRA P1249 SRM #6, 4 & 5 December 2024, p. 460-480.

Barillas-Diaz, J.L., Cooke, D.R., Zhang, L., Hong, W., Cajal, Y., Belousov, I., Chisnall, T. and Denholm, J., 2024, Critical metals at Avebury nickel deposit: RRC SRM #3, 27 November 2024, p. 134-170.

Belousov, I., 2024, Introduction to Element 1: Unlocking Critical Metal Resources: RRC SRM #3, 27 November 2024, p. 38-52.

Belousov, I., 2024, P1695: Chlorite and epidote chemistry for 1 sample: Report to BHP, Peru, 3 p.

Belousov, I., 2024, P1837: Copperman fertility and vectoring report: Report to Copperman, Chile, 12 p.

Belousov, I., 2024, P1837: Pyrite chemistry for 8 samples: Report to Copperman, Chile, 3 p.

Belousov, I., 2024, P1716: Chlorite and epidote chemistry for 8 samples: Report to Inflection Resources, 4 p.

Belousov, I., 2024, P1734: Chlorite and epidote chemistry for 1 sample: Report to First Quantum Minerals, 10 p.

Belousov, I., 2024, P1767: Chlorite and epidote chemistry for 11 samples: Report to Inflection Resources, 4 p.

Belousov, I. and Carrasco, C., 2024, P1745: Alunite/jarosite chemistry from 134 samples: Report to CODELCO, 3 p.

Belousov, I. and Carrasco, C., 2024, P1745: Carbonate chemistry from 134 samples: Report to CODELCO., 3 p.

Belousov, I. and Carrasco, C., 2024, P1745: Chlorite and epidote chemistry from 134 samples: Report to CODELCO, 4 p.

Belousov, I. and Carrasco, C., 2024, P1745: Quartz chemistry from 134 samples: Report to CODELCO, 4 p.

Belousov, I. and Carrasco, C., 2024, P1746: Alunite/jarosite chemistry from 124 samples: Report to CODELCO, 2 p.

Belousov, I. and Carrasco, C., 2024, P1746: Quartz chemistry from 124 samples: Report to CODELCO, 3 p.

Belousov, I. and Carrasco, C., 2024, P1789: Chlorite and epidote chemistry for 7 samples: Report to First Quantum Minerals, 4 p.

Belousov, I. and Carrasco, C., 2024, P1799: Chlorite and epidote chemistry for 11 samples: Report to Inflection Resources, 4 p.

Belousov, I., Carrasco, C. and Ward, J., 2024, P1746: Carbonate chemistry from 124 samples: Report to CODELCO, 3 p.

Belousov, I., Carrasco, C. and Ward, J., 2024, P1746: Chlorite and epidote chemistry from 124 samples: Report to CODELCO, 4 p.

Belousov, I., Cima, A. and Danyushevsky, L., 2024, Trace element compositions of micro inclusions extracted from mixed LA ICPMS signals: AMIRA P1249 SRM #6, 4 & 5 December 2024, p. 165-180.

Belousov, I. and Dai, F., 2024, P1800: U-Pb zircon geochronology report: Report to Barrick, Dominican Republic, 7 p.

Belousov, I. and Morissette, M., 2024, P1637 U-Pb zircon geochronology report: Report to Barrick, Dominican Republic, 11 p.

Belousov, I., Piquer, J., Cooke, D.R., Halley, S., Cracknell, M., Baker, M., Danyushevsky, L., Pacey, A., Gluchowska, J., Agnew, P. and Powell, W., 2024, Nolasco/Santa Clara - Rio Tinto blind test: Amira P1249 SRM #5, 12 & 13 June 2024, p. 408-420.

Belousov, I. and Ward, J., 2024, P1745: CODELCO fertility and vectoring report: Report to CODELCO, 22 p.

Belousov, I., Ward, J. and MacDonald, A., 2024, P1837: Chlorite and epidote chemistry for 8 samples: Report to Copperman, Chile, 4 p.

Cajal, Y., Piquer, J., Cooke, D.R., Campbell, I. and Carrasco-Godoy, C., 2024, Whole rock and magmatic mineral chemistry of Miocene-Pliocene intrusions in Central Chile: Amira P1249 SRM #5, 12 & 13 June 2024, p. 317-338.

Carrasco, C., Oalmann, J. and Dai, F., 2024, P1695: U-Pb zircon geochronology report on 5 samples: Report to BHP, Peru, 8 p.

Carrasco, C., Oalmann, J. and Dai, F., 2024, P1710A: U-Pb zircon geochronology report on 9 detrital samples: Report to Teck, Chile, 15 p.

Carrasco, C., Oalmann, J. and Dai, F., 2024, P1715B: U-Pb zircon geochronology report on 10 samples: Report to Anglo American, Chile, 10 p.

Carrasco, C., Oalmann, J. and Dai, F., 2024, P1727: U-Pb zircon geochronology report on 9 samples: Report to Anglo American, Chile, 10 p.

Carrasco, C., Oalmann, J. and Dai, F., 2024, P1734: U-Pb zircon geochronology report on 3 samples: Report to First Quantum, Argentina, 7 p.

Carrasco, C., Oalmann, J. and Dai, F., 2024, P1735A: U-Pb zircon geochronology report on 15 samples: Report to Anglo American, Chile, 13 p.

Carrasco, C., Oalmann, J. and Dai, F., 2024, P1735B: U-Pb zircon geochronology report on 15 samples: Report to Anglo American, Chile, 13 p.

Carrasco, C., Oalmann, J. and Dai, F., 2024, P1791: U-Pb zircon geochronology report on one sample: Report to BHP, Chile, 6 p.

Carrasco-Godoy, C., Campbell, I. and Cajal, Y., 2024, Zircon in porphyry Cu exploration: What have we learned from geochemistry and predictive modelling?: AMIRA P1249 SRM #6, 4 & 5 December 2024, p. 307-328.

Cima, A., Belousov, I., Cooke, D.R., Cracknell, M. and Montoya, P., 2024, Microinclusions as a vector and fertility assessment tool – Update: AMIRA P1249 SRM #6, 4 & 5 December 2024, p. 209-235.

Cooke, D.R. and the AMIRA P1249 research team, 2024, P1249 Forward program – June to December 2024: Amira P1249 SRM #5, 12 & 13 June 2024, p. 445-462.

Cooke, D.R. and the P1249 team, 2024, P1249 Forward Program – January – June 2025: AMIRA P1249 SRM #6, 4 & 5 December 2024, p. 481-487.

Cooke, D.R., Zhang, L., Osorio, J. and the AngloGold Ashanti exploration team, 2024, Wagen, Nevada – AngloGold Ashanti Active Exploration Site Test: Site overview – December 2024: AMIRA P1249 SRM #6, 4 & 5 December 2024, p. 358-419.

Cracknell, M. and the AMIRA P1249 research team, 2024, P1249 Module 2 – Characterisation and domaining – Overview and synthesis: Amira P1249 SRM #5, 12 & 13 June 2024, p. 22-68.

Cracknell, M. and the P1249 team, 2024, Amira P1249 Module 2 – Characterisation and domaining Overview and update: AMIRA P1249 SRM #6, 4 & 5 December 2024, p. 420-438.

Cracknell, M.J., Merrill-Cifuentes, J., Barker, S., Baker, M., Belousov, I., Cima, A. and Cooke, D.R., 2024, Inclusion Hunter – A method for detecting and visualising microinclusion populations in LA-ICP-MS mineral chemistry data: AMIRA P1249 SRM #6, 4 & 5 December 2024, p. 151-164.

da Cruz, V.G.P., Cooke, D.R. and Jago, C.M., 2024, Geology, mineralization and sphalerite – chalcopyrite by product potential of the southern Rosebery deposit: RRC SRM #3, 27 November 2024, p. 70-112.

Dai, F., Belousov, I. and Oalmann, J., 2024, P1829: Gold contents in pyrite and arsenopyrite in one sample: Report to ALS, 5 p.

Dai, F., Morissette, M. and Oalmann, J., 2024, P1705: Gold contents in pyrite in two samples: Report to ALS, 9 p.

Dai, F., Morissette, M. and Oalmann, J., 2024, P1706: Gold contents in pyrite and arsenopyrite in two samples: Report to ALS, 8 p.

