ORE SOLUTIONS

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

> WINTER 2018 **No.31**

GENERATIONAL CHANGE AT CODES

From 1 January 2018, CODES became known as the Centre for Ore Deposit and Earth Sciences, operating a research centre within the School of Natural Sciences, which itself is within the College of Sciences and Engineering at the University of Tasmania.

Future perfect: CODES Annual Review meeting, 1 December 2017, Hobart. CODES Director Professor David Cooke (front row, third from left) and Deputy Director Professor Leonid Danyushevsky (front row, second from right) setting the agenda for the newly restructured CODES.

FROM THE DIRECTOR,
PROFESSOR DAVID COOKE

CODES commenced operations in 1989, and is globally recognised as one of the leading research groups in ore deposits and mineral exploration. Over the years, our research has been underpinned by strong and continued support from the minerals industry, AMIRA International, the University of Tasmania and various government agencies, in particular the Australian Research Council's major funding initiatives, including the Key Centre, Special Research Centre, Centre of Excellence, and Industrial Transformation Research Hub funding schemes. CODES' continued success over almost three decades has been due to the collective and sustained efforts of its research staff and students, and the strong support of its stakeholders.

Over the past few years, CODES has been undergoing a gradual transformation as senior staff either retired or moved on to new opportunities, and as revenue streams evolved. In 2017, these gradual transformations came to a head with the untimely passing of Dr Garry Davidson and the early retirement of former CODES Director Professor Bruce Gemmell. The loss of two of our senior economic geology staff means that CODES is now at a point of generational change. Fortunately, with an upswing in the minerals industry, this is also a time of great opportunity for our up-and-coming research staff.

Professor David Cooke was appointed CODES Director in July 2017. After a review of our operations at that time CODES undertook a restructuring of its research programs to better reflect the research interests and activities of CODES staff and our industry stakeholders.

At the start of 2018, CODES took on its new name as the Centre for Ore Deposit and Earth Sciences. This name change reflects the fact that we want to encompass all of our research strengths under the CODES umbrella – from ore deposit research to more fundamental Earth sciences research.

From 2018, CODES will have six research programs. They span fundamental to applied research pertaining to mineral resources and the environments in which they form (see page 3 for details).

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CODES UNIVERSITY of TASMANIA

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GENERATIONAL CHANGE AT CODES (continued)

Several new research initiatives have commenced early in 2018, or are currently being negotiated with our industry stakeholders. This newsletter provides details of some of those new initiatives, and also highlights some of the major events that CODES staff and students will be organising in 2018, together with an update of some of our ongoing major research initiatives.

Associate Professor Shaun Barker joined the CODES research team in July, increasing our research capacity in sediment-hosted ore deposits and isotope geochemistry applied to exploration. Shaun will be a welcome addition to the team, and we look forward to his active participation in several of our major research initiatives.

It is an exciting time at CODES – we will continue to develop research projects and to deliver research outcomes of significance for our stakeholders across the fundamental-to-applied spectrum of research. We look forward to continued active engagement with all of our stakeholders, and also to the opportunity to generate new research possibilities and collaborations with all interested parties.

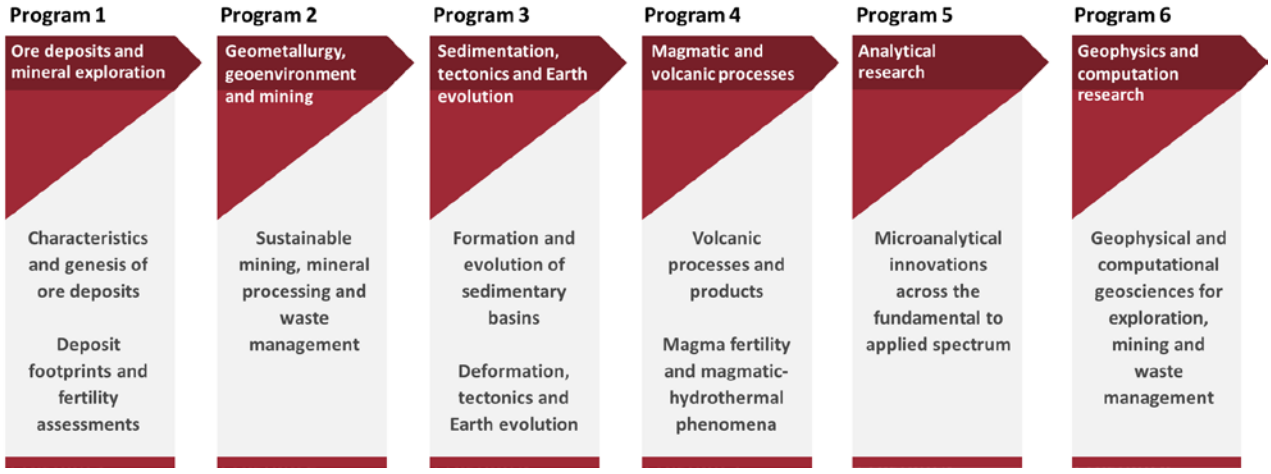
'Volcanology and Mineralisation in Volcanic Terrains' MEconGeol shortcourse participants (March 2018) gather in the shadow of Mount Ngauruhoe volcano, New Zealand (you may recognise it as Mount Doom from *The Lord of the Rings* film trilogy, in which it starred).

MASTERS OF DOOM

This year's Master of Economic Geology shortcourse on 'Volcanology and Mineralisation in Volcanic Terrains' ran from 4–19 March with 22 Masters students and two PhD students participating in field excursions to active and ancient subaerial and submarine volcanoes in New Zealand and Tasmania.

Mine site visits to Waihi, Rosebery, Hercules, Que River and Hellyer, and visits to active hydrothermal systems at Waiotapu, Waimungu, White Island and Tongariro were essential parts of the course, which provided the participants with a detailed understanding of how volcanic facies architecture can influence hydrothermal activity in subaerial and submarine mineralised settings.

