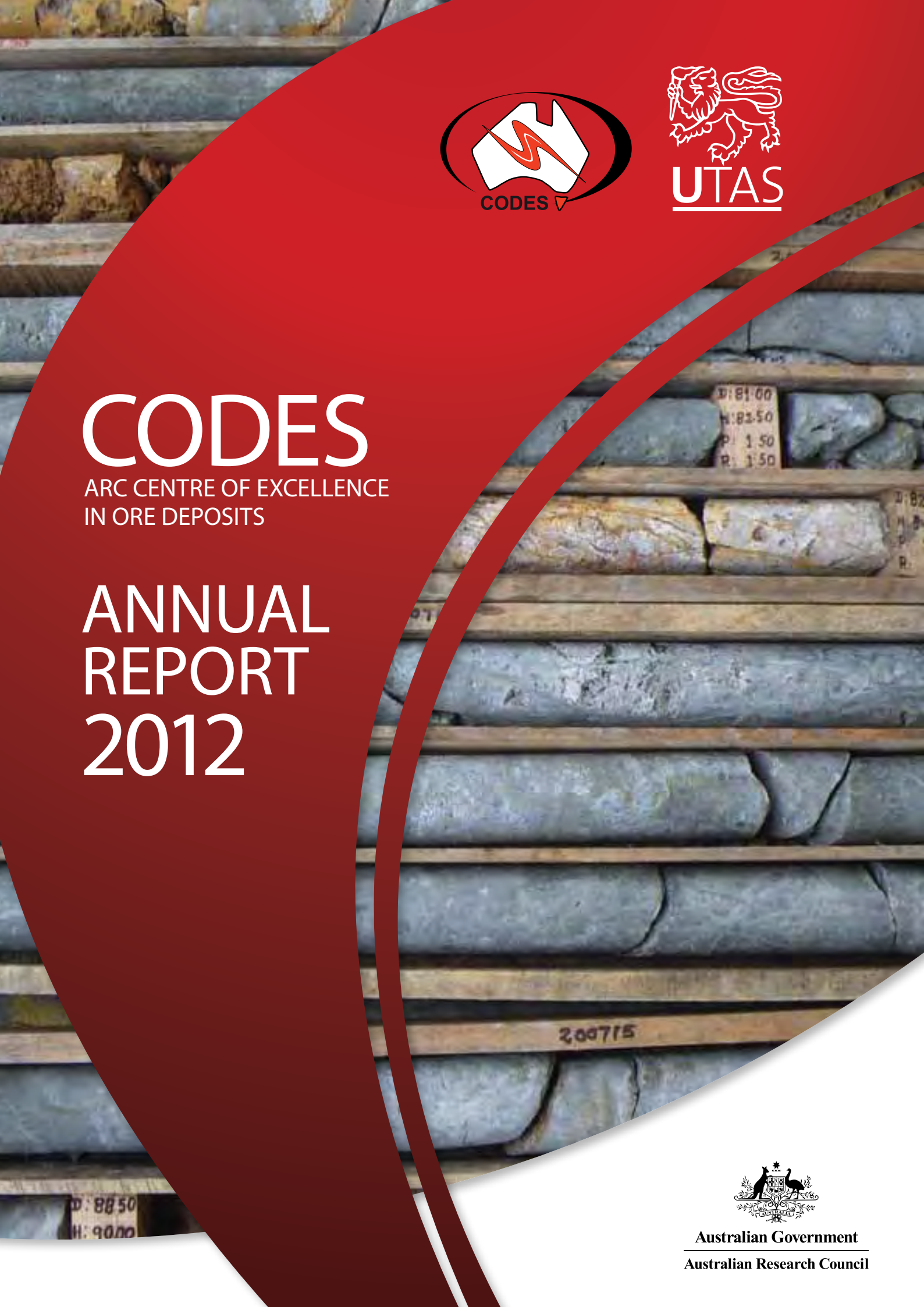
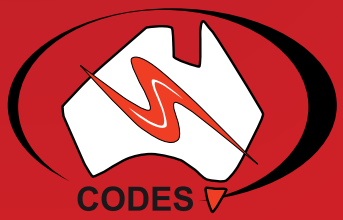


CODES

ARC CENTRE OF EXCELLENCE
IN ORE DEPOSITS

ANNUAL REPORT 2012

Australian Government
Australian Research Council



CODES

ARC CENTRE OF EXCELLENCE
IN ORE DEPOSITS

ANNUAL REPORT 2012

Australian Government

Australian Research Council

Vision

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

Mission

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

Goals

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

Contents

Front cover: Core samples from Colquijirca silver mine in Peru.
Back cover: Top: Participants in the Volcanology and Mineralisation in Volcanic Terrains short course on White Island, NZ. **Bottom:** PhD student, Francisco Testa, conversing in Spanish to visitors to the CODES booth at the Lima 2012 Congress in Peru.