Dai, F., Morissette, M. and Oalmann, J., 2024, P1717: Lithium contents in various minerals in one sample: Report to ALS, 4 p.

Dai, F., Morissette, M. and Oalmann, J., 2024, P1718: Gold contents in pyrite and arsenopyrite in two samples: Report to ALS, 9 p.

Dai, F., Morissette, M. and Oalmann, J., 2024, P1736: Phosphorus concentration in leucoxene and related phases in one sample: Report to ALS, 7 p.

Dai, F., Morissette, M. and Oalmann, J., 2024, P1737: HREE contents of various minerals from one sample: Report to ALS Global, 12 p.

Dai, F., Morissette, M. and Oalmann, J., 2024, P1738: Gold contents in pyrite in one sample: Report to ALS Global, 7 p.

Dai, F. and Oalmann, J., 2024, P1783: Palladium, gold contents in various phases in one sample: Report to ALS, 6 p.

Dai, F. and Oalmann, J., 2024, P1784: Phosphorus concentration in leucoxene and related phases in one sample: Report to ALS, 7 p.

Dai, F. and Oalmann, J., 2024, P1785: Gold, silver, arsenic and zinc contents in various minerals in one sample: Report to ALS, 11 p.

Dai, F. and Oalmann, J., 2024, P1810: Trace elements contents of various minerals from one sample: Report to ALS Global, 7 p.

Dai, F. and Oalmann, J., 2024, P1823: Gold contents in pyrite and pyrrhotite in one sample: Report to ALS, 7 p.

Dai, F. and Oalmann, J., 2024, P1824: Gold contents in stibnite in one sample: Report to ALS, 5 p.

Dai, F. and Oalmann, J., 2024, P1825: Trace elements in silicate minerals from two samples: Report to ALS Metallurgy, Canada, 5 p.

Dai, F., Oalmann, J. and Morissette, M., 2024, P1643: Lithium contents in various minerals in two samples: Report to ALS Global, 6 p.

Dyer, J. and Hollings, P., 2024, Characterization of the alteration footprint of the McFinley gold deposit, Red Lake, Ontario: AMIRA P1249 SRM #6, 4 & 5 December 2024, p. 236-262.

Dyer, J., Sulyman, N. and Hollings, P., 2024, Characterization of the alteration footprint of the McFinley gold deposit, Red Lake, Ontario: Amira P1249 SRM #5, 12 & 13 June 2024, p. 145-174.

Farias, P.G., Weisheit, A., Reno, B.L., Belousov, I. and Northern Territory Geological Survey, 2024, In situ LA-ICP-MS apatite and monazite U-Pb geochronology of the Entia Dome, Aileron and Irindina provinces, Central Australia: Report to Northern Territory Government, 26 p.

Fathi, M., 2024, Exploring anisotropic effects of grinding media for selective separation of scheelite and fluorite [Poster Speed Talk]: RRC SRM #3, 27 November 2024, p. 220-222.

Fathi, M., 2024, Insights into processing improvements of scheelite (CaWO4): A case study for Kara: RRC SRM #3, 27 November 2024, p. 225-240.

Gil-Rodriguez, J., Cooke, D.R., Missen, O.P. and Hong, W., 2024, Following the fault: distribution of critical metals at Renison Bell mine: RRC SRM #3, 27 November 2024, p. 53-69.

Halley, S., 2024, Calculated mineralogy update: Amira P1249 SRM #5, 12 & 13 June 2024, p. 95-116.

Hong, W., 2024, Greisen-hosted Li mineralisation in Eastern Tasmania – Textural, spectral and compositional characterisation: RRC SRM #3, 27 November 2024, p. 241-266.

Hong, W., Zhang, L., Cracknell, M., Belousov, I. and Cooke, D.R., 2024, Alunite chemistry and micro-inclusion hunting: vectoring to high-grade gold orebodies in the Martabe lithocap, Indonesia: AMIRA P1249 SRM #6, 4 & 5 December 2024, p. 181-208.

Hunt, J., 2024, Introduction to environmentally sustainable production of critical metals workshop: RRC SRM #3, 27 November 2024, p. 1-9.

Ila'ava, M., Jutzeler, M., Cas, R. and Carey, R., 2024, Volcanic stratigraphy of the Cowal Igneous Complex, NSW: Industry report.

Large, R.R., 2024, Geology of western Tasmania: setting of critical and strategic metal mineralisation: RRC SRM #3, 27 November 2024, p. 288-319.

Lounejeva, E., 2024, P1688: Identification and quantification of mineral phases by X-ray diffraction (XRD) in five December 2023 samples: Report to BMTJV, 2 p.

Lounejeva, E., 2024, P1721: Identification and quantification of mineral phases by X-ray diffraction (XRD) in five January 2024 samples: Report to BMTJV, 2 p.

Lounejeva, E., 2024, P1740: Identification and quantification of mineral phases by X-ray diffraction (XRD) in five February 2024 samples: Report to BMTJV, 2 p.

Lounejeva, E., 2024, P1754: Identification and quantification of mineral phases by X-ray diffraction (XRD) in five March 2024 samples: Report to BMTJV, 2 p.

Lounejeva, E., 2024, P1755: Identification and quantification of mineral phases by X-ray diffraction (XRD) in sixty-two samples: Report to BMTJV, 5 p.

Lounejeva, E., 2024, P1765: Identification and quantification of mineral phases by X-ray diffraction (XRD) in eight April and May 2024 samples: Report to BMTJV, 2 p.

Lounejeva, E., 2024, P1780: Identification and quantification of mineral phases by X-ray diffraction (XRD) in seven samples: Report to BMTJV, 2 p.

Lounejeva, E., 2024, P1786: Identification and quantification of mineral phases by X-ray diffraction (XRD) in four samples: Report to Sun Metals, 2 p.

Lounejeva, E., 2024, P1787: Identification and quantification of mineral phases by X-ray diffraction (XRD) in six Apr-Jun 2024 samples: Report to BMTJV, 2 p.

Lounejeva, E., 2024, P1808: Identification and quantification of mineral phases by X-ray diffraction (XRD) in four samples: Report to Sun Metals, 2 p.

Lounejeva, E., 2024, P1809: Identification and quantification of mineral phases by X-ray diffraction (XRD) in twelve July 2024 samples: Report to BMTJV, 2 p.

Lounejeva, E., 2024, P1828: Identification and quantification of mineral phases by X-ray diffraction (XRD) in seven August 2024 samples: Report to BMTJV, 2 p.

Lounejeva, E., 2024, P1838: Identification and quantification of mineral phases by X-ray diffraction (XRD) in nineteen August–September 2024 samples: Report to BMTJV, 2 p.

Lounejeva, E., 2024, P1850: Identification and quantification of mineral phases by X-ray diffraction (XRD) in twelve October 2024 samples: Report to BMTJV, 2 p.

Lounejeva, E., 2024, P1856: Identification and quantification of mineral phases by X-ray diffraction (XRD) in twenty samples: Report to BMTJV, 3 p.

MacDonald, A., Dai, F. and Oalmann, J., 2024, P1747: U-Pb zircon geochronology report on 7 samples: Report to ALS, 9 p.

MacDonald, A. and Oalmann, J., 2024, P1728: U-Pb zircon geochronology report on 11 samples: Report to Barrick, Chile/Ecuador, 11 p.

MacDonald, A. and Oalmann, J., 2024, P1851: Trace element contents in various minerals in three samples: Report to ALS, 19 p.



The 2024 KEA348 field trip to Tasmania's West Coast: Professor David Cooke teaching in typical western Tasmania weather on the King River delta.



Tertiary Volcanics unconformably overlying Paleozoic limestones and Proterozoic sedimentary rocks in the Range Front east of Superior, Arizona. The Resolution porphyry Cu-Mo deposit is covered by the Tertiary Volcanics.

MacDonald, A. and Oalmann, J., 2024, P1852: Lithium contents in various minerals in three samples: Report to ALS, 3 p.

MacDonald, A. and Oalmann, J., 2024, P1853: Nickel contents in various minerals in one sample: Report to ALS, 3 p.

MacDonald, A. Oalmann, J. and Dai, F., 2024, P1715A: U-Pb zircon geochronology report on 10 samples: Report to Anglo American, Chile, 10 p.