The course was led by Dr Rebecca Carey and Dr Martin Jutzeler, who imparted their passion for, and knowledge of, volcanic processes and products to a very enthusiastic student cohort. Rebecca and Martin were ably assisted in New Zealand by Professor David Cooke, and in western Tasmania by Dr Rob Scott and Dr Andrew McNeill (MRT). A big thank you to our guest lecturers Associate Professor Julie Rowland (University of Auckland), and Dr Andrew Rae and Dr Isabelle Chambefort (GNS), and for the mine geologists at each site visited, for their excellent contributions that helped to make the course such a great success.



SIX PROGRAMS REFLECT CODES' RESEARCH STRENGTHS

The new structure of CODES, comprising six programs along with its training, education and outreach activities, better reflects the future direction of our research interests and industry collaborations.

PROGRAM 1: Ore deposits and mineral exploration encompasses all of our research into the characteristics and genesis of ore deposits.

- It also includes our applied research that is strategically aligned with the mineral exploration industry's major challenges across all scales of exploration.
- We will train the next generation of ore deposit and exploration specialists through PhD, M Econ Geol and Honours research projects, many of which are undertaken in close collaboration with our industry partners.

PROGRAM 2: Geometallurgy, geoenvironment and mining aims to facilitate sustainable mining, mineral processing and waste management practices in the minerals industry.

- Transformations made to each phase of resource extraction and processing are achieved in collaboration with our industry partners.
- Our goals are to minimise the impacts, and maximise the benefits, of metallic mining in diverse environments, and to assist with remediation of legacy issues.

PROGRAM 3: Sedimentation, tectonics and Earth evolution aims to understand the formation and evolution of sedimentary basins, together with their histories of deformation and metamorphism.

- Basin development is placed within the broader context of geodynamic processes and Earth evolution through time.
- We aim to develop new and refined genetic and exploration models for sediment-hosted mineral systems.

PROGRAM 4: Magmatic and volcanic processes will research magma genesis and evolution, volcanology and the architecture of magmatic plumbing systems.

- Investigations of volcanic phenomena in subaerial and submarine settings will provide the geological framework for understanding alteration and mineralisation in volcanic terrains.
- Geochemical insights into magma fertility and the roles of mantle and crustal processes in magmatic-hydrothermal mineral systems will provide an improved understanding of magmatic, volcanic-hosted and magmatic-hydrothermal mineral systems.

PROGRAM 5: Analytical research underpins much of our most innovative research across the fundamental to applied spectrum.

- New developments in analytical research generated by CODES Analytical Laboratories provide the basis for CODES' global leadership in microanalytical techniques specifically applied to mineral exploration, mineral processing, ore genesis and waste management.
- It will also provide analytical services to government, academia and industry.

PROGRAM 6: Geophysics and computational geosciences provides geophysical data acquisition, processing and interpretation as a core component of CODES' research and training activities.

- Computational geosciences are becoming increasingly important as technological advances drive a step-change in automated data acquisition and imaging methods across the geosciences.
- We will address challenges with handling, processing, visualising and interpreting Big Data in the minerals industry, from exploration, mining and mineral processing to waste management.

ONLINE ROCK LIBRARY SUCCESS BUT MORE FUNDS NEEDED

Above: Michael Roach with a drone used to gather data for the AusGeol Virtual Library of Australia's Geology. **Below:** AusGeol's web portal.

The AusGeol Virtual Library of Australia's Geology (www.AusGeol.org) was a two-year project (2015–2017) funded by the Australian Government Office for Learning and Teaching and a consortium of universities and government geoscience agencies. Dr Michael Roach from Earth Sciences at UTAS has been instrumental in getting the library up and running.

This virtual library provides free online access to visualisations – which include photographs and descriptions – of geological samples from over 3,500 sites across the continent and provides access to accompanying educational resources. Its well-documented examples of important geological features aim to complement students' geological skills learnt in the field.

AusGeol delivers a range of visualisations including:

- photo-realistic 3D models derived from both terrestrial and UAV photography
- full-spherical panoramas and
- 'deep zoom' imagery.

Visualisations are integrated to generate virtual tours of each geological feature. All visualisations include metadata that facilitate display and retrieval of features that meet specific keyword, stratigraphic or lithological queries. These visualisations are delivered via the AusGeol web portal through an interactive map interface (Atlas tab) or by tabular selection and display (Sites tab).

Call for funding

Initial funding for the AusGeol initiative ended in April 2017. We are now keen to continue development of the AusGeol resource and are seeking partner organisations and funding (2018–2021) that will:

- improve the spatial and thematic coverage of the AusGeol database to include visualisations in large areas of the continent that currently have no data
- capture geological visualisations directly relevant to the exploration, minerals and energy industries
- establish new mobile facilities for 3D digitisation of samples from geological collections that are currently 'hidden' in the archives of museums, universities and government organisations (including drill core and mineralogical and palaeontological specimens)
- develop educational objects, tours and activities using new and existing visualisations. The generation of public outreach, minerals and energy-related content will be a particular objective
- continue the development of the GeoVis3D software to increase its functionality.

To become involved in this ground-breaking project, contact Dr Michael Roach at: Michael.Roach@utas.edu.au

SHAUN BARKER JOINS CODES AS LEADER OF PROGRAM 3

Associate Professor Shaun Barker talks about his background, his love of hydrothermal systems and why he's looking forward to being part of the CODES family

Shaun Barker, pictured here in the Ruby Mountains near the Carlin-type gold deposits of Nevada, joined CODES in July as leader of Program 3, and is excited at the prospect of working with a world-class team of researchers.

