

ORE SOLUTIONS

NEWSLETTER OF **CODES** CENTRE FOR ORE DEPOSIT AND EARTH SCIENCES

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CODES TEAM WINS BIG IN GLOBAL EXPLORER CHALLENGE

A team of researchers from CODES – aptly named Team deCODES – has won the Student Team Prize (\$50,000) in the Uearthed/OZ Minerals Explorer Challenge. This prestigious prize was one of a number of prizes awarded in the Explorer Challenge competition, which tasked entrants with finding new exploration targets in the Prominent Hill region, South Australia.

For the deCODES team, made up of five early career researchers – CODES PhD students Chris Leslie, Shawn Hood and Ayesha Ahmed, and CODES/TMVC postdoctoral researchers Dr Matthew Cracknell and Dr Angela Escolme – the prize represents an important step as they establish themselves in a competitive exploration environment. The five team members possess a varied skill set, spanning economic geology and mineral exploration, geophysics, data science, geochemistry and geometallurgy. Most of them have returned to academia following stints



Winning formula: In June the deCODES team was announced as the winner of the Student Team Prize (worth \$50,000) in the Uearthed/OZ Minerals Explorer Challenge: (L-R) Shawn Hood, Ayesha Ahmed, Dr Angela Escolme, Dr Matthew Cracknell and Chris Leslie.

working in mineral exploration in Australia and Canada.

The deCODES team was up against a large number of entrants; the Explorer Challenge attracted over a thousand participants globally from 62 countries, and required the deCODES team to trawl through over five terabytes of data from OZ Minerals' Mount Woods tenements in order to produce new exploration targets.

Team leader Chris Leslie says: 'Our approach was driven by considering an iron oxide copper gold (IOCG) metallogenic model, and then striving to produce digital proxies for all aspects of that model. Our prospectivity layers were created using a mix of manual and traditional data handling methods as well as

basic machine learning approaches'. He describes a process of building up 'layers of information' around the problem, then identifying areas with favourable geological characteristics.

'Some of these layers came from fairly traditional approaches, such as linking geophysical signatures to characteristic IOCG mineralogy, and others from less-conventional approaches (e.g., using simple natural language processing to extract significant keywords from geological logging notes).

'The resultant layers were integrated using a combination of machine learning tools and expert assessment of predictions and prediction confidence to generate our final models,' Chris explains.

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PhD student Shawn Hood points out that, 'although terms like "big data" and "machine learning" are prevalent in the field of economic geology, what isn't well understood by some is that these methods are just tools in the mineral explorer's toolbox, and not all problems are solved using the most sophisticated computational techniques'.

Careful not to overlook the value of sound geological knowledge in the generation of valid computer-assisted prospectivity models, and because of their backgrounds in traditional metals exploration, the group approached the project like they would any other: 'Understand the local geology and controls on known mineralisation, and then look for ways to extrapolate this domain knowledge into unknown areas.'

They say that the competition taught them a lot about problem solving, the importance of careful data management, and teamwork – particularly as some members of the team relocated to Canada mid-competition! 'Given our varied skill sets, we have also learnt new skills from each other, which is a great take away,' Dr Angela Escolme points out.

The competition has fed the deCODES researchers' appetite for tackling

similar exploration projects full-time. They say they'll be refining and applying components of the workflow that they developed during the competition in their own resource exploration endeavours.

Postdoctoral research fellow Matthew Cracknell says that the Explorer Challenge has also provided an excellent model for teaching and learning, and that the benefits of their participation could be far-reaching in future.

'The potential for learning and fostering problem solving, data management and teamwork skills offered by the Explorer Challenge is difficult to replicate in traditional teaching environments. Some of us, as tertiary-level educators, would like to explore the possibility of setting up teams of undergraduate and postgraduate students to work on future Unearthed projects.'

In addition to a \$1 million prize pool, the winning models produced by the teams in the Explorer Challenge will be tested in real life, with the top targets scheduled to be drilled by the end of 2019 with the prospect of unearthing the next big Australian mineral deposit.

This article incorporates edited text from the Unearthed website.

OUTREACH

'BORING BILLION' NO MORE...

CODES postdoctoral researcher Dr Indrani Mukherjee gave an extremely well-received and entertaining talk at the Tasmanian Museum and Art Gallery as part of the third Beaker Street Pop-up Science Bar, which took place in mid-August across several Hobart venues.

Her talk, entitled 'The evolution of life on Earth: Rethinking the 'Boring Billion', explored what shaped the transition from a microbe-dominated planet to the huge variety of life that exists today. This evolution has always fascinated geologists. Indrani's talk focussed on some of the key biological events between 1800 and 800 mya, infamously known as the 'Boring



Billion', and provided a geological explanation for the cause of these events. The talk tied together the geochemical conditions of the ocean and atmosphere, with evolution and diversification of complex microscopic life, that facilitated macroscopic life on Earth.

HIGH PRAISE FOR PAST CODES PHD GRADUATE

CODES PhD graduate Dr Dave Braxton has recently been awarded the prestigious Brian J. Skinner Award for the most outstanding paper to be published in the journal *Economic Geology* during 2018. His paper was based on his CODES PhD project, which he completed in 2007.

Dave Braxton's article was titled 'Geology of the Boyongan and Bayugo Porphyry Cu-Au Deposits: An Emerging Porphyry District in Northeast Mindanao, Philippines', and the associate authors were David Cooke (his PhD supervisor), Allan Ignacio and Patrick Waters.

Larry Meinert, Editor in Chief of *Economic Geology*, summarised the article as follows:

'This well executed and detailed study provides an excellent summary of the geology, alteration, and mineralization of the Boyongan and Bayugo porphyry copper-gold prospects in the Philippines. It presents an outstanding integration of observational data with the regional and local tectonostratigraphic and metallogenic setting; what these deposits look like and their mineralization, alteration, and grade footprints; and the interrelationships among magmatism, hydrothermal alteration and mineralization and how the deposits formed. It is also well written, beautifully illustrated, and readily comprehensible by any economic geologist. This paper will surely have a lasting impact in the field of economic geology due to its strong foundation in observational data from the field and drill core.'

Dave Braxton here gives a bit of background as to how he came to write the paper, his interest in geology and his time at CODES:

What does the award mean to you?

I am humbled that our paper has been so well-received and highly considered. I sincerely hope that it helps to inspire the next generation of economic geologists.

Can you explain a little about the background to the paper and how you came to write it?

The paper is derived from a PhD study I completed at CODES in 2007. The Boyongan and Bayugo copper-gold deposits represent porphyry discoveries by Anglo American in a district historically known for epithermal gold. Collectively their endowment exceeds 2.3 Mt contained copper and 7.3 Moz gold. As deposits that are completely concealed beneath post-mineralization volcanic and sedimentary cover, their discovery is emblematic of the challenges (cover) and opportunities (new search space) that the industry faces.

The Boyongan deposit has the deepest-known supergene oxidation profile of any porphyry system ever described, approaching 600 m below the paleosurface. In contrast, the supergene profile at adjacent Bayugo is substantially thinner and different in character (including an enriched and exotic copper zone). From a scientific perspective these geologically young (< 2.4 Ma) and well-preserved deposits provide an excellent laboratory to understand the duration of hypogene (< 200 ka) and supergene (1.6 Ma) processes contributory to superior grade development.



Award winner: Dr Dave Braxton pictured in China during fieldwork undertaken in 2018.

Tell us a little about your time at CODES

My experience at CODES as a PhD student was transformative for me as a scientist and an economic geologist. It was a privilege to work in such a diverse, dynamic and multi-disciplinary group passionate about understanding the critical processes of ore deposit formation. Dave [Cooke] was instrumental throughout the project, from its first conception, through his probing questions, and his unrelenting use of the red pen in the stages of writing the thesis and the derivative paper.

What is it that motivates you as a geologist?

I have a passionate and profound interest in attempting to understand the natural world and in applying this insight to create value (sensu lato) for society through discovery.

Can you talk a little about your current role at Anglo American and what you're working on?

I am currently the head of discovery strategy for Anglo American plc, a role linking my minerals systems interests to systems-wide value drivers in the natural resources sector. My responsibilities include setting the strategic framework and portfolio management for Discovery, leading the global generative group across a spectrum of commodities, and driving innovation in Minerals System science to unlock new strategic search space.

All at CODES join in congratulating Dave Braxton on his award.

WELL-DESERVED HONOUR FOR PROFESSOR JOCELYN MCPHIE

In June, Professor Jocelyn McPhie was presented with the Twelvetrees Medal for 2019 by the Tasmanian Division of the Geological Society of Australia for 'meritorious contributions to Tasmanian geology'.

Jocelyn is the first woman to receive this award and stands alongside an illustrious list of Tasmanian geologists. Other recipients since its inception ten years ago have been Keith Corbett (2010), Max Banks (2011), Nic Turner (2012), Clive Calver (2013), David Leaman (2015) and Ron Berry (2016). The medal is not necessarily awarded every year. The Twelvetrees Medal recognises either important contributions to the Earth Sciences within Tasmania (including Macquarie Island), or outstanding contributions to Earth Sciences while resident in Tasmania.

Jocelyn's significant contribution to the Earth Sciences both in Tasmania and globally is well-known. In the words of Dr Karin Orth:

Jocelyn has been instrumental in understanding the Cambrian-Cenozoic volcanic history of Tasmania. She has unpicked the complex volcanic and alteration history of the important ore-hosting Mt Read Volcanics in western Tasmania, and also made key contributions to understanding the geology of the more recent Tasmanian Cenozoic volcanic rocks. New understanding of the Tasmanian volcanic terrains has been achieved through her own research, collaborations with local, national and international researchers and industry partners through CODES, and by the supervision of Honours, Masters and PhD students at the University of Tasmania.



Professor Jocelyn McPhie accepts her Twelvetrees Medal for meritorious contributions to Tasmanian geology from Dr Andrew McNeill, treasurer of the Tasmanian branch of the GSA (photo: Matt Ferguson).

Jing shines again in China

Recently submitted PhD student Jing Chen (second from right) has again received an award in China. During April, Jing won an award for the best talk in her field at the 4th National Young Geologists Conference, which took place in Hefei.