MacDonald, A., Oalmann, J. and Dai, F., 2024, P1726A: U-Pb zircon geochronology report on 18 samples: Report to BHP, Chile, 14 p.

MacDonald, A., Oalmann, J. and Dai, F., 2024, P1726B: U-Pb zircon geochronology report on 6 detrital samples: Report to BHP, Chile, 12 p.

MacDonald, A., Oalmann, J. and Dai, F., 2024, P1768: U-Pb zircon geochronology report on 6 samples: Report to ALS, 9 p.

MacDonald, A., Oalmann, J. and Dai, F., 2024, P1771: U-Pb zircon geochronology report on 1 detrital sample: Report to ALS, 6 p.

MacDonald, A., Oalmann, J. and Dai, F., 2024, P1790: U-Pb zircon geochronology report on 10 samples: Report to Anglo American, Chile, 7 p.

Missen, O.P., 2024, Introduction to Element 2: Pathways to Production, November 2024 update: RRC SRM #3, 27 November 2024, p. 171-184.

Missen, O.P. and Cooke, D.R., 2024, Alkaline drainage in Merrywood Creek below former Merrywood coal mine: research and potential solutions for a rare Tasmanian problem: Report to

Mineral Resources Tasmania (MRT), 30 April 2024, 34 p.

Missen, O.P., Cooke, D.R. and Belousov, I., 2024, Sources and Drivers of Neutral Mine Drainage at the Former Merrywood Coal Mine: Report to Mineral Resources Tasmania (MRT), 18 June 2024, 40 p.

Mondal, P., Hunt, J., Missen, O.P. and Zhang, L., 2024, Vanadium potential at the Savage River magnetite deposit: RRC SRM #3, 27 November 2024, p. 185-210.

Montoya-Lopera, P., Cooke, D.R., Cracknell, J., Halley, S., Zhang, L. and Cima, A., 2024, Deciphering high-grade Cu-Mo porphyry mineralizing vectors through geochemical, mineralogical and textural signatures, Ocelot deposit, Arizona, USA: Amira P1249 SRM #5, 12 & 13 June 2024, p. 204-227.

Morissette, M. and Oalmann, J., 2024, P1640: U-Pb zircon geochronology report on twelve samples: Report to Anglo American, Canada, 9 p.

Morissette, M. and Oalmann, J., 2024, P1645: U-Pb zircon geochronology report on 13 samples: Report to BHP, Peru, 12 p.

Morissette, M. and Oalmann, J., 2024, P1649: U-Pb zircon geochronology report on 10 samples: Report to Teck, Australia, 11 p.

Morissette, M. and Oalmann, J., 2024, P1650: U-Pb zircon geochronology report on 6 samples: Report to Teck, USA, 9 p.

Morissette, M. and Oalmann, J., 2024, P1656: U-Pb zircon geochronology report for one sample: Report to Teck, Australia, 6 p.

Morissette, M. and Oalmann, J., 2024, P1658: U-Pb zircon geochronology report on five samples: Report to ALS Global, 8 p.

Morissette, M. and Oalmann, J., 2024, P1659: U-Pb zircon geochronology report on five samples: Report to ALS Global, 7 p.

Morissette, M. and Oalmann, J., 2024, P1671: U-Pb zircon geochronology report on five samples: Report to Anglo American, Chile, 8 p.

Morissette, M. and Oalmann, J., 2024, P1676: U-Pb zircon geochronology report on 4 detrital samples: Report to Empire Energy, 10 p.

Morissette, M. and Oalmann, J., 2024, P1678: U-Pb zircon geochronology report for one sample: Report to First Quantum, Chile, 6 p.

Morissette, M. and Oalmann, J., 2024, P1680: U-Pb zircon geochronology report on six samples: Report to Anglo American, Peru, 9 p.

Morissette, M. and Oalmann, J., 2024, P1684: Zircon U-Pb geochronology and trace elements in two samples: Report to BHP, Chile, 7 p.

Morissette, M., Oalmann, J. and Belousov, I., 2024, P1677: U-Pb zircon geochronology report on six samples: Report to Barrick, Dominican Republic, 7 p.

Morissette, M., Oalmann, J. and Olin, P., 2024, P1615: U-Pb zircon geochronology report on eight samples: Report to Anglo American, Peru, 9 p.

Morissette, M., Oalmann, J. and Olin, P., 2024, P1632: U-Pb zircon geochronology report on 8 detrital samples: Report to Teck, Peru, 14 p.

Morissette, M., Oalmann, J. and Olin, P., 2024, P1635: U-Pb zircon geochronology report on four samples: Report to Anglo American, Chile, 8 p.

Morissette, M., Oalmann, J. and Olin, P., 2024, P1639: U-Pb zircon geochronology report on eleven samples: Report to Anglo American, Chile, 11 p.

Naimbale, N.N., Cooke, D.R., Hong, W. and Scott, R., 2024, Severn tin deposit: mineral alteration and strategic/critical metals mineralisation: RRC SRM #3, 27 November 2024, p. 113-133.

Oalmann, J. and Dai, F., 2024, P1773: U-Pb geochronology report on 6 samples: Report to Anglo American, 19 p.

Oalmann, J. and Dai, F., 2024, P1788: U-Pb geochronology report on 9 samples: Report to Anglo American, 23 p.

Oalmann, J. and Dai, F., 2024, P1795: U-Pb zircon geochronology report on five samples: Report to ALS Global, 7 p.

Oalmann, J. and Dai, F., 2024, P1797: U-Pb zircon geochronology report on 2 samples: Report to ALS Global, 7 p.

Oalmann, J. and Dai, F., 2024, P1827: U-Pb zircon and apatite geochronology report on 3 samples: Report to First Quantum, Peru, 7 p.

Oalmann, J., Dai, F. and Carrasco, C., 2024, P1767: U-Pb zircon geochronology report on six samples: Report to Inflection Resources, 8 p.

Oalmann, J., Dai, F. and Morissette, M., 2024, P1714: U-Pb zircon geochronology report on 6 detrital samples: Report to Anglo American, Chile, 12 p.

Oalmann, J. and Morissette, M., 2024, P1624: U-Pb rutile and monazite geochronology report on 6 samples: Report to Anglo American, Namibia, 11 p.

Oalmann, J. and Morissette, M., 2024, P1633: U-Pb apatite, titanite, and rutile geochronology report on 12 samples: Report to Anglo American, Angola, 23 p.

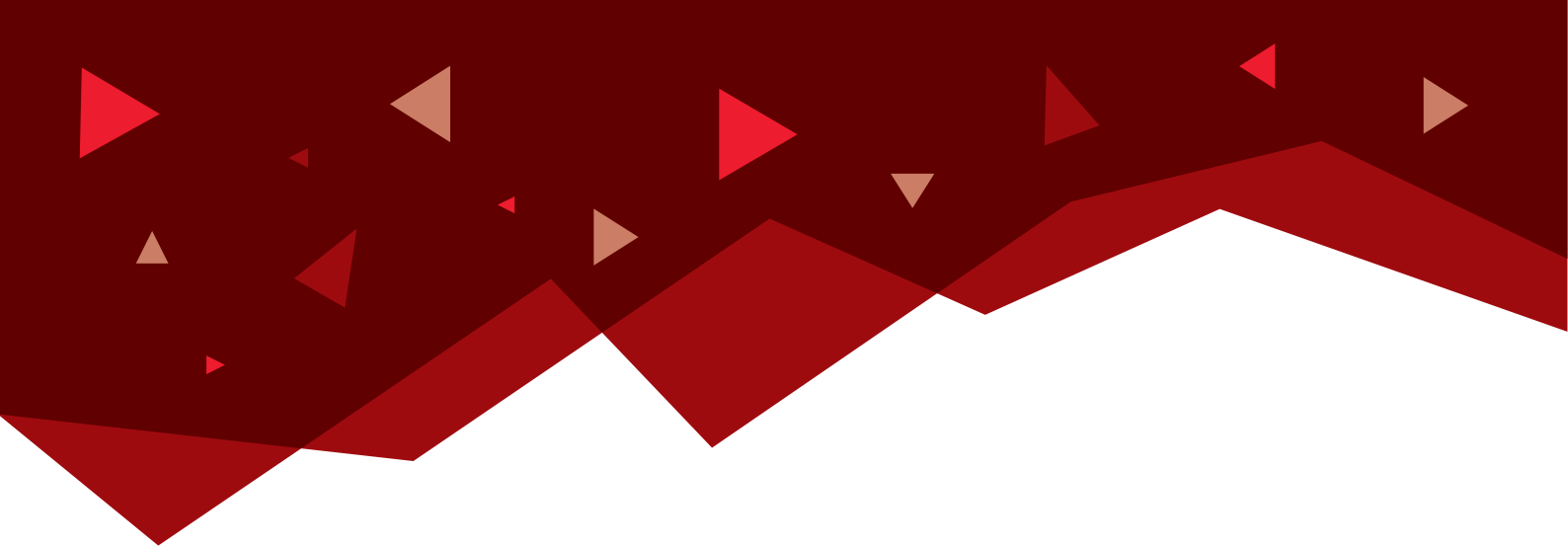
Oalmann, J. and Morissette, M., 2024, P1685B: U-Pb zircon geochronology report on ten samples: Report to BHP, Peru, 9 p.