I am originally from New Zealand, and completed my BSc (Hons) at the University of Otago in 2003, where I worked on fault-generated pseudotachylytes, before completing my PhD at the Australian National University in 2007. For my PhD I undertook a project in the Lachlan Fold Belt, near Yass, on a folded and faulted sequence of limestones and shales which hosted barren and uneconomic calcite-fluorite veins. My research aimed to determine the structural and chemical interaction of fluids and rocks. The project was a fusion of structural geology and geochemistry.

I then worked at the Mineral Deposit Research Unit , at the University of British Columbia, for five years, principally on a project sponsored by Newmont, Barrick and Teck on developing vectors towards Carlin-type gold deposits in Nevada. During this time, I undertook development of stable isotope methods that were more suited to minerals industry usage than conventional techniques. Following this, I worked as a senior lecturer at the University of Waikato for five years, where I taught across the undergraduate Earth sciences geology program, including field trips, and igneous petrography and geochemistry.

My main research interests are structurally controlled hydrothermal systems, and specifically how we can trace fluid flow within hydrothermal systems using a variety of novel geochemical approaches. I have applied these research interests in understanding fluid flow within Carlin-type gold deposits in Nevada, and low-sulfidation epithermal Au-Ag veins in New Zealand, working with the minerals industry to better understand what controls hydrothermal fluid flow and the distribution of mineralisation within these systems, and how we can vector towards mineralisation.

I am very pleased and excited to be joining CODES because of its fantastic faculty, staff and students, its world-leading reputation in mineral deposits research and teaching, and the opportunity to learn from academic and industry peers.

At CODES, I am hoping to initiate a research project examining how 'clumped' stable isotopes might be used to help us determine the distribution of heat within hydrothermal systems, which can then be used to test numerical models of fluid flow within hydrothermal systems as well as potentially be used to identify sharp thermal gradients and 'hot spots' within ore-forming hydrothermal systems that are associated with mineralisation.

I will also be involved in the new CODES AMIRA project P1202 on 'Far field and near-mine footprints' and will be able to bring my perspectives and understanding on metal transport and distribution within hydrothermal systems to this exciting project. Additionally, I am working with collaborators overseas on understanding the sources and redistribution of ore-forming and 'pathfinder' metals with the active orogen of New Zealand to test theories about what causes metal enrichment (or a lack of it) within hydrothermal systems in an area where we understand the underlying geology and active hydrothermal systems relatively well (at least compared to ancient environments).

At CODES I hope to be part of a group of researchers that lead the world in understanding ore-forming hydrothermal systems, as well as providing world-class education in mineral deposits for the next generation of students, who will be needed to supply the world with the mineral resources that will be required in the future.

The search for new tools continues…

AMIRA International is currently circulating a proposal for P1202 *Far field and near-mine footprints – find the next generation of Tier 1 ore deposits*.

This will continue the development of new and refined geochemical and geological tools for fertility assessments and vectoring in porphyry and epithermal districts, greenstone belts and carbonate-hosted mineral systems. These tools will ensure cost-effective exploration, with research outcomes pertinent to exploration at a variety of scales, from belt through camp and district to near mine.

Integration of footprints, geometallurgical and geoenvironmental assessments in early-stage exploration is the major underpinning philosophy of the ARC Transforming the Mining Value Chain (TMVC) Research Hub at CODES. P1202 will bring the footprints, geometallurgical, geoenvironmental and technology researchers of the TMVC together in one major research project aimed at addressing all of the major objectives of the research hub, and will be the culmination of the TMVC research program.

For more information on sponsoring this project, please contact Adele Seymon, Program Director, at: adele.seymon@amirainternational.com

A visitor to the Mt Dore core yard in the Mt Isa-Cloncurry region of NW Queensland, where work will start soon on a CODES project to seek out ore deposits.

What lies beneath?: A new CODES project, led by Jeff Steadman, at Mt Dore in NW Queensland hopes to yield new ore deposits.

NEW RESEARCH PROJECT AIMS TO UNCOVER HIDDEN RICHES IN NORTHWEST QUEENSLAND

CODES, University of Queensland, and the Queensland Department of Natural Resources and Mines join forces to rejuvenate exploration in the Mount Isa-Cloncurry region.

The Paleoproterozoic-Mesoproterozoic Mount Isa district, Northwest Queensland, anchors the Northwest Queensland Mineral Province, one of the preeminent mining districts of the world. However, many of the mines in the Mount Isa district are approaching end-of-life scenarios, which could have a significant negative socio-economic impact on the region. Finding new resources and revitalising the Northwest Queensland Mineral Province is therefore of paramount importance.

Over the past decade, mineral geochemistry has become increasingly recognised as the foremost technique for expanding the identifiable footprints of precious and base metal ore deposits, particularly those which sit at depth and/or under cover sequences. The strength of this approach has been facilitated by recent advances in laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS), including larger (and more efficient) sample chambers, improvements in mass spectrometer detection limits for key low-level trace elements, better standard reference materials, and more advanced data reduction software. For example, at CODES, the above improvements have led to a five-fold increase in sample throughput, leading to a 66% increase in our mineral geochemistry database over a two-year period.

CODES is at the forefront of mineral geochemistry research, both nationally and internationally. For the past 10 years, our laser labs have enabled us to produce cutting-edge results in pyrite, chlorite, and epidote vectoring and paragenetic studies, leading to high-profile publications in major peer-reviewed scientific journals. We therefore have the expertise and capacity to adequately handle high sample volumes and data analysis in a timely manner.

The new research venture in Northwest Queensland addresses a longstanding need for widespread systematic trace element analysis of key alteration minerals in the numerous world-class ore deposits of this region. We are pleased to partner with the Geological Survey of Queensland and the University of Queensland in this effort, and we look forward to significant outcomes for the Mount Isa district throughout the three-year course of the project.