Her talk centred around a paper she has worked on with other geologists, including those from CODES. The details of the talk were:

Jing Chen, Jose Piquer, David R. Cooke, David Selley and Lejun Zhang, 2019, 'Structural controls on geometry of orebodies of epithermal deposits – a case study of Zijinshan Au-Cu deposit, Fujian'.

Well done Jing!



WHERE ARE THEY NOW?

In our continuing series of short interviews with past CODES alumni, Dr Vanessa Lickfold talks about her current role with BHP and how the mining industry will evolve in the future.

'FABULOUS ROCKS' AND WHAT THEY REALLY MEAN



VANESSA LICKFOLD

Head of Geoscience, Western Australia Iron Ore, BHP

PhD: 'Intrusive history and volatile evolution of the Endeavour porphyry Cu-Au deposits, Goonumbla district, NSW, Australia', completed 2002 at CODES

What is your current job and your work responsibilities?

I head up the geology department for iron ore at BHP in Perth...Gee... how would I describe it? Essentially, I take full accountability for all of the geological aspects of production for the Pilbara iron ore operations, which includes brownfields exploration, resource definition drilling through to resource estimation, grade control modelling and operational geology, the whole lot.

What are the things you enjoy most about this role?

Probably the biggest thing at the moment is just seeing the team come to life and actually get the value of geology up and running... because without being really targeted, everything usually goes back to 'Oh that's just a bad geological model'... and the blame tends to sit with the geologists because they always get it wrong! But, what we are doing, and what I am really enjoying, is our geologists beginning to say 'Well, that's

actually what I do to make it work; that's the value in the geology'.

My view is that if we understand what's in the ground, we can actually make the right decisions going forwards for operational margins; it's really all about trying to translate what we see as 'fabulous rocks' into 'here's what this rock versus that rock means to the next person in the value chain'. That's probably the greatest enjoyment part. There are a lot of other things that come into the mix to get it to work like that...but that's probably the thing I like the most.

How did you end up getting into the position you're now in, and was it a logical progression?

Yes, it probably was...I started in production in open pit coal mining way back when, and then went into base metals exploration before going into heavy minerals sands exploration and mining project development. I then took time out from industry to complete my PhD at CODES in something completely different –

porphyry copper-gold deposits in NSW – before going back into geology as a resource evaluation geologist. When the company I worked for split in two, one part managing the iron ore assets, I got the opportunity to head up a small geology department for a few years before moving into business development and assessing iron ore opportunities in West and Central Africa. My husband, also a CODES PhD graduate, and I then moved to London to follow his career in oil and gas. I was lucky enough there to find an opportunity in facilitating early mining studies. This in a nutshell was just really how does geology work with mining engineering, minerals processing, infrastructure engineering and the whole kit and kaboodle to get a mining project to work.

And I then left that and went into consulting, which was a great eye-opener for where geology might fit into the future of mining automation. Then a job came up in BHP Australia doing a very similar thing to what I did for the iron ore company in South Africa – running a geology department for a number of operations. So, it was fairly logical that it would be a good job for me. It's funny though, it was Steve [my husband] who saw the advert and suggested I apply as I wasn't looking because I had been doing a whole bunch of other things and hadn't thought of going back into operations.

Did you find that more difficult being female?

No...although I do understand that there are challenges. I have been very lucky to have not experienced many real issues. Or, it's possibly that I see them but ignore them and refuse to make them relevant – but I think a lot of that is because it's just who I am. I do want to say though, just because that's who I am doesn't mean that's who everyone else should be like and I do see that other people don't necessarily

have the same attitude and therefore do find it a bit more difficult. I really respect this and acknowledge that in general, we all collectively have things to learn in the mining industry about being inclusive.

What has been your career highlight or greatest achievement to date?

Assisting getting a base metals project in Finland through the first phase so that it could go to pre-feasibility...that was really cool. The project had been a discovery that hadn't progressed through the evaluation process for a number of years for a variety of reasons. We then got the opportunity to do a whole bunch of work with a multidisciplinary team to think about it differently and actually managed to envisage a small, but potentially viable and valuable project...and we got it over the line.

When you were here at CODES what did you specialise in?

Porphyry copper-gold deposits...I did porphyry copper-golds at NorthParkes in New South Wales...stranger things have happened, but yeah...[laughs]...

And did that particular project help you get where you are today do you think?

Yes, it definitely did...not directly because I went straight back into something that had nothing to do with porphyries, but it certainly gave me the edge in a lot of the business development work that I did. For example, when I got the opportunity to go to Chile in my Early Studies role and say 'Well I actually do have porphyry copper experience...how can I help in that area of study?' So, my PhD on porphyry copper deposits certainly helped when it came to understanding mineralisation in a way that I could translate it into business value.

I do think having a PhD carries weight – weight in that it demonstrates you have to have overcome challenges, have gone beyond the everyday to seek something different; not the same weight everywhere you go, but there is weight behind a PhD. And there's definitely weight behind a PhD from here [CODES]...because everybody

'I do think having a PhD carries weight – weight in that it demonstrates you have to have overcome challenges, have gone beyond the everyday to seek something different...'

knows about CODES. You can almost go anywhere in the world and they'll say 'What were you doing in Hobart? Oh...you were at CODES, that's right'.

How has the industry changed over your career; how have you seen it change?

I think there is definitely more data out there and with more data people are expecting better answers and in a shorter period...and they're thinking they're going to get more and more deposits just because they've got more data, but that's not reality. The reality is that the easy deposits have already been found and we now have to employ more data and more sophisticated techniques to find them. It's just a better way of being able to assess the data...so the more you can assess, the fuller picture you get. But it's still going to be uncertain because you don't mine by teaspoon.

I do think there is an expectation that the more data you get the better deposits you're going to find. But that's not true; what is happening is that companies expect the uncertainty to be less, and hopefully, with the future of mining this is going to be the case.

And how do you see the industry developing into the future?

Technology... it's going to be automation...well, if it's not automated it's definitely going to be automated and it's going to be in real time. I don't think you'll ever replace geologists because we're doing quite a lot of work

in that space at the moment. You can operate your trains from Perth, you can operate your trucks from Perth, you can run your plant from Perth. You probably will at some point be able to drill remotely but you will always need to know 'How do I join that dot to that dot?' Because you can't tell data to do that until you can do that yourself. So, I do think it's going to be technology-driven, data-driven, but there will always be a verification and validation aspect to our geological decisions, autonomous or otherwise.

Do you have any words of wisdom for up-and-coming geologists?

Yes, I do actually, and they're probably dependent on which direction people go in. It's exciting to do some exploration and to find something but the question is what to do with it. So, it's being able to really start thinking about what you see as a geologist – somebody else isn't going to see it if they're not a geologist. So how do you translate what you see into language that somebody else understands. And really thinking who you're delivering your work to, why you're delivering it, versus 'I've got this beautiful geology'. That doesn't mean anything to anybody who's not a geologist. Not because I'm not passionate about geology. I absolutely am, and your geologists will be as well. But we need to be able to translate that into a language that other people can see as well. Because they'll just see a rock and say 'Well, I need to get that rock from there to there'. They're not really worried about what it looks like and how it got there. How do we translate that? And we as geologists don't traditionally do that very well, so here's our chance...

So it's communication?

...Yes, but it's communicating what you need, understanding what the other person wants and then being able to communicate that to them.

And a little-known fact or two about yourself?

I play classical guitar. I have an identical twin who didn't study science at all... what else? I'm a keen gardener, love gardens...that's probably enough [laughs]...

CODES PHD STUDENTS AT THE CUTTING EDGE



CODES Director Professor David Cooke reflects on the success – past and present – of the CODES PhD program...

Over the past three decades, CODES has built a strong reputation for training high-calibre PhD candidates with skills that are highly sought by the minerals industry. This is reflected by many of our graduates rising to senior positions in the minerals industry and academia. Our student cohort conducts research across the fundamental to applied spectrum, providing insights into diverse ore-forming environments, and into geological processes that can lead to ore formation across a range of scales. Our graduates are renowned for their ability to develop detailed orebody knowledge through geological, geometallurgical and geoenvironmental characterisation studies, and for developing new exploration techniques and insights.

Graduate students have been key members of CODES research teams working on our major industry-related research projects, and have delivered some of the most profound and far-reaching research outcomes from those projects. This tradition continues today – there are currently four PhD and four MSc students working on our Lachlan

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'Over the past three decades, CODES has built a strong reputation for training high-calibre PhD candidates with skills that are highly sought by the minerals industry.'

Fold Belt research initiative, and six CODES PhD students working on AMIRA P1202. The skills of our current student cohort are reflected in the recent success of the deCODES team, involving several of our PhD students and postdoctoral researchers, who won the student prize in the Unearthed/OZ Minerals Explorer Challenge (see page 1 of this newsletter).

Our proud tradition of graduate training continues unabated today, with a strong cohort of 37 PhD students working across our six research programs, with several other PhD students having recently completed and submitted their theses. In this edition of *Ore Solutions*, we showcase PhD students from each research program to highlight the breadth and depth of research activity taking place at CODES.

Volcanic processes: Adam Abersteiner was in the remote Kamchatka Mys, Far Eastern Russia, last year to collect samples of peridotites, picrites and basalts for his PhD research. He is pictured here with the Tolbachik volcano in the background.



ADAM ABERSTEINER

Supervisors: Vadim Kamenetsky, Maya Kamenetsky, Karsten Goemann (UTAS CSL)

Project title: Kimberlites and diamonds: Understanding their petrogenesis and uncovering the identity of their source composition

Adam Abersteiner's project is part of **Program 4: Magmatic and volcanic processes**, and his main PhD supervisor is Professor Vadim Kamenetsky, who has travelled with Adam to Russia on his sample collecting expeditions.

Adam commenced his PhD candidature in mid-2016, undertaking a project aimed at understanding the composition and evolution of kimberlite melts and the implications for the identity of their source in the mantle.

Kimberlites are amongst the rarest and most enigmatic igneous rocks, originating from the deepest derived terrestrial magmas. This deep origin, in conjunction with the intermittent relationship with diamonds, renders kimberlites an invaluable tool for examining magmatism in the subcontinental lithospheric mantle.