Oalmann, J., Morissette, M. and Dai, F., 2024, P1687: U-Pb zircon geochronology report on 11 samples: Report to Teck, Chile, 11 p.

Oalmann, J., Morissette, M. and Dai, F., 2024, P1729A: U-Pb zircon geochronology report on six samples: Report to Barrick, Peru, 11 p.

Oalmann, J., Morissette, M. and Dai, F., 2024, P1756: U-Pb zircon geochronology report on one sample: Report to ALS Global, 6 p.

Oalmann, J., Morissette, M. and Dai, F., 2024, P1757: U-Pb zircon geochronology report on two samples: Report to ALS Global, 7 p. Oalmann, J., Morissette, M. and Olin, P., 2024, P1624: U-Pb apatite and titanite geochronology report on 6 samples: Report to Anglo American, Namibia, 11 p. Oalmann, J., Morissette, M. and Olin, P., 2024, P1624: U-Pb zircon geochronology report on six samples: Report to Anglo American, Namibia, 9 p. Oalmann, J., Morissette, M. and Olin, P., 2024, P1638: U-Pb zircon geochronology report on 10 samples: Report to Anglo American, Peru, 11 p. Olin, P. and Dai, F., 2024, P1672: Cobalt and copper contents in various minerals in three samples: Report to ALS, 7 p. Olin, P. and Dai, F., 2024, P1673: Tin contents in iron hydroxides and oxyhydroxides in two samples: Report to ALS, 3 p.	Tasmania geochronology and infrared spectroscopy [Poster Speed Talk]: RRC SRM #3, 27 November 2024, p. 214-216. Sun, Y., Zhang, L., Escolme, A. and Cooke, D.R., 2024, Gold deportment study at the Lepanto QPG deposit, Mankayan District, Philippines: Amira P1249 SRM #5, 12 & 13 June 2024, p. 175-203. Sun, Y., Zhang, L., Escolme, A. and Cooke, D.R., 2024, Multiple porphyry and epithermal deposits associated with the Mankayan lithocap, Philippines: Amira P1249 SRM #5, 12 & 13 June 2024, p. 339-361. Turner, C., Hollings, P. and Zhang, L., 2024, Northwest Expo Lithocap, Canada - Pyrite Textures and Chemistry: AMIRA P1249 SRM #6, 4 & 5 December 2024, p. 329-357. Ward, J., 2024, Slab tearing as a driver of porphyry ore deposit formation in island arcs [Poster Speed Talk]: RRC SRM #3, 27 November 2024, p. 223-224.	Yuleridge, V., Oalmann, J. and Morissette, M., 2024, P1682: U-Pb zircon geochronology report on fifteen samples: Report to Anglo American, Chile, 13 p. Yuleridge, V., Oalmann, J. and Morissette, M., 2024, P1683: U-Pb zircon geochronology report on eleven samples: Report to Anglo American, Chile, 11 p. Yuleridge, V., Oalmann, J. and Morissette, M., 2024, P1685A: U-Pb zircon geochronology report on ten samples: Report to BHP, Peru, 11 p. Yuleridge, V., Oalmann, J. and Morissette, M., 2024, P1693: U-Pb zircon geochronology report on five samples: Report to ALS Global, 8 p. Yuleridge, V., Oalmann, J. and Morissette, M., 2024, P1694: U-Pb zircon geochronology report on three samples: Report to ALS Global, 7 p. Yuleridge, V., Oalmann, J. and Morissette, M., 2024, P1696: U-Pb zircon geochronology report on four samples: Report to First Quantum, Chile, 7 p.	
Olin, P., Oalmann, J. and Dai, F., 2024, P1689: Lithium contents in various minerals in one sample: Report to ALS, 4 p. Osorio, J., Cooke, D.R., Zhang, L. and Belousov, I., 2024, Vertical profile of hydrothermal alteration in the Valeriano deposit, Chile: Amira P1249 SRM #5, 12 & 13 June 2024, p. 362-407. Pimentel, G., Baker, M., Cracknell, M. and Hollings, P., 2024, Platreef data wrangling for mineral characterization: AMIRA P1249 SRM #6, 4 & 5 December 2024, p. 439-459. Piquer, J., 2024, Geology of the Nolasco-Santa Clara district: Amira P1249 SRM #5, 12 & 13 June 2024, p. 421-453. Piquer, P., Muñoz, S., Navarro, R., Belousov, I., Baker, M., Hollings, P., Cajal, Y. and Salazar, E., 2024, Mineral chemistry studies in the El Teniente district: AMIRA P1249 SRM #6, 4 & 5 December 2024, p. 263-306. Piquer, J., Navarro, R., Rojas, I., Uribe, J., Belousov, I. and Baker, M., 2024, El Teniente district tourmaline and white mica chemistry: Amira P1249 SRM #5, 12 & 13 June 2024, p. 290-316. Santos Costa, A.I., 2024, The world-class Dolphin W deposit, King Island,	Ward, J., Oalmann, J. and Dai, F., 2024, P1681C: U-Pb zircon geochronology report on five samples: Report to Teck, USA, 8 p. Ward, J., Rosenbaum, G. and Ubide, T., 2024, Slab tearing as a driver of porphyry ore deposit formation in island arcs: AMIRA P1249 SRM #6, 4 & 5 December 2024, p. 75-130. Yuleridge, V. and Oalmann, J., 2024, P1652: U-Pb zircon geochronology report on 8 detrital samples: Report to Teck, Peru, 14 p. Yuleridge, V. and Oalmann, J., 2024, P1654: U-Pb zircon geochronology report on 10 detrital samples: Report to BHP, Chile, 16 p. Yuleridge, V., Oalmann, J., Hohl, M. and Morissette, M., 2024, P1647: U-Pb zircon geochronology report on four samples: Report to Anglo American, Europe, 8 p. Yuleridge, V., Oalmann, J. and Morissette, M., 2024, P1681A: U-Pb zircon geochronology report on fifteen samples: Report to Teck, USA, 11 p. Yuleridge, V., Oalmann, J. and Morissette, M., 2024, P1681B: U-Pb zircon geochronology report on twelve samples: Report to Teck, USA, 11 p.	Yuleridge, V., Oalmann, J. and Morissette, M., 2024, P1707: U-Pb zircon geochronology report on 9 detrital samples: Report to First Quantum, Australia, 15 p. Yuleridge, V., Oalmann, J. and Morissette, M., 2024, P1708: U-Pb zircon geochronology report on 5 detrital samples and 2 igneous samples: Report to First Quantum, Zambia, 15 p. Yuleridge, V., Oalmann, J. and Morissette, M., 2024, P1709: U-Pb zircon geochronology report on two samples: Report to First Quantum, Argentina, 7 p. Yuleridge, V., Oalmann, J. and Morissette, M., 2024, P1713: U-Pb zircon geochronology report on four samples: Report to ALS Global, 8 p. Yuleridge, V., Oalmann, J. and Morissette, M., 2024, P1716: U-Pb zircon geochronology report on four samples: Report to Inflection Resources, 8 p. Yuleridge, V., Oalmann, J. and Morissette, M., 2024, P1733: U-Pb zircon geochronology report on one sample: Report to BHP, Chile, 6 p.	Hekla volcano in Iceland photographed by Rebecca Carey while doing fieldwork in 2024. Yuleridge, V., Oalmann, J. and Morissette, M., 2024, P1739: U-Pb zircon geochronology report on six samples: Report to Inflection Resources, 8 p. Yuleridge, V., Oalmann, J. and Morissette, M., 2024, P1743: U-Pb zircon geochronology report on two samples: Report to BHP, Chile, 7 p. Yuleridge, V., Oalmann, J. and Morissette, M., 2024, P1744: U-Pb zircon geochronology report on one igneous sample and one detrital sample: Report to BHP, Chile, 8 p. Yuleridge, V., Oalmann, J. and Morissette, M., 2024, P1679: U-Pb zircon geochronology report on ten samples: Report to Teck, Chile, 10 p. Yuleridge, V., Oalmann, J. and Morissette, M., 2024, P1766: U-Pb zircon geochronology report on one sample: Report to Barrick, Ecuador, 7 p. Yuleridge, V., Oalmann, J., Morissette, M. and Hohl, M., 2024, P1648: U-Pb zircon geochronology report on 8 detrital samples: Report to Teck, Australia, 14 p. Yuleridge, V., Oalmann, J., Morissette, M. and Hohl, M., 2024, P1651: U-Pb zircon geochronology report on twelve samples: Report to Anglo American, Canada, 9 p. Yuleridge, V., Oalmann, J., Morissette, M. and Hohl, M., 2024, P1653: U-Pb zircon geochronology report on nine samples: Report to Anglo American, Canada, 9 p. Yuleridge, V., Oalmann, J., Morissette, M. and Hohl, M., 2024, P1655: U-Pb zircon geochronology report on 10 detrital samples: Report to BHP, Chile, 16 p. Yuleridge, V., Oalmann, J., Morissette, M. and Hohl, M., 2024, P1633: U-Pb zircon geochronology report on twelve samples: Report to Anglo American, 11 p. Yuleridge, V., Oalmann, J., Morissette, M. and Hohl, M., 2024, P1660: U-Pb zircon geochronology report on seven samples: Report to ALS Global, 9 p. Yuleridge, V., Oalmann, J., Morissette, M. and Hohl, M., 2024, P1661: U-Pb zircon geochronology report on twenty-five samples: Report to ALS Global, 17 p. Yuleridge, V., Oalmann, J., Morissette, M. and Hohl, M., 2024, P1664: U-Pb zircon geochronology report on one sample: Report to ALS Global, 6 p. Yuleridge, V., Oalmann, J., Morissette, M. and Hohl, M., 2024, P1665: U-Pb zircon geochronology report on two samples: Report to ALS Global, 7 p. Yuleridge, V., Oalmann, J., Morissette, M. and Hohl, M., 2024, P1667: U-Pb zircon geochronology report on seven samples: Report to BHP Chile, 11 p. Yurdakul, E., 2024, Critical metal by-products of Cu – Au in the Western Tharsis high sulfidation epithermal deposit, Tasmania [Poster Speed Talk]: RRC SRM #3, 27 November 2024, p. 211-213. Zhang, L. and the AMIRA P1249 research team, 2024, P1249 Module 1 Introduction – Vectoring and Fertility: AMIRA P1249 SRM #6, 4 & 5 December 2024, p. 21-39. Zhang, L. and the AMIRA P1249 research team, 2024, P1249 Module 1 Synthesis – vectoring and fertility: Amira P1249 SRM #5, 12 & 13 June 2024, p. 228-289.