This flagship project, titled 'Mineral geochemistry vectoring: Uncovering Northwest Queensland's hidden potential' will be led by Jeff Steadman, who will work with team members David Cooke, Rob Scott and Peter McGoldrick, along with a new postdoc yet to be appointed.

A *MATERIALS WORLD* MEDAL FOR ANITA!

CODES/TMVC Senior Research Fellow in Geoenvironmental Studies, Dr Anita Parbhakar-Fox, has been jointly awarded the *Materials World* Medal for 2018, which will be presented to her at a ceremony in London in October.

Anita was nominated for the medal by the editor of *Materials World* after publication of an article she had written on mining waste.

Communication has evolved dramatically over the past decade with the introduction of a whole host of websites (e.g., 'The Conversation') providing digestible snapshots of research studies and their key findings to a huge audience. When the topic of research involves a range of stakeholders, using these platforms can be particularly advantageous, as Anita discovered.

In recent years, Anita's research focus has moved beyond characterising mine waste during early life-of-mine phases to looking at historical and legacy mine wastes and exploring innovative methods for their rehabilitation. Having attended several European conferences which thematically revolved around sustainable mining, Anita became interested in how the sustainable development goals could be applied in CODES Program 2 research. She wrote an article in 'The Conversation' on how we can recover 'treasure from trash', which led to several spin-off articles in other magazines and websites. One was *Materials World*, the monthly magazine for the British Institute of Materials, Minerals and Mining. The article, 'Waste is a design flaw', spoke of how mine waste materials should be geometallurgically characterised, particularly to find critical metals, to support our manufacturing needs as more Fortune-500 companies seek to develop greener technologies. Case study examples from Australia and Europe were provided from several research projects conducted at CODES. It was this article that led to her nomination for the medal.

Indrani Mukherjee wins *Minerals* Travel Award

A 2018 Travel Award sponsored by the journal *Minerals* and worth 800 Swiss Francs has been awarded to Postdoctoral Research Fellow Indrani Mukherjee. The award is for conference costs; Indrani will use it to attend Goldschmidt2018, in Boston, USA, during August. She will present her work on pyrite trace element distribution at this conference. Indrani was one of only two successful applicants out of a field of 101.

Indrani Mukherjee's postdoctoral research focusses on understanding pyrite trace element distribution along a single black shale unit (Lower Arthur Creek Formation) across the Georgina Basin (450 km) in northern Australia. Approximately 2,000 pyrite LA-ICP-MS analyses have been undertaken in these organic matter-rich black shales. Her study focusses on the variation in pyrite chemistry with sedimentary facies across the basin and factors controlling these variations, including changes in redox conditions and micronutrient availability. Results provide a measure of how robust the pyrite LA-ICP-MS technique is as a proxy for paleo-redox of the atmosphere-ocean system through time, and its potential for understanding cycles of sedimentary ore deposition.

Haddon Forrester King Medal 2018

Professor David Cooke, Director of CODES and the TMVC, has been awarded the Haddon Forrester King Medal for 2018.

This medal is awarded by the Australian Academy of Science, sponsored by Rio Tinto, for life-long achievement and outstanding contribution to science, and is considered one of the Academy's top honours.

David is in esteemed company, with recent past recipients of the award including Murray Hitzman (2016), Neil Williams (2014), Shunso Ishihara and Anthony Naldrett (2012), and former CODES director Ross Large (2005), all the way back to Roy Woodall (co-recipient in 1993).

David's main research is focused on geological, chemical and fluid processes that produce the world's major copper-gold porphyry deposits. His current interest in the chemistry of minerals surrounding these and associated mineral systems forms the premise of a series of AMIRA International projects. These are recognised for the development and testing of exploration fertility and vectoring techniques increasingly used as part of routine procedure by company exploration geologists in the search for magmatic copper-gold deposits.

PRESIDENT OF THE SEG

Former CODES Director Professor Bruce Gemmell is the 2018 President of the Society of Economic Geologists, Inc., (SEG). Formed in 1920, the SEG is the world's oldest, largest and most influential international organisation in the fields of economic geology and mineral deposit discovery. Based in Littleton, Colorado, in the USA, the organisation has more than 7,000 members in over 90 countries.

The main goals of the Society are the advancement of the science of mineral deposit geology, and the promotion of high professional and ethical standards among its members, and the economic geology profession as a whole. Bruce will play a key leadership role in helping the organisation to meet its objectives, and in setting its future directions.

The minerals industry is a vital source of economic activity and jobs, and a major contributor to income and wealth creation. Technical and scientific innovation is continually needed to maintain the industry's international competitiveness and to ensure that exploration and mining is conducted in an environmentally sustainable manner that is aligned with society's expectations. Minerals geoscience – encompassing geology, geochemistry, geophysics, geometallurgy and geoenvironmental – can aid in this undertaking and help find and exploit mineral resources in an environmentally sustainable manner. As President, Bruce wants to ensure that the SEG is positioned for the future by creating a forward-thinking strategic plan, maintaining high-quality and relevant geoscience knowledge products, as well as enhancing the next generation of mineral geoscientists through the SEG student chapters and the early career professionals program.

Bruce follows in the footsteps of former CODES Director, Emeritus Professor Ross Large, who was SEG President in 2004.

Royal Society of Tasmania Medal 2018

Emeritus Professor Ross Large has been awarded the Royal Society of Tasmania Medal for 2018.

The medal is awarded for substantial original research in any subject within the Society's purview. A significant part of the research should have been conducted while the recipient was a resident of Tasmania. Previous geologist winners associated with UTAS have been Max Banks, David Green and Pat Quilty. Ross will deliver 'The Royal Society of Tasmania Lecture' later this year, after presentation of the medal by the Governor of Tasmania at Government House in August.