Adam's study applies a broad range of petrographic, geochemical and melt/fluid inclusion analyses to circumvent processes of contamination and alteration that are pervasive in kimberlite magmas and rocks. This project encompasses the study of numerous kimberlite localities from around the world – including South Africa, Russia, Finland and Canada – in order to reconstruct a global model for kimberlite petrogenesis.

Outcomes of Adam's research so far have highlighted the significance of carbonates along with alkalis/alkali-earths and halogens in kimberlite



Unique opportunity: PhD student Rob Davidson takes a breather from examining pervasive advanced argillic alteration at a prospect within the Saladillo district, Mexico, in July 2017.

magmatism, and the potential for these components to be lost or overprinted during magmatic ascent and emplacement in the crust. Adam's research is part of an ongoing investigation aimed at understanding deep mantle processes and associated magmatism.

'The most fascinating part of research is trying to formulate answers to new questions. The deep mantle is especially intriguing, as there is little known about what truly occurs down there. The pursuit of understanding these geological conundrums and being part of continually developing global research is very exciting and rewarding.'



ROB DAVIDSON

Supervisors: Bruce Gemmell, David Cooke

Project title: Geology and genesis of the San Sebastian vein system, Durango, Mexico

Rob Davidson's project sits within **Program 1: Ore deposits and mineral exploration**. His main supervisor Professor Bruce Gemmell emphasises its importance to our Program 1 research: 'Rob Davidson's project clearly fits into Program 1 as it uses newly developed geological, and geochemical features of sedimentary rock hosted, intermediate sulfidation epithermal systems in order to devise better means of discovering mineral resources at surface and under cover in Saladillo district, Mexico'.

'I am studying the San Sebastian intermediate sulfidation Ag-Au-Cu-Pb-Zn deposit which is within the Saladillo District located 100 km northeast of Durango City, in Durango State, Mexico. The project is generously sponsored by Hecla Mining Company which owns and operates the mine and is an active explorer within the district.'

'The mine has produced nearly 21 million ounces of Ag and 0.25 million ounces of Au and sits within the Mexican Silver Belt which is host to many prolific Ag producing districts including Fresnillo, Guanajuato and Pachuca. San Sebastian is unique within Mexican epithermal deposits in that it is hosted entirely within Late Cretaceous mudstones, as opposed to the more common Oligocene volcanics. Thus, this deposit provides an excellent opportunity to investigate the unique, and seldom studied, interaction of an intermediate sulfidation epithermal system with variably carbonaceous mudstones.'

'My research is focussing on the characterisation of the vein mineralogy, vein stages, host rocks and alteration footprint of the deposit, all within the context of developing exploration vectors for use within the Saladillo district and other epithermal environments. Two field seasons have allowed me to selectively review and sample core archives as well as to observe the main veins underground and within the open pits. My analytical work is well underway and has included optical petrography, sodium cobaltinitrite staining, SEM work for mineral identification, mineral mapping and imaging of zircons, C and O isotope analysis of host rock and vein carbonates, Raman spectrometry of host rock carbonaceous material, portable XRF, short-wave infrared spectrometry, and whole rock geochemistry. In addition, building 3D interpretations of lithology, structure, and vein geometry by working with an extensive drillhole database, has provided a critical framework within which I can interpret the results gained from the analytical program.'

'After working for ten years in industry, I had a clear vision of what I wanted to get out of my graduate school experience. My central goal was to work on a practical, applied research project in economic geology at an institution with the faculty experience and analytical equipment required to do so. These priorities are in direct alignment with the research goals and expertise of CODES and that seamless mesh has made my time here extremely rewarding!'



FUMIHIKO IKEGAMI

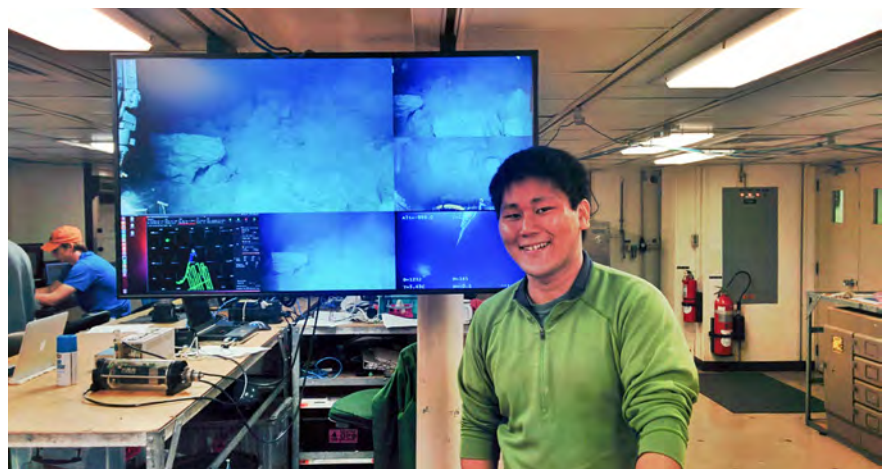
Supervisors: Rebecca Carey, Jocelyn McPhie

Project title: 2012 submarine silicic eruption of Havre volcano and implications for ancient submarine successions in Australia

Fumihiko Ikegami's project sits within **Program 4: Magmatic and volcanic processes**. Dr Rebecca Carey, Leader of Program 4 and Fumi's main supervisor, explains his PhD project and its significance for ancient submarine successions:

The seafloor beneath a deep ocean is one of the most remote places on the Earth: In 2015 Fumi took part in an international scientific voyage project to investigate a large submarine eruption of Havre caldera, New Zealand (1,519 metres below sea level), which occurred in 2012. He used geological and geospatial analyses, bathymetry, video, and rock samples acquired by underwater robots during the voyage to understand effusive and explosive eruption styles on the deep seafloor.

His results show that ~0.21 cubic km of lavas were erupted from 14 separate vents along the caldera rim. The



In-depth research: PhD student Fumihiko Ikegami in the lab of the research vessel RV *Roger Revelle* during seafloor rock sampling using a ROV (Remotely Operated Vehicle). The photo was taken in 2015 while Fumi was acquiring samples for his PhD research, in which he is investigating the 2012 large submarine eruption of Havre caldera, New Zealand.

vents occupy almost one-third of the caldera perimeter which suggests the ring fault of the caldera structure was significantly involved. Moreover, the emplacement environment seems to be the primary factor in lava morphology; some lavas descended the steep wall of the caldera with a slope of almost 40 degrees and formed extraordinary narrow tongue-like morphologies. The submarine lavas in the deep ocean that he has examined look similar to those of similar composition in subaerial environments, suggesting that eruption into water did not play a significant role in morphology. His current study is focussed on understanding how pre-existing sediments were remobilised in response to the lava emplacement on the caldera floor.

'The staff with their wide range of expertise, my amazing student colleagues, and the great structure and backup facilities of Earth Sciences and CODES have been significant factors in driving my research to arrive at a fundamental new understanding of deep ocean eruption processes. From attending seminars in a building at UTAS to standing in front of outcrops, I feel every discussion with these colleagues expands my knowledge of geology, volcanology and petrology. I also love the atmosphere here where there are many people of diverse backgrounds from countries all over the world, and I am so glad to be part of it.'



STEWART JACKSON

Supervisors: Michael Roach, Gerrit Olivier (Institute of Mine Seismology)

Project title: Integrating passive and active methods of seismic imaging for structural stability of tailings dams

Stewart Jackson's project lies within **Program 6: Geophysics and computational geosciences**. His main supervisor Dr Michael Roach

explains the importance of Stewart's research:

Recent tragic and highly publicised failures of mine tailings storage facilities have highlighted the need to better understand and characterise the mechanical properties and stability of both currently active and legacy tailings dams. Drilling and techniques such as cone penetrometer testing provide direct measurements of physical and mechanical properties but are expensive and provide only isolated information that often does not adequately characterise both lateral and vertical variability. Geophysical techniques, such as resistivity, self potential and electromagnetic methods, have been widely used on tailings dams to characterise hydrological parameters but provide only limited information on subsurface mechanical properties that affect dam stability. Active seismic techniques, including seismic refraction and multichannel analysis of surface waves (MASW), can provide indirect estimates of important physical properties that are relevant to dam engineering but the depth of investigation and three-dimensional coverage of these techniques is often inadequate to characterise the properties of deep dam and tailings materials or the underlying geology.

This project takes advantage of recent advances in seismic data acquisition hardware, imaging software and passive seismic methods and will provide three-dimensional images of both the shallow and deep features of mine tailings facilities. Shear wave velocities derived from these methods can be used to help assess the risks of static liquefaction and dam failure. Time series data from passive seismic deployments can also be used to assess the spatial pattern of dynamic responses due to natural and anthropogenic seismic disturbances. This work is being conducted as a collaboration between CODES, the Institute of Mine Seismology and engineering/environment consultancy GHD. The first passive seismic equipment deployment will be conducted at the Cadia mine tailings facility in NSW.



CHRISTOPHER LESLIE

Supervisors: Sebastien Meffre, David Cooke, Jeff Steadman

Project title: Porphyry and epithermal deposits of Cowal District, New South Wales

Christopher's research lies across **Program 1: Ore deposits and mineral exploration** and **Program 3: Sedimentation, tectonics and Earth evolution**.

Christopher Leslie commenced his PhD in late 2016 as part of a multidisciplinary ARC Linkage research project titled 'Ore deposits and tectonic evolution of the Lachlan Orogen, SE Australia'. Christopher's research is focussed on the Cowal District, New South Wales, where he aims to unravel the metallogenic evolution of this unique part of the Ordovician Macquarie Arc.

The Cowal District hosts a variety of mineral deposit types ranging from alkalic-type epithermal gold deposits to calc-alkalic porphyry Cu+Mo deposits/prospects and base metal-rich VMS prospects. This diversity in mineralisation styles makes for an



Wise words: CODES PhD student Christopher Leslie presenting on 'Fertile magma genesis: a zircon perspective' at PACRIM 2019.

interesting story of arc evolution and ore genesis.