Appendices

CODES postgraduate students 2024

Bachelor of Science (Honours) (2)

Student	Supervisors	Research Program	Project	Support
William Grant ^	Roach, Duffett (MRT)	6	Geophysical investigation into the geometry of dolerite intrusions of North Bruny Island, Tasmania	MRT, GSA
Sarah Purdom ^	Meffre, Steadman	1	Genesis of a possible IRGS deposit near Stawell, Victoria	Battery Minerals

Graduate Certificate in Economic Geology (13)

Student	Supervisors	Research Program	Project	Support
Sammy Bakie ^			coursework only	
Caitlin Brown			coursework only	
Erick Camara Corona ^			coursework only	
Ristch Camille ^			coursework only	
Danielle Kelly			coursework only	
Stephen Ledger			coursework only	
Thomas Lucas ^			coursework only	
Bethany Moore			coursework only	
John Robinson ^			coursework only	
Chadwick Tilly ^			coursework only	
Joel Verus			coursework only	
Alice Wilkinson			coursework only	
Zhi Yen Yow			coursework only	

Degree completed, not yet graduated ^ Graduated § Withdrawn

Master of Economic Geology (69)

Student	Supervisors	Research Program	Project	Support
Michael Adams ^			coursework only	
Greg Amalric			coursework only	
Dale Annison			coursework only	
Samantha Ash-Minto			coursework only	
Jessica Askew ^			coursework only	
John Ateny			coursework only	
Stuart Badock			coursework only	
Ashleigh Ball	Cooke	1	Geology, structural control and exploration implications of Au mineralized Fenix gold project, Maricunga Belt, Chile	Rio2 Limited
Grace Barber			coursework only	
Joel Blake ^			coursework only	
Kymren Bolling-Mcdougall			coursework only	
James Bresnahan			coursework only	
John Brewster			coursework only	
Callan Brown			coursework only	
Lachlan Burrows			coursework only	
Ristch Camille			coursework only	
Kaitlin Catalano			coursework only	
Mark Chamberlain			coursework only	
Duncan Chessell			coursework only	
Brianna Clark ^			coursework only	
Jesse Coates-Marnane			coursework only	
Sarah Cochrane			coursework only	
Samuel Connell			coursework only	
Craig Crossland			coursework only	
Jamie Cudby			coursework only	
Roseanna Dale ^			coursework only	
Jonathan Davis			coursework only	
Alison Dines			coursework only	
Lucas Doherty			coursework only	
Santiago Duque Palacio			coursework only	
Emmet D'Urso			coursework only	
Mark Eastlake			coursework only	
Paul Edmonds ^			coursework only	
Brynache Ellingworth			coursework only	
Erik Fabreschi			coursework only	
Joshua Greene	Zhang	1	The geological and geochemical fingerprinting of high-grade gold mineralisation in the Shepherd deposit, Costerfield Victoria	Mandalay Resources
Shelley Greener			coursework only	
Michael Harris			coursework only	
Jane Harvey			coursework only	
Calvin Hayre			coursework only	
Fungai (Grace) Jaravani			coursework only	
Lucy Jones ^	Berry, Escolme	2	Characterisation of ore textures at Cannington Mine by Automated Mineral Analysis and implications for processing	South32

Degree completed, not yet graduated ^ Graduated § Withdrawn

Student	Supervisors	Research Program	Project	Support
Elizabeth Liepa			coursework only	
Esther Little			coursework only	
Francisco Maturana			coursework only	
Corinna-Lee Mostyn			coursework only	
Dominic Murphy #			coursework only	
Ana Nichols			coursework only	
Craig Pereira			coursework only	
Luke Pickering			coursework only	
David Gerardo Portocarrero Ccaccya ^			coursework only	
Nicholas Poznik #			coursework only	
Steven Rennick ^			coursework only	
Alex Richards			coursework only	
Callum Richardson			coursework only	
Torrin Rowe			coursework only	
Nicholas Ryan			coursework only	
Md Sadikul Islam			coursework only	
Henry Schaumburg	Zhang, Hong	1	The Kara Fe-W skarn: A mineral chemistry and age dating study to better determine controls on skarn formation	self-funded
Joel Sidoruk			coursework only	
Callum Spink			coursework only	
Antoinette Stryk			coursework only	
Laura Talbot			coursework only	
James Taylor			coursework only	
Alan Till			coursework only	
Madeline Wallace			coursework only	
Alexander Waters			coursework only	
Megan Weatherman			coursework only	
David Willis			coursework only	

Doctor of Philosophy (47)