Publication in *Nature*

CODES researchers Indrani Mukherjee, Ross Large and Leonid Danyushevsky, along with Ross Corkrey from the Tasmanian Institute of Agriculture, have been published in *Nature*. Their paper – 'The Boring Billion, a slingshot for Complex Life on Earth' – was published online in March 2018, and is available at: https://www.nature.com/articles/s41598-018-22695-x
Congratulations to all involved!

The abstract for the article follows:

The period 1800 to 800 Ma ('Boring Billion') is believed to mark a delay in the evolution of complex life, primarily due to low levels of oxygen in the atmosphere. Earlier studies highlight the remarkably flat C, Cr isotopes and low trace-element trends during the so-called stasis, caused by prolonged nutrient, climatic, atmospheric and tectonic stability. In contrast, we suggest a first-order variability of bioessential trace-element availability in the oceans by combining systematic sampling of the Proterozoic rock record with sensitive geochemical analyses of marine pyrite by LA-ICP-MS technique. We also recall that several critical biological evolutionary events, such as the appearance of eukaryotes, origin of multicellularity and sexual reproduction, and the first major diversification of eukaryotes (crown group) occurred during this period. Therefore, it appears possible that the period of low nutrient trace elements (1800–1400 Ma) caused evolutionary pressures which became an essential trigger for promoting biological innovations in the eukaryotic domain. Later periods of stress-free conditions, with relatively high-nutrient trace-element concentration, facilitated diversification. We propose that the 'Boring Billion' was a period of sequential stepwise evolution and diversification of complex eukaryotes, triggering evolutionary pathways that made possible the later rise of micro-metazoans and their macroscopic counterparts.

MOVING IN/MOVING OUT
STAFF CHANGES JULY 2017–2018

LEFT OR RETIRED

Professor Bruce Gemmell retired as director of CODES in July 2017, but retains an honorary role as Adjunct Professor at CODES. He also works as a consultant in economic geology and mineral exploration.

Dr Sean Johnson stepped down from his role as a Postdoctoral Research Fellow and took up a position with iCRAG – the Irish Centre for Research in Applied Geoscience, based at University College Cork.

Steve Calladine left his role as CODES Communications Manager in mid-2017 and is enjoying his retirement.

Ian Little stepped down from his position as CODES/ Earth Sciences Maintenance, Field Equipment and Safety Officer in mid-2017 and now manages a dance school.

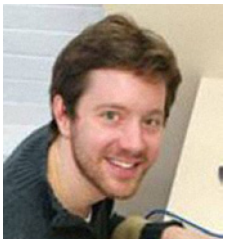
June Pongratz relinquished her part-time role as Publications Officer and in retirement plays serious croquet and enjoys overseas travel.

NEWCOMERS/RETURNEES

Dr Shaun Barker joined CODES in July 2018 as an Associate Professor and will lead CODES Program 3. He was previously with the University of Waikato, New Zealand.

James Tolley, from the UK, joined CODES in April 2018 after completing a PhD in experimental petrology at the Research School of Earth Sciences at ANU. He works as a Research Fellow in LA-ICP-MS.

Karen Huizing rejoined CODES in November 2017 as an administrative assistant working in travel organisation and general administration.



Francisco Testa returned to CODES in April as a Postdoctoral Research Fellow in epithermal ore deposits in the ARC TMVC Research Hub and has recently been carrying out fieldwork in Argentina.

Indrani Mukherjee finished her PhD at CODES and took on the role of a Postdoctoral Research Fellow. She is working within Program 3 on the Neoproterozoic Tapley Hill Formation, South Australia.

Troy Finearty joined CODES in mid-2017 as our new Maintenance, Field Equipment and WHS Officer.

December 2017 graduates

Four more PhDs were awarded to CODES students in December 2017: Bruce Gemmell and David Cooke flank newly-minted PhDs Margy Hawke, Stephanie Sykora, Richelle Awid-Pascual and Jacob Mulder.

PHD PROJECTS UNDERPIN CODES' RESEARCH STRENGTH

CODES currently has 47 PhD students working on projects spanning every continent as well as lab- and computer-based research. The number of PhD students carrying out research at CODES has gradually increased over recent years and they are vital to our ongoing research success.

Several exciting new PhD projects have commenced at CODES/TMVC in recent months:

PHD STUDENT	START DATE	PROGRAM	PROJECT TOPIC
 **Rob Davidson**	September 2017	Program 1, working with Bruce Gemmell and David Cooke	Geology and genesis of the San Sebastian vein system, Durango, Mexico
 **Sibele Cristina do Nascimento**	October 2017	TMVC, working with Anita Parbhakar-Fox, David Cooke and Matt Cracknell	Geoenvironmental characterisation of historic mine tailings
 **Yi Sun**	October 2017	TMVC, working with Lejun Zhang, Angela Escolme and David Cooke	Mineralogical and geochemical characterisation of Lepanto Quartz-Pyrite-Gold system, Philippines
 **Amery Jackson**	November 2017	Program 2, working with Nathan Fox, Matt Cracknell and Anita Parbhakar-Fox	Geometallurgical controls on grade by size fractionation in gold systems
 **Thomas Schaap**	December 2017	Programs 3/6, working with Sebastien Meffre, Joanne Whittaker (IMAS), Michael Roach and Matt Cracknell	Plate tectonic modelling of the Early Palaeozoic evolution of SE Australia
 **Nanda Yusentri Mrabawani**	January 2018	TMVC, working with Leonid Danyushevsky and Sebastien Meffre	Technology and method development of LA-ICP-MS on complex matrices of plagioclase feldspar and apatite
 **Emily Smyk**	January 2018	TMVC, working with David Cooke	Magmatic mineral chemistry as a tool for detecting fertile intrusive complexes associated with porphyry copper deposits
 **Umer Habib**	April 2018	Program 3, working with Sebastien Meffre	Paleomagnetism and tectonic reconstruction of the Palaeozoic of SE Australia