While his main focus is on arc metallogeny, Christopher is also investigating magma fertility and deposit fingerprints using mineral chemistry. He is primarily focussed on zircons and is using new analytical methods developed at CODES to image the spatial distribution of trace elements in individual ~50–100 micron zircon grains. Zircons are excellent petrochronological tools because they record, in discrete crystal zones, the petrogenesis of the magma from which they crystallised. We have used this method to investigate when porphyry-related magmas inherit their high oxidation state and high-water contents, and also to fingerprint zircon signatures from fertile and barren intrusions.

'After first hearing about CODES in 2007 while working on my MSc at the University of British Columbia in Canada, I knew then that I would pursue my PhD at UTAS. Ten years later, the timing was perfect, an excellent opportunity surfaced, and we made the move to beautiful Hobart. I love being part of the wider research team here and learning from world-renowned experts in ore deposits. It's a great collaborative environment to be part of and has really opened my eyes to new avenues of research in economic geology.'



JAVIER MERRILL

Supervisors: Matthew Cracknell, Angela Escolme

Project title: Spatial interpolation of comminution indices using textural domains and features

Javier's project lies within **Program 2: Geometallurgy, geoenvironment and mining**, and the TMVC, and is part of the AMIRA P1202 Module 4 research. One of his supervisors, Dr Angela Escolme, explains the



High energy: Javier Merrill (left) pictured in April 2019 with Mike Baker (CODES), Alina Gaibor (BHP Spence) and one of his PhD supervisors, Angela Escolme (CODES), in the BHP Spence mine, Chile, where they were undertaking core logging and observing the textural variability of the core.

significance of Javier's research from a geometallurgical perspective: 'Javier is working at the forefront of one of the major challenges in the minerals industry: how to systematically identify and quantify textural features in rocks and determine what the implications of variability in these features are for the comminution stage of mineral processing. Javier's work will enable significant value to be unlocked from drill core imagery and provide links between inherent geological variability and mineral processing properties'.

The mining industry is well known for its high energy consumption, of which over half is used at the rock comminution stage of mineral processing. In the next six years this consumption is expected to increase by 30%, mainly due to the finer grinding required to liberate increasingly complex or refractory ore minerals.

From a mineral processing point of view, rock variability is a major source of inefficiency. Variability in rock properties challenge a plant's intended capacities by continually changing the feed attributes. These variations, especially when combined with

underestimated power consumption, can cause mineral processing plants to operate at suboptimal levels.

'In my PhD project, the relationship between rock composition and texture, with energy consumption at the comminution stage will be studied. The project involves the development of a technique for recognising textural features in hyperspectral drill core imagery and reviewing the relationship between texture and measured comminution indices. I intend to develop new approaches to accurately predicting the estimation of power consumption and thus processing costs. Successful outcomes will enable the installation of pre-emptive control measures for processing parameters. This will not only improve business profitability but will also assist in managing environmental and social impacts.'

'Studying at CODES represents an important opportunity for me as a mining engineer and a metallurgist to interact with geologists and build a more holistic view of the minerals industry. At the same time, it allows me to live in Tasmania, which is such a great place!'



SIBELE NASCIMENTO

Supervisors: Anita Parbhakar-Fox (external advisor), Matthew Cracknell, David Cooke

Project title: Geoenvironmental characterisation of historic mine tailings: Evaluating opportunities for reprocessing

Sibele Nascimento's PhD research lies within **Program 2: Geometallurgy, geoenvironment and mining**. Her external advisor Dr Anita Parbhakar-Fox emphasises the importance of the work that Sibele is doing:

'Realistic planning for the ongoing management of mine waste storage facilities and their eventual closure is increasingly demanded. Sibele's research includes gathering data on the chemical and physical characterisation of mine waste (e.g., waste rock, tailings, slag and spent heap leach materials). Ultimately, these data inform the engineering design for the long-term storage of these waste materials. If they are not well designed then there is strong potential to induce acid and metalliferous drainage (AMD) whereby sulfides contained in mine waste oxidise or catastrophic structural failures can occur as demonstrated at the Brumadinho Dam, Brazil, in January 2019.'

This study focusses on the Queen-King rivers system and King River Delta in western Tasmania and its legacy associated with waste rock/tailings repositories and AMD. This is the largest such site in Tasmania among the 215 historical mine sites with similar issues in the state.

Tailings at this site were generated by the Queenstown Mount Lyell Company, which was once the dominant mining company in western Tasmania, and operated from 1893 until 1994. As a result of non-existent environmental controls for the majority of the period



Economical potential: Sibele Nascimento carrying out a seismic and resistivity survey at the King River Delta, western Tasmania, during research for her PhD which examines the geoenvironmental characterisation of historic mine tailings in Tasmania.

of mining operations, mine wastes and pyritic tailings were disposed of into the Queen-King rivers system from 1916 to 1994 causing AMD and leading to a legacy of environmental degradation. Currently, this waste pyritic material resides in the overbank areas, river bottom and delta of the Queen-King rivers.

This research aims to characterise the tailings stored at the King River Delta using a range of instruments available at CODES and the Central Science Laboratory at UTAS (e.g., pXRF, XRD, MLA, SEM, LA-ICP-MS) as well as establish the geophysical constraints of the delta using different methods including seismic, resistivity and electromagnetics. Ultimately, investigations within this project will determine the economic potential of the tailings storage within the river system and delta.

'What excites me the most about this project is the idea of finding value in materials that were once defined as waste. In a world that is constantly seeking new inventions, obtaining critical metals from mineral waste is crucial for a more sustainable society and to ensure a better environment for future generations.'

Sibele was awarded the prize for the best student oral presentation in her field at the SGA meeting in Glasgow in August; this will be covered in our next newsletter.



THOMAS SCHAAP

Supervisors: Sebastien Meffre, Jo Whittaker (IMAS), Michael Roach, Matthew Cracknell

Project title: Plate tectonic modelling of the Early Palaeozoic evolution of South Eastern Australia

Tom's research project lies across **Program 3: Sedimentation, tectonics and Earth evolution** and **Program 6: Geophysics and computational geosciences**.

Associate Professor Sebastien Meffre explains the importance of this PhD project: 'Thomas' work will reconstruct the geometry of the crustal blocks in SE Australia in the Early Paleozoic. He will be using both new and existing data to improve the existing models and make a computer model in the G-Plates computer program. This work will also reconstruct the position of existing ore deposits in the area and help predict where the location of hidden undiscovered deposits'.



Tectonic trek: Tom Schaap setting off on a six-day trek to find outcrops for paleomagnetic analysis on the south coast of Tasmania for his PhD research into the plate tectonics of the Lachlan Orogen.

'The Lachlan Orogen is a collection of Palaeozoic geological and structural terranes, mostly situated in southeast Australia and with portions in Tasmania, Antarctica and New Zealand. The Lachlan has been studied by geologists for generations, including here at CODES, with particular focus on its mineral deposit wealth; however, there remains a significant degree of uncertainty over its tectonic history.'

'A vast array of literature has presented various models which describe the tectonic processes that generated the Lachlan Orogen. Arguments in these models arise from concepts such as Tasmania's role as a potential microcontinent – with an inferred northern extension beneath Victoria; the role and number of subduction zones – their timing, polarity, and location; and the hypothesis that the Lachlan Orogen was folded as a giant orocline. My work involves using modern plate reconstruction software to digitise the main competing models of the Lachlan Orogen. Digital models can

then be compared against knowledge and data in a consistent manner, such that the individual strengths and weaknesses of each model can be determined. This information will be used to ultimately construct a new series of models which can robustly explain the tectonic evolution of the Lachlan Orogen. Following on from this, geological, geochemical, and geophysical data sets will be integrated into the models and reconstructed through geological time to experiment with the effects of tectonic deformation. This information may then enhance our understanding of ore deposit evolution in the Lachlan which may aid explorers as we increasingly look into mining deposits buried deep beneath cover.'

'Working on this project at CODES allows me the freedom to pursue different avenues of research, with unlimited access to resources and some of the greatest minds in the business. When my work here is done, I know that I can proudly call myself a CODES graduate as a mark of a great international reputation.'



JAY THOMPSON

Supervisors: Leonid Danyushevsky, Sebastien Meffre

Project title: Understanding the specifics of H₂O-free aerosol behaviour in the inductively-coupled plasma in geochemical LA-ICP-MS applications involving U-Pb dating and accurate trace element analysis in silicate minerals and glasses

Jay's project sits within **Program 5: Analytical research**. His main supervisor, Professor Leonid Danyushevsky, Leader of Program 5, explains the context of the work Jay is doing in the labs here at CODES:

Jay joined CODES Analytical Laboratories in 2011 as a Laboratory Analyst in charge of one of our laser ablation analytical laboratories. From the outset he has shown a keen interest in analytical developments and became involved in a range of research projects aimed at better understanding the laser ablation process, developing methods



Analytical techniques: PhD student and Laboratory Analyst Jay Thompson assembling tubing that connects the laser cell (the gold-coloured box in the background) to the mass spectrometer at CODES. He is connecting tubing to a valve that allows the laser cell to be disconnected from the ICP-MS for sample exchanges.

for analysis of different silicate minerals, and developing methods for the Time-of-Flight mass-spectrometer. In 2015 he enrolled in the UTAS PhD program with a project focussed on understanding sample aerosol digestions in inductively-coupled plasma and development of U-Pb dating methods. His project has led to two publications in the *Journal of Analytical Atomic Spectrometry*, the leading journal in this field, with two further publications planned for submission in 2019.

'The results from my PhD project will benefit CODES directly by improving the analytical techniques performed here and this will also have a wider impact in the field of LA-ICP-MS. One aspect of this project is improving the accuracy and precision of U-Pb dating of minerals by investigating mineral-specific interactions during analysis by the LA-ICP-MS. Additionally, I am attempting to better understand processes occurring in the high temperature plasma used to ionize the aerosol from laser interaction with specific minerals. This improved understanding of processes during laser ablation can result in improved engineering of laser ablation systems going forward.'

'During my time at CODES I have had ample opportunity to learn from experts in the fields of economic geology and applications of LA-ICP-MS. Working with Leonid [Danyushevsky] has been a great opportunity to learn more about laser ablation, how instrumentation works and analytical method development. I will use the knowledge gained at CODES during my PhD as I progress in my career as an analytical geochemist.'