PLEASE NOTE: IN VARIOUS PLACES THROUGHOUT THIS PUBLICATION, IMAGERY HAS BEEN USED FOR GRAPHIC PURPOSES ONLY. CAPTIONS HAVE NOT BEEN PROVIDED IN THESE INSTANCES.

Director's Report

It has been an eventful year for CODES, which has seen a number of changes and developments. Therefore, I believe that it is appropriate for me to begin this report with one of the most significant of those changes: the end of Professor Ross Large's highly successful tenure as Director.

Without Ross there would be no CODES. The Centre was his brainchild. It was his tenacity, enthusiasm and perseverance that secured its inception; and it has been his leadership, astute management and unique character that has seen it blossom and grow into what it is today: a world leader in ore deposit research and training.

Ross recognised a need for a centre that delivered tangible economic benefits for industry. He had the vision to see that CODES could not only perform fundamental research alongside applied research, it could also merge the two areas, and utilise its extensive fundamental knowledge base as a catalyst for successful industry-focused outcomes. Thus, CODES developed a truly team-based approach built around a series of programs covering the full spectrum of geological research, from genesis through to mineral recovery.

Under his leadership, the Centre has also become internationally recognised for the excellence of its postgraduate programs. There are literally hundreds of alumni around the world who now have successful careers in the geosciences that owe a large debt of gratitude to Ross… but then we all do.

I am honoured to take over as Director from Ross, and to be given the opportunity to build on what he has achieved over 23 remarkable years. However, I am very pleased to be able to stress that Ross has not left CODES. He retains an office at the Centre to focus on research, and will be playing a role in the new mineral research laboratory, which I will cover later in this report.

Two other key players in CODES evolution, John Dow and Tony Crawford, also stepped down from their roles during the year. John had been Chair of the Advisory Board virtually since the beginning of our tenure as a Centre of Excellence, providing exceptional guidance and advice on numerous pivotal decisions along the way. On behalf of everyone at CODES, I wish to thank John for the significant contribution he has made to our success. He will be a hard act to follow, but we were very pleased to be able to secure the services of another high calibre person, Paul Heithersay, as his replacement. Paul has more than 20 years' experience in the mining industry in Australia, SE Asia and China, and is currently Deputy Chief Executive Resources and Energy at the South Australian Government's Department of Manufacturing, Innovation, Trade, Resources and Energy (DMITRE).

Tony Crawford retired at the end the year and stepped down from leading the Location Program, which is being taken over by one of our finest researchers, Jocelyn McPhie. Tony has been instrumental in developing the extensive knowledge base of fundamental research, which I mentioned earlier, so it is important that his skills are not being lost to our team. Tony will be associated with CODES as an Honorary Research Professor.

It has been another productive and successful year in terms of research, a highlight of which was Geology at UTAS receiving the highest possible ranking of five in the Excellence in Research for Australia (ERA). Our publication performance also remained high in terms of quantity, as well as quality. Our researchers had 62 refereed journal articles published, which is a commendable performance in light of the high number of industry reports that were also produced by the team. The AMIRA P1060 (Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems) project reached its halfway point and is progressing on schedule. I am also pleased to report that the team, led by David Cooke and myself, has been successfully rebuilt to full strength after we lost a number of key members from the AMIRA P765A group – the forerunner to this project. The Olympic Dam project, funded by BHP Billiton, continued to provide impressive results, which have led to a further funding extension. The Ore Deposits of SE Asia project also continued to expand, with the addition of two new industry sponsors.

CODES is known for its extensive worldwide collaborations, and those relationships continued to flourish in 2012. In total we now have over 80 collaborations with universities and various types of institutions around the globe, plus alliances with over 60 industry-based companies. Highlights included Rebecca Carey being invited to join an international research team on a 16-day research cruise to the northern Izu-Bonin Arc, conducted by JAMSTEC (the Japan Agency for Marine-Earth Science and Technology). The principal aims of the cruise were to improve the geological understanding of three silicic volcanoes in the area.

Our researchers were once again rewarded for the excellence of their research via a number of awards and accolades. A paper by Ross Large and Stuart Bull from CODES, and Valeriy Maslennikov from the Russian Academy of Sciences, received the highly prestigious Brian J Skinner Award from the SEG for the best scientific paper published in *Economic Geology*. A team led by David Cooke and myself received the inaugural AMIRA International Award for Geoscience Research Excellence (for research related to AMIRA projects P765, P765A, and P1060). Other notable highlights included Vadim (Dima) Kamenetsky receiving the UTAS Vice-Chancellor's Award for Internationally recognised research, and Khin Zaw deservedly being promoted to professor after many years building and expanding ore deposit research in SE Asia.