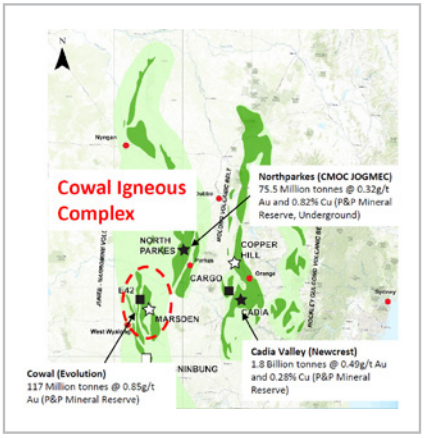
THE LACHLAN OROGEN: THE ROAD TO SUCCESS

Sebastien Meffre reports that the 'Ore deposits and tectonic evolution of the Lachlan Orogen, southeast Australia' project is paying dividends

This ARC Linkage project aims to improve economic mineral discoveries through an increased understanding of the geology and tectonic evolution of the Lachlan Orogen in southeast Australia; and to integrate that knowledge with existing geological information to subsequently develop predictive and explanatory models.

The project started in December 2016 and is due to finish in December 2019. This study involves a total of 15 students, five universities, four geological survey organisations and ten mining companies. The project is going well with a number of important results being reported at various conferences and in publications during 2017. These include the following highlights:

A paleomagnetic study in Tasmania by Honours student Kathryn Job, Dr Michael Roach and Dr Robert Musgrave (Geological Survey NSW) suggests that the Mount Read Volcanics in northern Tasmania may have been significantly rotated in the Silurian or Devonian, relative to those in western Tasmania. This rotation formed part of a hypothesis put forward by Geological Survey of Victoria Geologist Dr Ross Cayley. Further measurements are being undertaken this year by CODES PhD students Thomas Schaap and Umer Habib to decrease the statistical uncertainty of the initial results. Umer will also acquire paleomagnetic data in NSW and Victoria.



A study by CODES PhD student Chris Leslie has been improving the techniques that are used to predict whether a porphyry is likely to be prospective. Zircon trace element chemistry has been used to make these predictions for the past 15 years; however, the technique can be problematic, particularly in the Lachlan Orogen intrusive rocks, due to the strong compositional zonation. Chris is making chemical maps of the zircons to overcome this issue and applying these results to make predictions about intrusive rocks from the Lake Cowal area.

Cambrian rocks that can be shown to form part of the basement to the Macquarie Arc have been discovered and documented for the first time. These rocks consist of diorites with island arc affinities, probably related to the Victorian island arc volcanics.

A study by CODES PhD student Tristan Wells has been characterising the chemistry of the mineralised and unmineralised intrusive rocks in and near the Northparkes Mine. He has found that the portable X-ray fluorescence spectrometer is able to be used to rapidly identify mineralised intrusive porphyries.

A study by CODES MSc student Peerapong Sritangsirikul is investigating the tectonic setting of the Rockley-Gulgong volcanic belt of the Macquarie Arc (located over the Blue Mountains near Sydney). His work is confirming that the belt was in a distal setting with respect to the arc volcanoes during the Ordovician.

This ARC Linkage project is now in its main data collection phase and is on track, and is delivering interesting results that will help improve the understanding of the ore deposits fertility and tectonics of the Lachlan Orogen.

Top: PhD student Umer Habib and Robert Musgrave (Geological Survey NSW) on the Gordon River Road in Tasmania deciding where to take paleomagnetic samples.

Above: Major deposits from the Macquarie Arc, New South Wales, where the ARC Linkage project on the Lachlan Fold Belt is based.

CODES IS KEY IN PLANNING MAJOR INTERNATIONAL GATHERING

Autumnal view of Waterville Valley, New Hampshire, the setting for the Gordon Research Conference and Seminar on the geochemistry of Mineral Deposits.

Researchers from CODES/TMVC are intimately involved in the organisation of the next Gordon Research Conference on the Geochemistry of Mineral Deposits and associated Gordon Research Seminar, scheduled for 4–10 August 2018 at Waterville Valley, New Hampshire, USA.

Gordon Research Conferences (GRC) provide a unique international forum for the presentation and discussion of frontier research in the biological, chemical, and physical sciences, and their related technologies. The 2018 conference is being organised by Professor David Cooke (CODES/TMVC), Professor Sarah Gleeson (GFZ Potsdam), and Dr Claire Chamberlain (Teck Resources). The inaugural Gordon Research Seminar is being organised by PhD student Ayesha Ahmed and Postdoctoral Research Fellow Dr Angela Escolme, both from CODES/TMVC.

The theme of the 2018 meeting is 'Mineralizing Processes Across All Scales'. The meeting will provide a state-of-the-art appraisal of mineralising phenomena across all scales, from nanoparticle creation to tectonic plate migration. A diverse program of oral and poster presentations has been planned that will investigate mineralising phenomena, their key geological drivers, and environments that promote their effective operation. The committee aims to bring together industry, academic and other research geoscientists with the intent to ensure upcoming talent, and global and gender diversity are fully represented in order to facilitate a vibrant and stimulating conference. Confirmed discussion leaders for the conference include Thomas Monecke, Steve Piercey, Sally Goodman, Ross Large, Shaun Barker, Isabelle Chambefort, Eduardo Campos, Katy Evans and John Thompson.

New to the 2018 conference will be the 'Student Seminar' (GRS), showcasing some of the brightest PhD and early career researchers in the field. The GRS will provide a platform for students to present new ideas and research not only to their peers but to a select group of academic and industry leaders. Students and early-career researchers from 13 countries have applied to participate in the GRS.