'I am starting a new position in September as an isotope geochemist working with NASA at the Johnson Space Centre analysing astromaterials by LA-ICP-MS for their chemical and isotopic contents. Working with NASA I hope to further our understanding of the solar system and answer significant questions in the scientific community. I have enjoyed my time at CODES and will miss the people and the place.'

Man on a mission: Tristan Wells suits up for another field trip to carry out further research into his PhD, which is examining magmatic apatite and zircon in the Lachlan Fold Belt, New South Wales.



TRISTAN WELLS

Supervisors: Sebastien Meffre, David Cooke, Jeff Steadman

Project title: Geochemistry and cathodoluminescence of magmatic apatite and zircon as vectors to mineralised centres within the Lachlan Fold Belt

Tristan's PhD research lies within

Program 1: Ore deposits and mineral exploration and **Program 3: Sedimentation, tectonics and Earth evolution.**

Supervisor Associate Professor Sebastien Meffre says that Tristan's work will examine the chemistry of minerals and rocks associated with known porphyry deposits focussing in particular on the Northparkes deposit. This work will help identify areas in SE Australia that are prospective for this type of deposit.



'I am studying the magmatic fertility of the Macquarie Arc of eastern Australia. To do this I am using a combination of whole rock geochemistry, apatite colour cathodoluminescence, and apatite, chlorite, epidote and pyrite mineral chemistry to assess magmatic fertility and to provide vectors towards mineralisation. I commenced my PhD in 2018 as part of the "Ore deposits and tectonic evolution of the Lachlan Orogen" ARC Linkage project, and have used the Northparkes district (central-west NSW) as a pilot area to test my methods and then expanded to other field areas and utilised publicly available data hosted by the Geological Survey of New South Wales.'

'As part of my research I have discovered a reliable wholerock geochemical indicator that is associated with mineralising intrusions in the Northparkes district. The geochemical indicator can be tested using low-cost, portable XRF analysis which provides much shorter turnaround than traditional assay methods. Apatite cathodoluminescence and mineral chemistry were tested to assess the viability of apatite as an indicator of and proximal to mineralised centres and to refine the geochronology of the Northparkes district. Initial results are relatively positive. I had planned to use zircons but they were in surprisingly low abundance in the porphyries at Northparkes.'

'Chlorite and epidote mineral chemistry were assessed from Northparkes and across the Macquarie Arc. The data will be used for vectoring in the Northparkes district and as a baseline data set for further studies in the Macquarie Arc. All data generated from this study will be used by Tom Schaap in his re-creations of the Macquarie Arc through time in order to better constrain the timing and likely location of the mineralised centres.'

'I chose to conduct my research at CODES due to the facilities available and the chance to work with leaders in the fields of economic geology and geochronology. The chance to be part of an ARC Linkage project on the Lachlan Orogen was also a key reason. I've enjoyed my time at CODES and look forward to continuing to conduct collaborative research after the completion of my PhD mid-next year.'

Location of current CODES/TMVC PhD projects



1. ADAM ABERSTEINER
CANADA, FINLAND, RUSSIA, SOUTH AFRICA

2. NATHAN CHAPMAN
GAWLER CRATON, SOUTH AUSTRALIA

3. ROB DAVIDSON
DURANGO, MEXICO

4. PETER DUERDEN
LACHLAN OROGEN, NSW

5. KYLE EASTMAN*
INDONESIA, ARGENTINA

6. ALEX FARRAR
CENTRAL ANDES, CHILE

7. MATT FERGUSON
GAWLER CRATON, SOUTH AUSTRALIA

8. AMOS GARAY*
LAS BAMBAS, PERU

9. UMER HABIB
LACHLAN OROGEN, VICTORIA, NSW

10. JACOB HEATHCOTE
ZAMBIA

11. MAX HOHL
MOUNT ISA, NORTHWEST QUEENSLAND

12. FUMIHIKO IKEGAMI
HAVRE VOLCANO, OFF NEW ZEALAND

13. LAURA JACKSON*
NEW SOUTH WALES

14. COLIN JONES*
EASTERN TASMANIA

15. JOSEPH KNIGHT
MYANMAR

16. ERIN LAWLIS
LIHIR, PAPUA NEW GUINEA

17. CHRISTOPHER LESLIE
COWAL DISTRICT, NSW

18. JAVIER MERRILL*
CHILE

19. SIBELE NASCIMENTO*
TASMANIA

20. THOMAS OSTERSEN
TASMANIA

21. NAOMI POTTER
TANZANIA, RUSSIA

22. THOMAS SCHAAP
TASMANIA, NSW, VICTORIA

23. XIN NI SEOW*
SOUTH KOREA

24. EMILY SMYK*
ARIZONA, USA

25. TOBIAS STAAL
ANTARCTICA

26. YI SUN*
PHILIPPINES

27. JENNIFER THOMPSON*
INDONESIA, PHILIPPINES

28. TRISTAN WELLS
LACHLAN FOLD BELT, NEW SOUTH WALES

Lab- and computer-based projects

- 29. PETER BERGER**
- 30. STEWART JACKSON**
- 31. STEPHEN KUHN***
- 32. ELENA LOUNEJEVA**
- 33. STEPHEN MEYER**
- 34. PETER MORSE**
- 35. ANNAH MOYO***
- 36. NANDA YUSENTRI MRABAWANI***
- 37. JAY THOMPSON**

*ARC TMVC Research Hub projects

CODES WELL-REPRESENTED AT PACRIM 2019

CODES PhD student Christopher Leslie reports on a successful PACRIM conference in New Zealand and why so many attendees went down the tubes.

In April a delegation of CODES PhD candidates and academic staff travelled to beautiful Auckland, New Zealand, for the 2019 PACRIM (Pacific Rim) conference. The conference theme was 'Mineral systems of the Pacific Rim' and attracted a large contingent of academia and industry representatives from around the world.

Technical sessions had a global flavour with topics covering New Zealand and Australian ore deposits through to Carlin-type deposits in Nevada. Additional ore deposit-focussed topics included epithermal and porphyry deposits in the Philippines, PNG and Indonesia, recent and ancient VMS deposits and an innovative session on new advancements in geometallurgical studies.

Research by CODES students and staff figured prominently: papers were presented by PhD students Shawn Hood and Christopher Leslie, Research Fellow Dr Matthew Cracknell, Associate Professor Shaun Barker, and a keynote address was given by Professor David Cooke. Recent CODES alumni were also well represented with session chairs and speakers scattered throughout the program. Dr Anita Parbhakar-Fox and Dr Nathan Fox chaired and presented papers in the Geometallurgy session with additional presentations by Ned Howard and Laura Jackson. Dr Stephanie Sykora also presented a paper in the Advances in Exploration Techniques session. PhD student Shawn Hood and Research Fellow Dr Matthew Cracknell also organised and led a well-attended short course focussed on the application of machine learning and data analytics in the geosciences.

The conference kicked off with a one-day field trip to Rangitoto Island, the largest and youngest (1400–1450 AD) volcano in the Auckland Volcanic

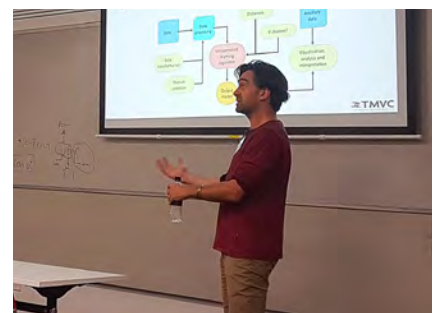


PhD student Shawn Hood relishes daylight before his descent into a lava tube, Rangitoto Island, Auckland, New Zealand, during the PACRIM 2019 field trip.



Professor David Cooke gives a keynote address to a packed house at PACRIM 2019.

Field. The trip consisted of a steady hike to the top of the volcano which presented fantastic views of the volcanic crater and of Auckland harbour. A highlight was exploring lava tunnels or tubes which required moderate agility but in turn offered a



Dr Matthew Cracknell presenting part of a short course on machine learning at PACRIM 2019.

unique and memorable experience. Significant participation in the conference by current and past CODES personnel attests to the international reputation that CODES has as a leader in ore deposit research and geoscientific training.

JULIE HUNT RETURNS TO CODES



Julie Hunt, pictured here at Mt. Teide, Tenerife, rejoined CODES in May.

Following her move back to Tasmania from Canada, Dr Julie Hunt will lead the 'Geological controls on grade by size fractionation' project, a CODES–CRC ORE collaboration

Julie completed a BSc (Hons) and an MSc at the University of British Columbia (UBC), Canada. She then worked in exploration and regional mapping in northern Canada before commencing a PhD in economic geology at James Cook University, Queensland, Australia. Her PhD research focussed on iron oxide-copper-gold mineralisation hosted in the Wernecke Breccias, Yukon, Canada. This research involved deposit genesis, formation and exploration characterisation. After completing her PhD in 2004 Julie returned to Canada to continue work for the Yukon Geological Survey as a Mineral Deposit Geologist.

In 2006 Julie joined CODES and until 2015 was part of the Geometallurgical Mapping and Mine Modelling (GEM; AMIRA P843 and P843A) industry collaborative projects. In 2015 she became part of the GeMME (Minerals Engineering, Materials and Environment) group at the University of Liege and from 2017–19 led the Geometallurgy Initiative at the Mineral Deposit Research Unit (MDRU) at UBC.

She is now back at CODES leading a CODES–CRC ORE collaborative project focussed on grade by size fractionation. This is a form of natural deportment that has been demonstrated to occur in a range of ore types and deposit styles whereby economic phases partition into specific size fractions

CONTINUED ON P.18.



The University of Tasmania is an Essential Participant in CRC ORE – the Cooperative Research Centre focussed on Optimising Resource Extraction for the mining sector.

CRC ORE works to minimise the impact of declining grades and radically improve the productivity, energy and water signatures of mining operations. CRC ORE is jointly funded by Essential Participants – which include mining companies, METS (mining, equipment, technology and services), research organisations – and the Australian Government. The centre is a trusted, independent broker and facilitator, driving collaboration across all its activities.