Student	Supervisors	Research Program	Project	Support
Christopher Allen	Meffre, Miller, Cracknell, Missen	2	Optimising remediation of legacy mines – mineralogical controls on long-term waste rock weathering and mine drainage	UTAS, MRT, Bluestone Mines
Alfredtina Appiah	Hunt, Missen, Fathi	2	Pathways to production: Magnesite deposits at Prospect Ridge, northwestern Tasmania	UTAS, RRC, GWR
Fuseini Atanga	Baker, Armistead, Zhang	1	Deposit characterisation and exploration vectors for the Akyem orogenic gold deposit, Ghana	Newmont, UTAS, Amira P1249
José Barillas Diaz	Cooke, Zhang	1	Atypical nickel mineralization in metasomatic rocks – The Avebury Ni deposit, Western Tasmania	RRC, UTAS, Avebury Nickel Mine
Billy Beas	Cooke, Zhang, Carey	1	Orebody knowledge, halogen deportment and vectoring implications of the E44 Au-Cu deposit, Northparkes District, New South Wales, Australia	UTAS, Amira P1249

Degree completed, not yet graduated ^ Graduated § Withdrawn

Student	Supervisors	Research Program	Project	Support
Damian Braize	Steadman, Meffre	3	Mineral chemistry and geochronology of the Tennant Creek IOCG deposits	UTAS, Emmerson Resources, Geoscience Australia, NTGS
Catherine Brown	Carey, Oalmann	4	Volcano rock properties	UTAS
Isaac Brown	Zhang, Cooke, Rodemann (CSL)	1	Geology, geochemistry and genesis of the Havieron gold copper deposit, Paterson Province, Western Australia	Newmont, UTAS, SEG
Axel Cima	Belousov, Cooke, Cracknell	1, 5, 6	Microinclusions in porphyry Cu deposits	UTAS, Amira P1249, CODES
Acacia Clark	Carey, Jutzeler, Fox (IMAS)	4	Dynamics of subaerial silicic explosive volcanism: The 1315 CE Kaharoa eruption and the Late Bronze Age eruption of Santorini	UTAS, GNS, ANZIC, GSA Endowment Fund
Takeshy Coaquira	Cooke, Zhang, Escolme	1, 2	Mineral chemistry tools for targeting copper porphyry deposits: A case study of the supergiant high-grade Resolution Cu-Mo deposit, Arizona	ARC TMVC, Amira P1202, UTAS
Stephen Cooke	Cracknell, Baker, Zhang	1, 6	Pathways to mineral discoveries through computer-based modelling of geochemical data	UTAS, Amira P1249
Francisco Cuadra Amaro	Baker, Hunt, Cracknell	1, 2, 6	Nautanen IOCG Deposit: Geometallurgical program	UTAS, Boliden Mineral AB, Amira P1249
Vinicius da Cruz	Cooke, Zhang, Carey	1	Characterisation of the complex orebodies in the Rosebery Middle Mine: implications for ore processing and mineral exploration	RRC, UTAS, MMG
Isaac Evinemi	Cracknell, Baker, Zhang	1, 6	Mineralogical domaining and predictive modelling of porphyry copper deposits using deep learning approach	Amira P1249, UTAS
Alex Farrar ^	Cracknell, Cooke	1, 3, 6	Tectonic and structural controls on the spatio-temporal distribution of giant porphyry copper deposits in the Central Andes	First Quantum Minerals
Shannon Frey	Jutzeler, Carey	4	Behaviour of submarine caldera-forming silicic eruptions in the Kermadec arc, New Zealand	UTAS
Javier Gil Rodriguez	Cooke, Missen, Hong	1	Characterisation of skarn-type deposits: Renison Bell Sn deposit	UTAS, RRC, Bluestone Mines, SEG
Declan Higgins §	Carey, Oalmann	4	Volcanic architectures	UTAS
Max Hohl ^	Steadman, Cloutier, Barker	3	Defining the mineral chemistry footprints of the Starra iron oxide-copper gold deposits in northwest Queensland	UTAS, GSQ
Malai Ila’ava #	Jutzeler, Carey, Cas	4	Cambro-Ordovician volcanic facies, stratigraphy, and geochemistry of the Cowal Igneous Complex, New South Wales, Australia	ARC Linkage, UTAS, Evolution Mining, GSNSW
Colin Jones ^	Meffre, Cooke, Orovan	3, 4	The petrogenesis of the Devonian granites of the East Tasmania Terrane	MRT, ARC TMVC, UTAS
Rhiannon Jones ^	Cooke, Zhang, Escolme	1, 2	The significance of phyllic alteration at the E26 porphyry Cu-Au deposit, NSW, Australia	Amira P1202, ARC TMVC, UTAS
Bridie Le’Gallais	Belousov, Falloon, Carey	4	The tectonic significance of mafic/ultra mafic igneous rocks in western Tasmania	UTAS, MRT, CODES
Catherine Lit	Jutzeler, Carey, Belousov	4	Tephra geochemical fingerprinting	ARC Discovery, UTAS

Degree completed, not yet graduated ^ Graduated § Withdrawn

Student	Supervisors	Research Program	Project	Support
Elena Lounejeva [^]	Steadman, Large	3	Trace element geochemistry of pyrite in sediments across the Permian Triassic boundary	ARC Discovery, CODES
Javier Merrill [^]	Cracknell, Escolme	2	Quantification of mineral texture for geometallurgical predictive modelling	Amira P1202, Minerals Council of Australia, BECAS Chile, ARC TMVC
Pratichée Mondal	Hunt, Zhang, Missen	2	Critical metal potential in the Savage River magnetite deposit, northwest Tasmania	RRC, UTAS, Grange Resources
Hannah Moore [#]	Carey, Jutzeler	4	Reconstructing eruption and transport processes of the 1886 basaltic Plinian eruption at Tarawera volcano, New Zealand	UTAS, UHawaii, UOtago, GNS Science
Emmanuel Dogara Musa	Hunt, Missen, Fathi	2	Pathways to production for critical metals: Kara W deposit, western Tasmania	RRC, UTAS, Tasmania Mines
Nelao Natukondje Naimbale	Cooke, Hong, Scott	1	Characterisation of the Heemskirk tin project	RRC, UTAS, Stellar Resources
Jaime Osorio	Zhang, Cooke	1	Anatomy of the porphyry-epithermal transition in the Valeriano Cu-Au deposit, Chile	ARC TMVC, UTAS, Amira P1202, SEG, ATEX Resources
Giovana Pimentel	Baker, Cracknell, Hollings (Lakehead)	1	Rock characterisation of Platreef Style PGE mineralisation	Anglo American, Amira P1249, UTAS, SEG
Olive Ponyalou	Cooke, Missen, Zhang	1	Geology, genesis, and exploration significance of Cu-Au veins and altered rocks in the Kainantu Cu-Au district, PNG	K92 Mining, UTAS
Arka Sahu	Zhang, Cracknell, Rodemann (CSL)	1, 6	Method development for quantitative prediction of mineralogy, mineral chemistry, and proximity to orebody in porphyry deposits from near-infrared spectral data: Case studies from El Teniente (Chile), and Batu Hijau (Indonesia)	UTAS, Amira P1249
Angela Isaura Santos Costa	Cooke, Zhang, Cajal	1	Characterisation of tungsten mineralisation at Grassy, King Island, Tasmania: Implications for magmatic-hydrothermal sources, ore genesis, and exploration	UTAS, RRC, Group 6 Metals
Thomas Schaap [#]	Meffre, Whittaker (IMAS), Cracknell, Roach	3, 6	Tectonic evolution of the early Palaeozoic Lachlan Orogen	ARC Linkage, UTAS
Xin Ni Seow [^]	Zhang, Cooke, Orovan	1, 5	Genesis, geochemistry and spectral characteristics of alunite supergroup minerals: Implications in lithocap and porphyry explorations	ARC TMVC, UTAS, Amira P1202, SEG
Emily Smyk [^]	Cooke, Baker, Cracknell	1	Geology, geochemistry, geochronology and exploration footprints of the Christmas porphyry Cu-Mo deposit, Arizona	Amira P1202, ARC TMVC, UTAS
Peerapong Sritangsirikul	Meffre, Khin Zaw, Charusiri (CU)	1, 3, 4	Tectonic evolution and related mineral deposits of mainland SE Asia: Insights from geochemistry and geochronology of zircons	Royal Thai Government Scholarship
Markus Staubmann	Cooke, Hunt, Cracknell	1, 2, 6	Geology, geochemistry, and geometallurgy of the GRE46 epithermal gold deposit, Cowal District NSW	Evolution Mining, UTAS, Amira P1249