Registrations for this event have now closed; information is available at: https://www.grc.org/geochemistry-of-mineral-deposits-conference/2018/

Angela Escolme (left) and Ayesha Ahmed, pictured here at the Australian Synchrotron in Victoria, are organising the inaugural Gordon Research Seminar. Angela says: 'We are really excited to chair this inaugural seminar; the meeting will showcase some of the brightest emerging talent we could find in the field of geochemistry of mineral deposits'.

DREDGING SUBMARINE VOLCANOES IN THE KERMADEC ARC YIELDS BIG DATA!

Top: German research vessel R/V *Sonne*, looking towards the stern while she is underway during the March 2017 research expedition in which Martin Jutzeler participated. **Above:** Pumice samples are brought aboard the R/V *Sonne* during Martin's research cruise along the Kermadec arc in 2017. **Left:** Martin displays a coarse, rafted pumice clast from the 2012 deep submarine eruption of Havre volcano.

In March 2017 , Dr Martin Jutzeler was invited to participate in a six-week voyage to dredge multiple submarine volcanoes along the Kermadec arc, north of New Zealand. Led by Professor Kaj Hoernle (GEOMAR, Germany), the expedition aimed at reconstructing the magmatic evolution associated with the splitting of the former Vitiaz arc during the Neogene, and subsequent formation of the modern Kermadec arc front and its back-arc basin.

The voyage covered more than 200,000 km^2 over the former and modern arcs, the back-arc basin, and the fore-arc. As the sole volcanologist/sedimentologist aboard, Martin had prime access to the fine-grained volcanoclastic sediments and pumiceous material collected at over 179 dredging stations. This enormous dataset will be used to identify pyroclast dispersal in the context of island arcs, by chemical comparison of rocks collected at known eruption centres.

Additionally, Martin collected pumiceous material derived from the 2012 deep submarine eruption of Havre volcano in the Kermadec arc. This pumiceous material was rafted at the surface of the ocean, until finally sinking by progressive waterlogging. These samples will be compared with pumices and lavas collected by a Remotely Operated Vehicle during the MESH voyage led by Dr Rebecca Carey (CODES) in 2015, in which Martin also participated.

THE LIGHTER SIDE…

The staff team after their victory, inspired by Garry.

Sheer delight on Michael Roach's face after receiving the 'trophy' on behalf of the Staff!

The student team played valiantly but lost.

Garry would have loved it!

The Garry Davidson Inaugural Touch Football Match: Staff vs Students, 20 April 2018

Garry Davidson was always bounding around at lunchtimes. Often he would organise touch football or frisbee on the oval and get Earth Sciences staff and students out in the middle of the day. Garry's enthusiasm for these sports, exercise and bringing people together was a driver to organise a touch football Staff versus Students match in his honour earlier this year.

The Staff were pumped and ready for action. With black commemorative armbands and headbands – and some war paint – they were ready to meet their younger rivals. The Students were perhaps a bit complacent. They may have underestimated the competitiveness of the other team.

Two 15-minute halves were played across the lower soccer oval. Staff scored early and appeared to pull away in the first half. The Students, in a critical situation, brought out some big hitters in the second half and rallied. But Staff held out to win the day.

After all that running around, everyone enjoyed a barbeque cooked by the SEG student chapter. Michael Roach accepted the winner's trophy on behalf of the staff team. Spectators and players were all pleased by the convivial interaction. Garry would have loved this event. We hope it will become an annual undertaking.

Rock opera

Izzy von Lichtan, our Rock Library curator, provided a specimen of celestite from Madagascar to filmmaker Keith Deverell which was used as the basis for backdrops in Melbourne Opera's highly acclaimed production of Richard Wagner's Tristan and Isolde in February this year.

Keith Deverell used close-ups of the celestite to produce the look of blue cave-like structures in both photographs and video format, which were widely used during the opera. This artistic endeavour was facilitated by CODES researcher Dr Anita Parbhakar-Fox.

Celestite consists of strontium sulfate ($SrSO_4$) and derives its name from its beautiful crystals with their delicate blue hue. The mineral used for the opera was from the Mahajanga (Majunga) Province of Madagascar; the blue variety of celestite is found only in Madagascar.

Top: Rock Curator Izzy von Lichtan holds a piece of celestite used to create a backdrop for Melbourne Opera's Tristan and Isolde earlier this year.

Above: A scene from Melbourne Opera's Tristan and Isolde with the celestite-inspired backdrop clearly visible. Photo: Robin Halls (from the arts blog Simon Parris: Man in Chair)

VALE PROFESSOR DEE BRADSHAW (1958–2018)

Professor Dee Bradshaw will be greatly missed by the CODES family.

Anita Parbhakar-Fox pays tribute to a great mentor and highly regarded CODES collaborator

We extend our condolences to the family and friends of Professor Dee Bradshaw, University of Cape Town, South Africa, who passed away recently. Dee was internationally renowned as an expert in the field of flotation with her reputation for excellence developed over four decades. She obtained her PhD in 1997 in Chemical Engineering from the University of Cape Town (UCT) and went on to lecture at UCT until 2008.

Dee first became involved with CODES in 2008 during her sabbatical at the University of Queensland where she met Dr Steve Walters, then leader of the AMIRA P843 GeM project. Dee worked closely with the CODES GeM team (including Anita Parbhakar-Fox, Ron Berry, Julie Hunt) where she co-supervised PhD students and went on to lead the flotation module in the AMIRA P843a GeM project (2009–2013). She continued her work at CODES through her appearance as a guest lecturer in the Geometallurgy unit within the Master of Economic Geology program (2012, 2013 and 2015). Dee was very popular and inspired many dozens of students, teaching them not only about flotation but also challenging them to set career goals and build skills to realise those targets.

In 2016, Dee came full circle and returned to her Alma Mater where she was appointed as the South African Research Chair in Minerals Beneficiation and the Director of the Mineral to Metal Initiative. She was a great leader, truly unique in her desire to understand people, scientific problems and society. Her passion was illuminating and she inspired all around her; she made a huge contribution to the mining industry. Dee leaves us with the legacy of her new book 'Green Mining: Beyond the Myth'. CODES and the mining community will miss her immensely.