In addition to the CODES–CRC ORE collaborative project focussed on grade by size fractionation led by Dr Julie Hunt, CRC ORE is continuing to develop and successfully trial its key solutions: Grade Engineering® and the Integrated Extraction Simulator. Grade Engineering® is an innovative approach to the early separation of ore from waste material. It is working to minimise impacts of declining grades and productivity in the Australian minerals sector. And the Integrated Extraction Simulator represents the next generation of high-performance mineral processing simulation driven by the power of cloud computing.

More information on CRC ORE and its innovative solutions can be found at: crcode.org.au.

during early comminution stages (e.g., blasting, primary crushing). This tendency represents the underlying driver for CRC ORE's Grade Engineering® approach. Testing of drill core and bulk materials indicates that in some cases most of the metal can be contained in less than 50% of the mass of the material being tested (www.crcore.org). Utilisation of natural deportment on a mine scale has the potential to improve mill feed grades through rejection of uneconomic coarse size fractions early in the comminution circuit.

The current project is focussed on geological controls on grade by size fractionation for gold ores and copper ores. Using a combination of drill core logging, integrated data sets and laboratory-scale analyses the project

will evaluate mineralogical and textural drivers for the natural deportment of valuable minerals during rock breakage at both laboratory and operational scales.

Nathaly Guerrero

Nathaly Guerrero is also part of the CODES–CRC ORE collaborative project. She joined CODES in June as a Master of Science student. Her project is entitled 'Geometallurgical controls on grade by size at the Gramalote Au deposit, Colombia'. The project aims to evaluate the roles of paragenesis, mineralogy and texture in influencing rock breakage and natural fractionation of valuable minerals and elements.



Nathaly Guerrero, pictured here at the Cascabel project, Ecuador, joined CODES in June.

THE VISITORS' BOOK

CODES has again played host to a number of prominent speakers within the geology community over the past six months.

In March **Dr J Paul Winberry** from Central Washington University gave a talk entitled 'How much? How fast? Seismology's role in understanding the future of Antarctica's ice sheets'.

The Society of Exploration Geophysicists 2019 Pacific South Honorary Lecturer, **Professor Boris Gurevich** of Curtin University and CSIRO, gave a talk entitled 'Seismic attenuation, dispersion, and anisotropy in porous rocks: Mechanisms and Models' at the end of March.

In April **Dr David Close**, UTAS geophysics Alumnus, presented 'Geology and hydrocarbon potential of Proterozoic super-basins and sub-basins in the NT, Australia'. David completed his PhD at Oxford University on the evolution of the continental margin of east Antarctica. He is currently General Manager, Onshore New Ventures for Santos.



Dr Steve Garwin spoke to a packed room of CODES staff and students in August.

In May the annual Darcy Lecture in Groundwater Science, titled 'Starting from the problem and working backwards', was hosted by CODES and presented by **Dr John Doherty** from Watermark Numerical Computing. He highlighted why modellers must be educated in the mathematics and practice of inversion, uncertainty analysis, data processing, management optimisation, and other numerical methodologies to effectively design and implement modelling strategies that process optimal environmental data.

Also in May **Dr Nick Roberts**, MRT Natural Hazards Geologist, presented 'Understanding landslides in La Paz, Bolivia, with the aid of InSAR'.

Professor Michael Asten from Monash University presented 'Synchronous natural climate cycles of the Common Era, for Europe, China and globally – existence and implications for future temperature trends' at the end of May.

Dr Gerrit Olivier, Director and Head of Applied Geophysics at the Institute of Mine Seismology, presented on 'The 2018 eruption of Kilauea Volcano: Insights from ambient seismic noise interferometry' in June.

In July **Associate Professor Bernhard Pracejus** from the Department of Earth Sciences at Sultan Qaboos University, Oman, gave a talk on 'Copper slags in Oman: Key to origin of hydrothermal fluids?'.

Dr Marita Bradshaw, one of the Australian Geoscience Council's National Geoscience Champions, gave a presentation about the future of geoscience in August.

Dr Steve Garwin, Chief Technical Advisor to SolGold Plc, addressed CODES and Earth Sciences students and staff in August. Steve is one of the leading authorities on porphyry, epithermal and Carlin-style mineralisation in the circum-Pacific region.

OPEN DAYS 2019



Left: UTAS Vice-Chancellor Professor Rufus Black is here enjoying a little hands-on experience with a seismic signal display at the Sandy Bay campus while Earth Sciences staff Dr Michael Roach and Dr Robert Scott explain what's happening. The VC is using a sledge hammer to create a seismic signal that was recorded by a set of 24 geophones spread out across the grass. Surveys such as this are widely used for shallow subsurface investigations for engineering and environmental purposes. During the demonstration the VC said he was very excited about the work that Earth Sciences is doing.

Below: Visitors to the Sandy Bay campus loved getting up close and personal with Rosie the dinosaur.

Bottom: The Earth Sciences stalls at all three UTAS Open Days entail much organisation and voluntary work from our dedicated volunteer students and staff.



UTAS Open Day at the Sandy Bay campus on 4 August again proved to be a crowd-puller with the CODES dinosaurs keeping the younger prospective students amused and entertained.

The popularity of last year's Earth Sciences activities ensured that they were repeated this year, so visitors to the campus were again treated to:

- roving dinosaurs (of course)
- a fabulous rock display
- a fossil dig
- a seismic display (organised by Dr Michael Roach).

PhD students Tristan Wells and Joe Knight were among the Earth Sciences/CODES people to travel to the Newnham and Cradle Coast campuses Open Days on 10 and 11 August where they organised the highly popular gold panning events. Tasmanians proved again that they believe 'There's gold in them thar hills' as they flocked to take part in this activity.

A huge thanks to all Earth Sciences/CODES staff who gave up their time to help organise the Open Day events.



WOMEN IN MINING MAKING A BIG IMPACT



Honours student Johanna van Balen undertaking fieldwork in western Tasmania: Johanna values the role WIMnet can play in progressing the careers of women in mining after attending several WIMnet events this year.

CODES Honours student Johanna van Balen reports on the success and growth of WIMnet during the year and looks ahead to even greater things for the group in the future.

For WIMnet Tasmania the first half of 2019 has been a highly successful six months. WIMnet stands for Women in Mining Network and the group is run as part of the Tasmanian Branch of the Australasian Institute of Mining and Metallurgy (AusIMM).

The year began with the launch of our highly anticipated Mentoring Program, which was held on 29 March in Hobart. This event aimed to bring together young females – either about to start their career or those who have just started – with a member of the mining industry. From this event the idea is that a member of the industry takes the role of a mentor and helps their less experienced counterpart develop their leadership skills, better their communication skills and strengthen their access to resources through a year-long developing relationship. This event was a great success with upwards of 15 in attendance, including local member of parliament, Joan Rylah. As a result of this event, nine pairs have successfully

been formed with regular interaction between the mentor and mentee. Mentors can be men or women working within the mining industry.

In May WIMnet, in conjunction with the Tasmanian Minerals, Manufacturing and Energy Council (TMEC), held the annual Women in Resources Awards at Parliament House, Hobart. This was another very successful event with over 50 people attending. Awards were given for five different categories this year to the well-deserved recipients. The categories of the awards included: Exceptional Young Woman in Resources; Outstanding Tasmanian Tradeswoman; Exceptional Woman in Engineering and Professional Services; Exceptional Woman in Manufacturing; and Exceptional Woman in a Non-Executive Role. The evening was an amazing opportunity to network with such a diverse range of industry professionals.

Our latest event occurred in Queenstown on 19 June. WIMnet held a panel event with four female panellists from MMG, Diversified Minerals and Grange Resources who were given the opportunity to speak about their experiences in the mining



The launch of WIMnet Tasmania's Mentoring Program took place in March this year and has led to many successful pairings of mentors and mentees within the mining industry.

industry. The topic of the evening was 'The importance of mentoring and the importance of women in leadership positions in the resources sector'. Approximately 40 people attended the event including residents from surrounding West Coast towns. Again, this event was successful with feedback from attendees encouraging similar events showcasing female mining talent and female-based career stories.

WIMnet is looking forward to hosting more events later in the year with proposed locations including the North-West Coast (Burnie) and Hobart.

NEW OPPORTUNITIES FOR TASMANIAN COMPANIES TO WORK WITH CODES

CODES will increase the number of partnership opportunities available for minerals industry companies that wish to be involved in supporting CODES' research by introducing a new Copper level to the industry partnership program, which will be available only to Tasmanian-based companies from 2020 onwards.

The new Copper level will enable Tasmanian companies to commit a minimum of \$10,000 per annum to CODES, and is the most affordable category available to potential partners. Partnership funds are used by CODES to support research, administration and external communications, thus ensuring that valued funding for specific industry projects is directed solely into activities related to those studies.

For more details on our Industry Partnership Program, please visit our website: <https://www.utas.edu.au/codes/about-us/industry-partnership-program>

Benefits of an industry alliance with CODES:

Opportunities to focus research activities where they will have maximum impact for your organisation.

Early-mover advantage when implementing research outcomes to enhance discovery potential and optimise existing reserves.

One-on-one research projects tailored to company requirements.

Access to world-class geoanalytical facilities.

Access to a comprehensive range of industry-focussed training courses – tailored to your requirements.



Newcrest's Chris Miller inspects drill core at Newcrest Mining's Telfer core shed with past CODES Honours student Hannah Couper.

2019 Industry Partners

GOLD



RioTinto

Teck

SILVER



GEOLOGY ROCKS AT AGFEST!

CODES PhD student Joe Knight enthuses about recent Earth Sciences outreach activities at Agfest and predicts a stratospheric rise in the number of students studying geology at UTAS in future years.



The School of Natural Sciences volunteers in the UTAS tent at Agfest put in a great effort over the three days of the event. They are (L-R): Zara Marais (ARC Centre for Forest Value), Brenda Mooney (Chemistry), Matthew Fielding (Zoology), Kelsey Picard (Plant Science), Anna Flittner (Plant Science) and Joe Knight (CODES).

Agfest is an agricultural show that is a Tasmanian success story, injecting millions of dollars into the local economy and attracting a large crowd with diverse backgrounds. 2019 saw nearly 64,000 people attending across three days, and 728 exhibitors, including the University of Tasmania, showing their wares.