Degree completed, not yet graduated ^ Graduated § Withdrawn

Student	Supervisors	Research Program	Project	Support
Yi Sun [^]	Zhang, Escolme, Cooke	1, 2	Geology of the Quartz – Pyrite – Gold (QPG) mineralization and the new model of the Mankayan District, Northern Luzon, Philippines	ARC TMVC, Amira P1202, UTAS, SEG, Lepanto Consolidated
Victor Torres Pacheco	Cooke, Zhang, Hunt	1, 2	Geology, genesis, and geometallurgy of Cu-Au-Ag mineralized tourmaline breccia pipes at Soledad, central Peru	Chakana Copper, UTAS
Poliana Vidal Salgado	Baker, Steadman, Cajal	1, 4	Characterization and paragenesis of the Magdalena VHMS Deposit, Iberian Pyrite Belt, Spain	UTAS, Sandfire MATSA, Amira P1249
Shouchun Yu	Meffre, Steadman, Cracknell	1	Mineral geochemistry of IOCG deposits	UTAS, IOCG [§]
Emrecan Yurdakul	Zhang, Baker, Scott	1	Orebody knowledge of the Western Tharsis Cu-Au deposit, Tasmania: implications for ore processing and mineral exploration	UTAS, MRT, UTAS Foundation, CMT, Sibanye-Stillwater
Zebedee Zivkovic [^]	Baker, Cracknell, Barker	1, 4	Trace element systematics in whole rock analysis of magmatic-hydrothermal ore deposits	MRT, Mineral Mapping, Dreadnought Resources

Degree completed, not yet graduated ^ Graduated § Withdrawn

Major externally funded research projects^

ARC Discovery Grants 2024

Investigators	Project	Funding Body	Period	ARC Funding for 2024
Jutzeler, Carey, Gallagher (UMelb)	Eruption dynamics and tsunami potential from submarine volcanoes	ARC	2023–2026	\$258,928
Seton (USyd), Carey, Williams (IMAS), Coltrice (ENS Lyon), Duncan (Oregon)	How Earth's deep interior communicates with the surface	ARC	2020–2024	**

ARC Discovery Grants – Fellowships 2024

Investigators	Project	Funding Body	Period	ARC Funding for 2024
Carey (Future Fellowship)	Decoding risks and unlocking rewards of oceanic volcanism	ARC	2024–2028	\$162,944

ARC Linkage Grants 2024

Investigators	Project	Funding Body	Period	ARC Funding for 2024	Partner Funding for 2024
Carey, Cas, Cooke, Meffre, Bull (GSNSW), Rowland (UAuckland), Heap (IPGS)	Exploration targeting from next-generation volcanic facies reconstruction	ARC, Evolution Mining, Mineral Resources Tasmania	2020–2024	**	\$2,000

Department of Education Grants 2024

Investigators	Project	Funding Body	Period	DESE Funding for 2024	Partner Funding for 2024
Cooke, Hunt, Fraser, Rodemann (CSL), Zhang, Belousov, Beasy, Cirkony, Cracknell, Missen, Fathi, Cajal, Hong, Armistead, Pirard (ULiege)	Building capacity in Regional Australia to enhance Australia's economy through research, training, and environmentally sustainable production of critical metals	Department of Education, Mineral Resources Tasmania	2022–2025	\$1,915,091	\$0

Industry and other externally funded research grants 2024

Investigators	Project	Funding Body	Period	Funding for 2024
Cooke, Baker, Cracknell, Escolme, Zhang, Ailleres (Monash), Halley (Mineral Mapping), Hollings (Lakehead), Piquer (UAustral)	Amira P1249: Exploring, characterising and optimising complex orebodies – upscaling orebody knowledge to add value across the Mining Value Chain	Amira Global representing: Anglo American, BHP, Boliden Mineral, Codelco, Evolution Mining, Fortescue Metals Group, Mount Isa Mines, Newcrest Mining, Newmont Goldcorp, Rio Tinto Exploration, South32, First Quantum Minerals, CMOC Mining, Sandfire Resources, AngloGold Ashanti	2022–2027	\$794,736
Zhang, Testa	Unlocking hidden mineral resources in the Pajingo district, North Queensland, Australia	Auspin Exploration	2024–2025	\$200,000
Meffre, Armistead, Steadman	Exploring for the future: Temporal controls on mineralisation	Geoscience Australia	2022–2026	\$85,455

^ projects with greater than \$2,000 external funding per year ** all project funding received, project still active

Investigators	Project	Funding Body	Period	Funding for 2024
Steadman	Iron oxide copper-gold deposits: Geochemistry and geometallurgy	Evolution Mining, Geological Survey of Queensland, Geological Survey of South Australia, Georgina Resources, Mineral Resources Tasmania, Mount Isa Mines, OZ Minerals, Red Metal, Rex Minerals, Spanish National Research Council	2022–2025	\$150,000
Steadman	Mineral chemistry and event chronology of the Tennant Creek, Rover, and East Tennant IOCG districts, Northern Territory	Emmerson Resources, Northern Territory Geological Survey	2024–2027	\$75,000
Roach	Immersive virtual excursions on critical minerals for clean energy transitions	RWTH Aachen University	2023–2025	\$68,401
Baker, Armistead, Zhang, Atanga (student)	Deposit characterisation and exploration vectors for the Akyem orogenic gold deposit, Ghana	Newmont Australia	2023–2027	\$62,500
Zhang, Cooke, Rodemann (CSL), Brown (student)	Geology, geochemistry and genesis of the Haviron gold-copper deposit, Paterson Province, Western Australia	Newcrest Mining	2021–2025	\$60,938
		Society of Economic Geologists Foundation	2023–2024	\$7,624
Baker, Hunt, Cracknell, Cuadra (student)	Nautanen IOCG deposit characterisation	Boliden Mineral AB	2024–2028	\$60,000
Cooke, Missen, Zhang, Ponyalou (student)	Geology, genesis, and exploration significance of Cu-Au veins and altered rocks in the Kainantu Cu-Au district, PNG	K92 Mining	2024–2028	\$48,370
Montoya	Detailed petrography characterisation of Ag high-grade hydrothermal mineralisation, geochronostratigraphy and tectonic events of the San Marcial deposit, Mexico	GR Silver Mining	2024–2025	\$42,500
Baker, Cracknell, Hollings (Lakehead), Pimentel (student)	Rock characterisation of the PlatReef	Anglo American	2024–2027	\$31,500
Baker, Steadman, Cajal, Vidal (student)	Magdalena VHMS deposit paragenesis	Sandfire MATSA	2024–2028	\$20,000
Hunt	Methodology development for gangue liberation assessment	CSIRO	2022–2024	\$7,588
Cooke, Hong, Missen, Gil Rodriguez (student)	Characterisation of skarn-type deposits: Renison Bell Sn deposit	Society of Economic Geologists Foundation	2024–2025	\$7,268
Cooke, Zhang, Cajal, Costa (student)	Characterisation of tungsten mineralisation at Grassy, King Island, Tasmania: Implications for magmatic-hydrothermal sources, ore genesis, and exploration	Society of Economic Geologists Foundation	2024–2025	\$7,179
Meffre, Missen, Cracknell, Miller, Jamieson (Queens U), Allen (student)	Optimising remediation of legacy mines – mineralogical controls on long-term waste rock weathering and mine drainage	Mineral Resources Tasmania	2022–2025	\$0
		Bluestone Mines	2022–2025	\$5,000
Meffre, Steadman, Goemann (CSL)	Mineral chemistry research for Battery Minerals	Battery Minerals	2022–2024	\$4,713
Miller, Cracknell, Cooke, Hunt, Staubmann (student)	Integrated ore deposit knowledge: optimising mineralogical characterisation through the mining value chain	Evolution Mining	2022–2025	\$3,726
Zhang, Osorio (student)	Porphyry to epithermal transition at the Valeriano Cu-Mo-Au Deposit, Chile	Society of Economic Geologists Foundation	2024–2025	\$3,633

^ projects with greater than \$2,000 external funding per year ** all project funding received, project still active