Visiting scholar working with ES/CODES researchers

In March–April 2018, Dr Adam Soule from the Woods Hole Oceanographic Institute came to UTAS for three weeks on a Visiting Scholars Award. Adam is the Chief Scientist of Deep Submergence at the US National Deep Submergence Facility. Together with scientists from the Institute of Marine and Antarctic Studies, Rebecca Carey and Martin Jutzeler planned a funding and ship-time submission to the US National Science Foundation and an Australian Research Council Linkage proposal with external New Zealand partners.

Above: Visiting Scholar Dr Adam Soule at work.

Economic Geology

A Special Issue of *Economic Geology* devoted to porphyry and epithermal deposits of the southwest Pacific was published in January this year. CODES researchers and research associates who contributed include: Mike Baker, Evan Orovan, Adi Maryono, David Cooke, Terence Hoschke, David Braxton, Allan Ignacio, Erin Lawlis, Rachel Harrison, Jay Thompson, Stephanie Sykora, Sebastien Meffre, Aleksandr Stepanov, Robert Scott, David Selley, Anthony C Harris, Lindsay Clark, Bruce Gemmell and Marc Rinne.

Understanding hydrothermal systems

In February 2018, scientists from GNS Science and the New Zealand Institute for Water and Atmospheric Research visited the Earth Sciences and CODES staff at UTAS to workshop research on how hydrothermal systems recover after large-scale submarine eruptions. The 2012 eruption of the submarine Havre volcano, Kermadec Arc, New Zealand, devastated the existing hydrothermal systems and inhabitant biological species as observed with a Remotely Operated Underwater Vehicle in 2015. The research team at UTAS plans to submit ship-time voyage proposals with NZ and US collaborators to revisit the volcanoes to track recovery dynamics.

GARRY DAVIDSON SYMPOSIUM

22–24 OCTOBER 2018

In conjunction with the Ore Deposit Models shortcourse offered by CODES in October 2018, we are holding a three-day symposium celebrating Garry Davidson's career and contributions to ore deposit research. Many of Garry's close colleagues and collaborators will give presentations at this event.

The Garry Davidson Symposium honours Garry's memory by providing a state-of-the-art appraisal of the characteristics, origins and exploration of these significant mineral resources.

CODES

SYMPOSIUM PROGRAM

DAY 1 IOCG AND RELATED DEPOSITS:

David Cooke, Nick Oliver, Subira Sharma Steadman, Kathy Ehrig, Terry Hoschke, Roger Skirrow, Peter Sorjonen-Ward, Lesley Wyborn, Penny Sinclair, Karin Orth.

DAY 2 SEDIMENT-HOSTED BASE METAL DEPOSITS:

David Selley, Peter McGoldrick, Stuart Bull, Scott Halley, Tony Webster, Steve Bodon, Danny Huisman, Rod Allen.

DAY 3 VHMS DEPOSITS:

Ross Large, Bruce Gemmell, David Huston, Margy Hawke, Andrew McNeill, Sarah Jones, Neil Martin, Rob Scott, John Walshe, Michael Nugus, Paul Kitto, Mike Roach, Scott Halley, David Green.

Ore Deposit Models and Exploration Strategies

22 OCT–2 NOVEMBER 2018

The CODES Master of Economic Geology shortcourse, Ore Deposit Models and Exploration Strategies, presented by a range of CODES and invited experts, provides an up-to-date synopsis of key ore deposit types including porphyry, epithermal and skarn deposits, IOCG deposits, orogenic, Carlin and Witwatersrand gold deposits, volcanic-hosted massive sulfide and sea-floor hydrothermal deposits, sediment-hosted-Cu deposits, sedex and Broken Hill-type Zn-Pb deposits. Most deposit types receive a full day of lectures and practical exercises, addressing the location, characteristics, genesis and exploration strategies.

Ore Deposit Models and Exploration Strategies is offered as part of the National Minerals Geoscience Masters program, and will be held at CODES, University of Tasmania, Hobart. The first three days of the course comprise the Garry Davidson Symposium, which you can register for separately if required (see above for details).

Monday 22 October	**Garry Davidson Symposium – Day 1** IOCG and uranium deposits
Tuesday 23 October	**Garry Davidson Symposium – Day 2** Sediment-hosted base metal deposits **Conference dinner**
Wednesday 24 October	**Garry Davidson Symposium – Day 3** VHMS and orogenic gold deposits
Thursday 25 October	**Skarns** *Presenter: Zhaoshan Chang*
Friday 26 October	**Granite-related Sn-W deposits; Tasmanian ore deposits; introduction to the excursion** *Presenters: Lejun Zhang, Evan Orovan and David Cooke*
Saturday 27 October	**Magmatic-hydrothermal textures – field excursion to Freycinet Peninsula** *Presenters: Evan Orovan, David Cooke and Lejun Zhang*
Sunday 28 October	**Private study**
Monday 29 October	**Porphyry-Cu, Au and Mo deposits** *Presenters: Noel White, Lejun Zhang and David Cooke*
Tuesday 30 October	**High sulfidation epithermal deposits and lithocaps** *Presenters: Noel White, Lejun Zhang and David Cooke*
Wednesday 31 October	**Low and intermediate sulfidation deposits** *Presenters: Noel White and David Cooke*
Thursday 1 November	**Carlin-type Au deposits** *Presenters: Rob Scott and Shaun Barker*
Friday 2 November	**Student presentations**

Register online for the symposium and the shortcourse at: http://www.utas.edu.au/codes
For further details **email:** Robert.Scott@utas.edu.au or **phone**: +61 3 6226 2786