The UTAS tent won the award for 'Most Accessible Site', based on street appeal, visual appeal, first impressions and effective use of space. There were a variety of displays from various UTAS schools and disciplines, including the School of Natural Sciences, Menzies, the Australian Maritime College and IMAS. The School of Natural Sciences was well represented with displays from the disciplines of Zoology, Plant Science, Chemistry and, most importantly, Earth Sciences.

As any geologist knows, it can be rather difficult to explain to a non-geologist what we do and why geology is so interesting and relevant. In spite of these difficulties, the Earth Sciences display was particularly popular with patrons of all ages. The displays

presented included gemstones from around the world, fossils of trilobites from the Paleozoic (supplied by our rock curator Izzy von Lichtan), and augmented reality highlighting rock photogrammetry (supplied by Mike Roach).

Getting people to approach a stall is often somewhat difficult, especially when you look like me. However, the lure of shiny gemstones (sadly no fromies¹) managed to surpass the fear of approach, bringing many a punter in. From here, they got to have a look at one of the most successful forms of life to exist (the trilobites) and hear about how it survived three mass extinction events. They then got to look at 3D models of rocks on a tablet, which recognises images of the rocks and then displays the appropriate corresponding 3D model. After this I explained the concept of folding rocks through orogenesis with the use of a schematic cartoon of a fold hinge. When the tablet camera was held up to this cartoon, it displayed a 3D model from Wilsons Promontory.

What initially started as excessive attraction to shiny objects turned into real fascination for many of the people who partook in the displays. The benefit of studying Earth Sciences at UTAS and CODES was spruiked unashamedly. Enrolment forecast modelling suggests numbers of Earth Sciences students to increase by 283% by 2026.²

¹ Fromies is the nickname for sapphires found in the Frome River near Derby in Tasmania.

² This is solely intuition and not based on any form of quantitative analysis whatsoever. The author does not accept any responsibility if these projections are not accurate.



CODES PhD student Joe Knight (right) explains the intricacies of augmented reality rock photogrammetry to young enthusiasts at the 2019 Agfest event in May (with Anna Flittner (Plant Science) assisting).

GRANT SUCCESS FOR SUBMARINE VOLCANOLOGY TEAM



Examples of pumiceous facies from IODP Hole 1437D in the Izu-Bonin-Mariana arc, south of Japan. These facies are part of a ca. 4 Ma volcanoclastic succession formed by a submarine explosive eruption that Dr Martin Jutzeler and collaborators will investigate to assess eruption and transport processes. Funding will be provided by a recently awarded grant from the Australian and New Zealand International Ocean Discovery Program Consortium (ANZIC). The core samples are 6.4 cm in width.

Dr Martin Jutzeler and CODES Program 4 leader Dr Rebecca Carey have been successful in securing a \$20,000 grant from ANZIC, the Australian and New Zealand International Ocean Discovery Program Consortium.

The grant money will be used to further the team's understanding of volcanic architecture and eruption behaviour at Site U1437 Izu-Bonin-Mariana rear-arc, IODP 350, and has been allocated for the period 2019–2020. This 'legacy grant' specifically covers research into existing cores and is for geochemical analyses.

Dr Jutzeler and Dr Carey applied for the grant in conjunction with Professor Cathy Busby from the Coastal and Marine Sciences Institute, University of California at Davis, and Professor Susan DeBari, College of Science and Engineering, Western Washington University.

This project aims to reconstruct the volcanic architecture and eruption and transport processes that occurred at an IODP site in the Izu-Bonin-Mariana arc, south of Japan, where sediments and rocks date from the Miocene to the present. The project will involve a PhD

student, who is being recruited now, as well as an Honours student.

Dr Jutzeler, Professor Busby and Professor DeBari were part of the original expedition to drill this area in 2014.

The project aims are:

- to reconstruct the volcanic architecture of Site U1437 in its entirety; and
- to quantify eruption and transport processes in key units.



Thinking inside the squares

CODES students and staff feature on the cover of the new UTAS 2020 Undergraduate Course Guide, which has just been released.

Third-year Earth Sciences student Stewart Cox, postdoctoral researcher Indrani Mukherjee and PhD student Joe Knight feature on the front cover of the course guide, which is designed to entice students to study at UTAS next year.

Stewart, Indrani and Joe were chosen for the cover because the idea of picturing both students and staff in an outdoor setting to emphasise the fact that not all the teaching at UTAS happens in lecture theatres was one of the driving forces behind the marketing concept for the 2020 course guide.

Indrani enjoyed the experience and was really pleased with the finished shots. It meant a 5am start from Hobart in order to capture the sunrise but the Eaglehawk Neck tessellated pavement at dawn on a clear day was well worth it.

The 'hero shot' (in marketing speak) taken for this cover is now also displayed on a large billboard at the ABC roundabout in Hobart and is clearly visible as you drive past. And Stewart also features prominently on the cover of the new Bachelor of Science brochure, with Indrani and Joe on the back cover.

Great coverage for CODES and Earth Sciences!

Garry Davidson Memorial Touch Football Match and BBQ



CODES staff and students pictured following the 2019 Garry Davidson Memorial Touch Football Match and BBQ; it was a cold, grey day in May but Garry would have been proud of the spirit of play that was evident on the field.

10 May at 12 noon, Staff v Students

Match report by Karin Orth

For the second year running the staff versus students touch football match was held on the lower rugby field at the UTAS Sandy Bay campus. This match is played to honour the memory of our number one touch football fanatic Dr Garry Davidson, who passed away in April 2017. The unicorn prize, much admired by young visitors to the tearoom, was again up for grabs.

It was a cool but not rainy May lunchtime when the two teams met.

The staff played valiantly, missing many of their star players from last year –

Michael Roach, Rob Scott, Mike Baker, Rebecca Carey and David Cooke. New recruits Shaun Barker, Angela Escolme, Miles Smith (Admin) and some assistance from IT staff helped bolster the team, which played an excellent match against the student Hi-Viz team. The students had some experienced rugby players in their ranks, including their secret weapon, Michaelyn Arumbi, who plays for the University of Tasmania women's 12 aside rugby team. Despite the talent in the student team, things went well for the staff in the first half, with the students down, the final score being 1-0.

The referee, Ryan Brunton, decided to up the pace in the second half and this

suitied the students who then evened the score to one all. It was only in the final minutes that the staff snuck through the student defence line to win the day with the final score at 2-1. The staff retained the unicorn for another year and it will continue its pride of place on the fridge in the tearoom!

A BBQ lunch for the players and spectators was funded by the Discipline of Earth Sciences and CODES, and organised by students of the local chapter for the Society of Economic Geologists.

A great event to commemorate Garry.



ON THE HIGH SEAS

Dr Karin Orth (right) and Earth Sciences student Chantelle Ridley are now on board the *RV Investigator* in the Coral Sea with IMAS colleague Associate Professor Jo Whittaker. They are collecting rocks and geophysical data about the oldest volcanic plateaus and edifices associated with two age-progressive volcanic chains offshore of eastern Australia.

They are testing hypotheses around the tectonic evolution of this region in the northern Coral Sea, and whether a large submarine plateau is volcanic, and if so, whether it could be the flood basalt province associated with the hotspot tracks of the volcanoes.

For regular updates of their discoveries, see the Earth Sciences Facebook page at <https://www.facebook.com/EarthSciUTAS/>

CHANGING FACES

There have been several staff moves in the six months to September and two new PhD students have joined us.

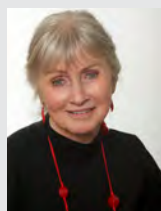
PHD STUDENT	START DATE	PROGRAM	PROJECT TOPIC
 Alex Farrar	March 2019	Program 6, working with Matt Cracknell	Crustal architecture and geodynamic controls on the formation of giant porphyry copper deposits in the Central Andes
 Max Hohl	September 2019	Program 3, working with Shaun Barker	Defining the mineral chemistry footprints of IOCG deposits in Northwest Queensland

Arrivals



Dr Julie Hunt returned to CODES in May to head up the 'Geological controls on grade by size fractionation' project, a joint CODES–CRC ORE collaboration (see page 17). She will be assisted in this role by new Masters student **Nathaly Guerrero**.

Departures



Dr Jane Higgins left her position as PA to the Director of CODES in June, and is now working within UTAS in two part-time administrative roles.



Jay Thompson resigned from his position as a laboratory analyst at CODES in August and will take up a role as an isotope geochemist with NASA at the Johnson Space Centre at Houston, USA, in September, and will continue his PhD from afar. His wife **Jennifer Thompson** will also continue her CODES PhD while in the USA.



PHD ATTAINED!

Dr Cassady Harraden pictured at her graduation ceremony on 16 August with one of her supervisors, Associate Professor Ron Berry. Cassady's PhD topic was 'Geotechnical and geometallurgical assessment by Corescan and complementary microanalytical techniques'. She now works at the Corescan facility in Vancouver, Canada.

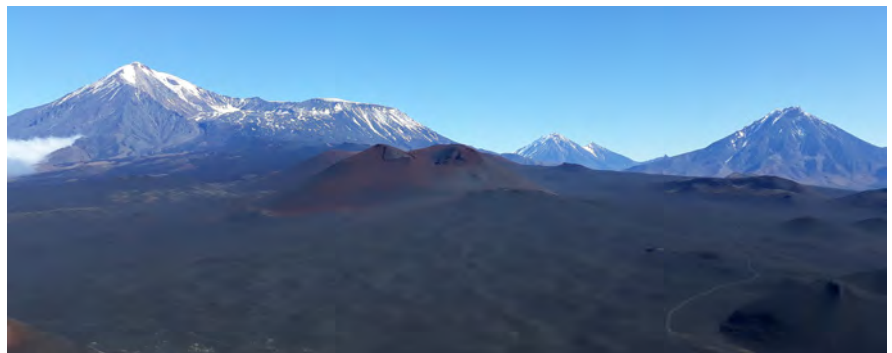
EXTREME SAMPLE COLLECTING

CODES PhD student Adam Abersteiner reports on last year's expedition to the remote Russian Far East where he and CODES Professor Dima Kamenetsky gathered peridotites, picrites and basalts in one of the most barren and unforgiving landscapes in the world.