Investigators	Project	Funding Body	Period	Funding for 2024
Missen, Cooke	Sources and drivers of neutral mine drainage at the former Merrywood coal mine	Mineral Resources Tasmania	2023–2024	\$2,200
Zhang, Baker, Scott, Yurdakul (student)	Nature of the Western Tharsis mineralisation	UTAS Foundation	2024–2026	\$2,000
Carey, Jutzeler, Clark (student)	Submarine deposits from the Late Bronze Age (Minoan) eruption – IODP Exp 398: Hellenic Arc Volcanic Field	ANZIC-IODP (via Australian National University)	2023–2025	**
Cooke, Zhang, Hunt, Torres (student)	Geology, genesis and geometallurgy of Cu-Au-Ag mineralised tourmaline breccia pipes at Soledad, central Peru	Chakana Copper	2022–2028	**
Belousov, Falloon, Carey, Le'Gallais (student)	The tectonic significance of mafic/ultramafic igneous rocks in western Tasmania	Mineral Resources Tasmania	2019–2026	**
Jutzeler	Antarctic volcanism record in the Amundsen Sea, IODP 379	ANZIC-IODP (via Australian National University)	2023–2025	**
Zhang, Greene (student)	The geological and geochemical fingerprinting of high-grade gold mineralisation in the Shepherd deposit, Costerfield Victoria	Mandalay Resources	2023–2025	**
Cooke, Cloutier	Exploring for the future: uncovering Australia's exploration potential	Geoscience Australia	2021–2025	**
Carey, Clark (student)	Dynamics of subaerial silicic explosive volcanism: The 1315 CE Kaharoa eruption and the Late Bronze Age eruption of Santorini	IODP (via Australian National University)	2023–2024	**
		Geological Society of Australia	2023	**
Cooke, Portocarrero (student)	Multi-stage intrusion, brecciation and mineralization at the Antakori Cu-Au-Ag project, northern Peru	Regulus Resources	2022–2024	**
M Kamenetsky	Olympic Dam fluid/melt inclusion project	BHP	2021–2024	**
Cooke, Baker, Cracknell, Meffre, de Selincourt (student)	Application of mineral chemistry to aid exploration for Cu-Au-Mo porphyry mineralisation in the Temora district, New South Wales	Sandfire Resources	2021–2024	**

^ projects with greater than \$2,000 external funding per year ** all project funding received, project still active

Visitors 2024

INDUSTRY VISITORS TO CODES IN 2024

NAME	COMPANY
Jeffrey Bigelow	Newmont
John Bishop	Mitre Geophysics
Scarlett Blewett	Rio Tinto
Renato Bobis	South32
Natalee Bonnici	Venture Minerals
Neil Chalmers	Strategic Energy Resources
Jing Chen	AngloGold Ashanti
Kate Cocker	Rio Tinto
Iain J Dalrymple	Anglo American
Rob Duncan	Rio Tinto
Erik Fabreschi	Investigator Resources
Alex Farrar	First Quantum Minerals
Russell Fitzpatrick	Newmont
Bright Makafui Foli	Amira Global
Ingrid Flemons	Rio Tinto
Kim Frankcombe	ExploreGeo
Karyn Gardner	Evolution Mining
Mohsen Hadizadeh	Rio Tinto
Scott Halley	Mineral Mapping
Ben Hames	AngloGold Ashanti
Anthony Harris	Newmont
Brett Harris	AngloGold Ashanti
Tobias Hermansson	Boliden
Ned Howard	Evolution Mining
Jonathon Hoyer	Evolution Mining
Richard Inglis	Newmont
Andrew Jenkins	AngloGold Ashanti
Alan Kobussen	Rio Tinto
Atsuhiko Kuroda	Sumitomo Metal Mining Oceania
Kit Lai	Fortescue Metals
Alexey Lygin	Grange Resources
Haley McGillivray	Amira Global
Aaron Megaw	Sumitomo Metal Mining Oceania
Adam Pacey	Rio Tinto
Paull Parker	Sandfire Resources
Josh Phillips	GP Geoscience
Alejandro Pizarro	BHP
Cameron Quinn	Evolution Mining
Luis Quispe Renteria	First Quantum Minerals
Jay Robbie	AngloGold Ashanti
Carolina Rodriguez	Codelco
Ivan Semenov	Rio Tinto

INDUSTRY VISITORS TO CODES IN 2024 cont.

NAME	COMPANY
Xin Ni Seow	AngloGold Ashanti
Anil Subramanya	Amira Global
Stephen Swatton	CopperCorp Resources
Luke Swift	AngloGold Ashanti
Helen Thomas	Boliden
Victor Torres Pacheco	Anglo American
Blake Tyrell	Rio Tinto
Marina Veter	Rio Tinto
Michael Whitbread	Rio Tinto
Alexander Willcox	Newmont
David Wood	Anglo American
Matthew Zengerer	Gondwana Geoscience

NATIONAL ACADEMIC AND GOVERNMENT VISITORS TO CODES IN 2024

NAME	INSTITUTION
Michael Anenburg	Australian National University
Jessica Askew	Student
Stephen Barnes	CSIRO
Evgeniy Bastrakov	Geoscience Australia
Steve Beresford	Centre for Exploration Targeting & Trillion Metals
Phil Blevin	University of New England
Steve Boger	Geoscience Victoria
Kymren Bolling-Mcdougall	Student
Ralph Bottrill	Mineral Resources Tasmania
Ray Cas	Monash University
Mark Chamberlain	Student
Joshua Chambers	[attended symposium, no affiliation]
Yanbo Cheng	Geoscience Australia
Maria Cherdantseva	University of Western Australia
Duncan Chessell	Student
Jonathan Cloutier	Geoscience Australia
Grace Cumming	Mineral Resources Tasmania
Jonathan Davis	Student
Josh Denholm	[attended symposium, no affiliation]
Mark Duffett	Mineral Resources Tasmania
Pablo Farias	Northern Territory Geological Survey
Muhammad Fariz	University of New South Wales
Arianne Ford	Geoscience Australia
Denis Fougrouse	Curtin University
Ignacio Gonzalez-Alvarez	CSIRO
David Green	Mineral Resources Tasmania
Lorraine Ingham	CoSE, UTAS

NATIONAL ACADEMIC AND GOVERNMENT VISITORS TO CODES IN 2024 cont.

NAME	INSTITUTION
Verity Kameniar-Sandery	Mineral Resources Tasmania
Carmen Krapf	Geological Survey of South Australia
Ryan Manton	CSIRO
Andrew McNeill	Mineral Resources Tasmania
Rachael Morgan	Geoscience Australia
Indrani Mukherjee	University of New South Wales
Mareen Loesing	University of Western Australia
Thomas Rodemann	CSL, UTAS
Mareike Rosemann	Monash University
Nicholas Ryan	Student
Henry Schaumburg	Student
Charlys Vaz de Sant’Anna Neves	Monash University
Michael Vicary	Mineral Resources Tasmania
Zhen Wang	Monash University
Samuel Waugh	Geoscience Victoria
Zhi Yen Yow	Student

INTERNATIONAL ACADEMIC AND GOVERNMENT VISITORS TO CODES IN 2024

NAME	INSTITUTION
Jason Dyer	Lakehead University, Canada
Xuejing Gong	Chinese Academy of Geological Sciences, China
Jiafeng He	Nanjing University, China
Peter Hollings	Lakehead University, Canada
Zhang Jing	China University of Geosciences (Beijing), China
Simon Jowitt	University of Nevada, Reno, USA
Kobul Khiaosanuan	Chulalongkorn University, Thailand
Yiguan Lu	China University of Geosciences (Beijing), China
José Piquer	Universidad Austral de Chile, Chile
Nafiu Sulyman	Lakehead University, Canada
Chase Turner	Lakehead University, Canada
Lin Yang	China University of Geosciences (Beijing), China
Yaoyao Zhang	Chinese Academy of Geological Sciences, China



Participants on the Volcanology and Mineralisation in Volcanic Terrains Masters short course pictured at the top of Mt Tarawera, New Zealand, in March 2024.

CODES
Centre for Ore Deposit and Earth Sciences
University of Tasmania
PO Box 807, Sandy Bay, Tasmania 7006,
Australia
Tel +61 (0) 3 6226 2472
ISSN: 1440-6411
© Centre for Ore Deposit and
Earth Sciences

Compilation: Caroline Mordaunt
and Helen Scott
Editing: Caroline Mordaunt
Design: Before Creative, Hobart