During August and September 2018, Professor Dima Kamenetsky and I participated in fieldwork in the Kamchatka Peninsula (Far East Russia), which is located in the northwest corner of the Pacific Ring of Fire, above an extremely active subduction zone. The Kamchatka Peninsula is one of the largest and most active volcanic arcs and is populated by around 160 volcanoes, with 29 of them currently active. This expedition was part of a multifaceted collaborative project with the Institute of Volcanology and Seismology – Far Eastern Branch of the Russian Academy of Sciences.

The first part of the expedition involved a field trip to Kamchatksy Mys (Russian for *Cape*). This locality is of great geological interest for numerous reasons, as it is situated at the junction between the Kuril-Kamchatka and Aleutian arcs, and it is the site where the long series of seamount chains (Hawaii-Emperor, Detroit and Meiji), which extend for more than 6,000 km from Hawaii and across the Pacific Ocean, intersect land. Consequently, Kamchatksy Mys is considered to be the birthplace of Hawaii magmatism. It consists of structurally complex ophiolites (~93-112 Ma); however, its origin and evolution remain poorly understood.

We set off into the depths of this untamed and isolated landscape in a massive six-wheel-drive truck. Basecamp was established in the remote wilderness and numerous expeditions by foot were carried out to collect new samples of peridotites, picrites and basalts. Even at the height of summer, snow still persisted and brown bears were known to roam the land. In addition, in-situ chromites in peridotite and alluvial platinum group minerals (PGMs) were collected from various streams and rivers. Numerous studies are currently underway, which



Top: PhD student Adam Abersteiner and Professor Dima Kamenetsky in Kamchatksy Mys hiking out to collect picritic rocks, September 2018. **Above:** The scorched volcanic landscapes of Kamchatka. In the foreground are cinder cones formed during the 1975–76 Great Tolbachik Fissure Eruption. In the background are the Tolbachik (left), Oval'naya Zimina (centre) and Bol'shaya Udina (right) volcanoes.

aim to further characterise the origin and evolution of the Kamchatksy Mys ophiolite complex, mineral parageneses of PGMs, geodynamics and >100 Ma geochemical fingerprint of the Hawaii hotspot.

The second part of this expedition was to the Tolbachik volcano and the 1975–76 Great Tolbachik Fissure Eruption zone in Central Kamchatka, an area populated by numerous massive (3,000–4,000 m above sea level) volcanoes and smaller cinder cones, and where the ground is scorched black and almost devoid of any plant life. The purpose of this expedition was to:

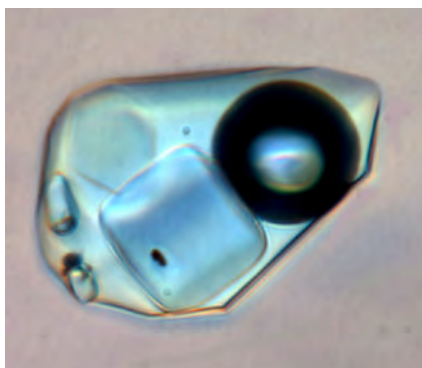
- collect olivine xenocrysts and peridotite xenoliths, which aim

to characterise the geochemistry and magmatic processes occurring beneath Kamchatka and understand silicate-sulfide immiscibility; and

- examine encrustations that formed on the walls of lava tubes and fumaroles, which were formed during gas-rock interactions.

Here, unique styles of mineralisation occurred, including the precipitation of gold, salts, tenorite, Cu-rich spinels and numerous previously unknown exotic sulfate minerals. This section of the journey aimed to contribute to ongoing research seeking to characterise different styles of mineralisation that occur during subduction-related volcanism.

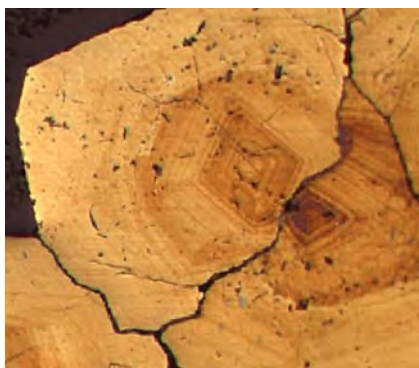
BUMPER TURNOUT FOR JUNE MASTERS SHORT COURSE



Research higher degree coordinator at CODES, Associate Professor Shaun Barker, reports on another well-received short course.

CODES successfully ran the Master of Economic Geology short course KEA709 'Ore deposit geochemistry, hydrology and geochronology' over 12 days in Hobart during June.

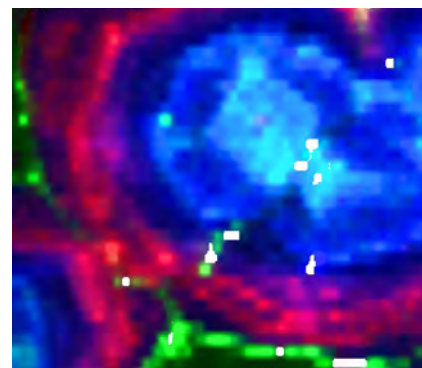
The course was well received by 48 participants, made up of a mixture of Masters of Economic Geology students (many of whom work for a variety of Australian and international mineral resource companies), industry and government participants and CODES PhD, MSc and BSc(Hons) research students. Industry participants in the short course included representatives from Glencore, Newmont, Sandfire Resources, South32 and



KGL Resources. In addition, two participants from the Queensland Government's Department of Natural Resources, Mines and Energy attended the course.

The course was presented by Phil Blevins (Geological Survey of New South Wales), Stephen Cox (Australian National University), Poul Emsbo (United States Geological Survey), Scott Halley (Mineral Mapping Pty), Nick Oliver (HCOV Global), Lesley Wyborn (Australian National University) as well as numerous CODES current and emeritus research staff.

A number of standout topics were highlighted by the students during discussion about the course. These included: Scott Halley presenting workflows to recognise lithological and alteration patterns within copper porphyry deposits from



lithogeochemical data; Nick Oliver highlighting the use of 'complexity mapping' as a tool to help simplify vein-hosted hydrothermal deposits; and Poul Emsbo giving an overview of the scale and significance of the processes responsible for forming SEDEX deposits, and particularly demonstrating the power of a multi-disciplinary approach to help recognise the processes involved in forming an important class of base metal deposits.

CODES thanks all of the participants and presenters on the course; their enthusiastic engagement at all levels helped to make it highly successful. The course is always a highlight in the calendar with the variety of presenters making KEA709 an informal 'must attend' for many of our professional and research staff.

UTAS excels in ERA rankings for Earth Sciences

Associate Professor Sebastien Meffre congratulates all in the Discipline of Earth Sciences and CODES on an excellent result in the newly released ERA rankings.

The University of Tasmania has done very well in the Australian Research Council: Excellence in Research for Australia (ERA) National Report for 2018–19.

In Earth Sciences (04 field of research code) we were ranked highest out of all the Australian universities when taking into account impact, engagement, quality of research output and number of categories assessed. Note that other Disciplines and Centres of UTAS, which conduct research in the Earth and marine sciences, contribute to the research outputs.

Well done everyone for contributing, and thank you to Professor Ross Large and Dr Rebecca Carey for collecting and collating the data.

To see the relevant parts of the ERA National Report for 2018–19, go to: <https://dataportal.arc.gov.au/ERA/NationalReport/2018/>

Scroll down to the 'Explore the report' page and go to Section 5, then choose '04 Earth Sciences' to display a list of the rankings: 'University of Tasmania' is towards the bottom of the page.



UPCOMING MASTER OF ECONOMIC GEOLOGY SHORT COURSES

ORES IN MAGMATIC ARCS – SOUTH AMERICA

11–26 OCTOBER 2019

COURSE LEADERS: DAVID COOKE AND MIKE BAKER

A field-based short course taught in Ecuador, Peru and Chile which includes visits to world-class porphyry and epithermal deposits, studies of the regional and local geology, and detailed evaluations of ore deposit characteristics, mineralisation styles and genetic models. Exploration techniques are discussed and evaluated.

The itinerary includes visits to Quito, Cuenca, Loma Larga, Cascabel (Ecuador); Lima/Soledad (Peru); and Calama, Northern Chile, El Abra, Radomiro Tomic/Chuquicamata, Santiago, Los Sulfatos, Rio Blanco and Central Chile (Chile).

GEOMETALLURGY

4–15 NOVEMBER 2019

COURSE LEADERS: ANGELA ESCOLME AND JULIE HUNT

A comprehensive overview of practical geometallurgy, from deposit characterisation and Grade Engineering®, to improved management of mine waste. Geometallurgy involves a quantified and comprehensive approach to ore characterisation in terms of critical processing attributes such as blasting, crushing, grinding, liberation, recovery and environmental management. Key outcomes of increased geometallurgical knowledge are improved forecasting, reduced technical risk, enhanced economic optimisation of mineral production, and improved sustainability.

The course introduces the major mineral processing methods and a range of techniques for ‘early-stage’ (e.g., exploration, pre-feasibility) collection of geological information that is relevant to mining engineers and metallurgists. The two-week course includes lectures, practical exercises, site visits and a range of computer-based modelling exercises.

VOLCANOLOGY AND MINERALISATION IN VOLCANIC TERRAINS

7–24 MARCH 2020

COURSE LEADERS: MARTIN JUTZELER, SHAUN BARKER, DAVID COOKE AND ROBERT SCOTT

This short course is a highly practical, field-based unit in which participants gain first-hand experience in the recognition, classification and interpretation of modern and ancient volcanic rocks. The course begins with studying well-preserved modern and recent volcanic landforms, volcanic deposits and associated hydrothermal systems on the North Island of New Zealand. By visiting a range of spectacular field locations, participants gain insights into the processes and products of different eruption styles, contrasts in scale and structure of volcanoes, and the identification, description, logging and interpretation of key volcanic facies associations. Armed with an understanding of volcanic products and processes based on the inspection of New Zealand examples, where primary textural and compositional features are well-preserved, participants travel to western Tasmania to inspect deformed and altered ancient (~500 m.y. old) volcanic successions of the Mount Read Volcanics and associated mineral deposits.



More detailed itineraries, and information about costs and payment options are available from the CODES website:
www.utas.edu.au/codes

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