It was another highly productive year for our HDR program, led by Jocelyn McPhie. Fifteen students had theses under examination, eight of whom graduated. In total, there were 46 students enrolled in the program, which included 37 overseas students from 20 countries – bearing testament to the high regard for the program internationally.

Rob Scott and the team involved in the Master of Economic Geology Program had one of their busiest and most successful years, which included a very full program of courses, record student enrolments for some units, and the introduction of a new course on Geometallurgy – the first of its kind in the world. Eleven new people joined the program, bringing the total number of UTAS-based students active in the national program to a very healthy figure of 41 for the year. It was also a good year for completions, with eight students completing their degrees. On a less positive note, funding from the Minerals Tertiary Education Council (MTEC) ceased at the end of the year. While this shortfall will create significant challenges to the financial viability of the program, such is its importance and popularity that I am very confident that it will continue to go from strength to strength.

A statistic that stands out in this year's Finance figures is the huge increase in industry funding, which has risen by more than 100% compared to the 2011 figure. While in some ways this is indicative of our strong support from the minerals industry, unfortunately the majority of this increase is due to anomalous fluctuations in our funding payments. Payments previously delayed due to late contract finalisations were included in this figure, plus Newcrest's payment of $1.2 million towards the initial costs associated with establishing the new mineral research laboratory.

This new facility is a major vote of confidence by Newcrest in the future of CODES well beyond our tenure as a Centre of Excellence. In addition to the initial $1.2 million mentioned above, they have committed a further $1.3 million over five years to help run the facility.

There is no doubt that there are major challenges that lie ahead, the most significant of which is acquiring funding to replace the Centre of Excellence support from the ARC that ceases at the end of 2013. Notwithstanding these challenges, I believe that based on 2012 there are many reasons for CODES to look forward with optimism. We have retained an exceptionally strong team. Many of our research projects have been expanded. Our HDR and Masters programs have gone from strength to strength, and we have enjoyed the continued support of our highly valued partners in the minerals industry. Not least of which is the support for the new minerals research facility. This major development, which will be managed by Ross Large, with Leonid Danyushevsky as the Scientist in Charge, will considerably enhance our LA-ICP-MS facilities, as well as our R&D capabilities.

This ongoing support of CODES reinforces the fact that our activities have provided significant benefits to the minerals industry over the years. Our aims are to consolidate and build on these benefits, while evolving to meet the changing needs of our industry.

I thank all of our stakeholders for their support in 2012, and I look forward to working with you all in the coming year to help secure our future and build on our success.

Professor J Bruce Gemmell,
Director and Chief Operations Officer.

Outcome-driven Research

~ Built on teamwork, worldwide collaborations and excellence in training

CODES is the Australian Research Council Centre of Excellence in Ore Deposits, based alongside the School of Earth Sciences at the University of Tasmania. Formed in 1989, the Centre has grown substantially over the years and is now widely regarded as a global leader in ore deposit research. It is home to 60 highly qualified research staff and 110 postgraduate students, further cementing its position as the largest university-based team of ore deposit researchers in the world.

Highly productive worldwide collaborations have been developed with over 60 industry companies, plus a host of joint research initiatives with 88 institutions and universities – 17 in Australia and 71 overseas. It currently has 46 major research projects spanning 29 countries, and is the leading academic group to publish in *Economic Geology*.

In 2012, it maintained its reputation for delivering excellence in technology transfer by producing 119 reports to industry and conducting 28 workshops and short courses in 13 countries, spread across all six permanently inhabited continents.

Key Statistics – 2012	
Academic research staff	60
Postgraduate students	110
Major research projects	46
Countries involved	29
Publications in refereed journals	62
Research reports to industry	119
Funding:	
Industry	$6.0 million
ARC	$3.1 million
UTAS	$2.4 million
Worldwide collaborations:	
Industry	60
Institutes and universities	88

Framework for Leading Research

The Centre has adopted an holistic approach to the science that encompasses all areas of the research cycle. This is achieved through five major research programs – Location, Formation, Discovery, Recovery and Technology. In very basic terms, these programs can be explained as follows:

- **Location** seeks to improve our knowledge of the tectonic and geological controls on the location of ore deposits.
- **Formation** develops practical, process-based ore genesis models to help explorers understand the formation of deposits.
- **Discovery** focuses on the acquisition, processing and interpretation of scientific ore deposit data to assist in the discovery of minerals.
- **Recovery** is an integrated, cross-disciplinary field that seeks to enhance mineral processing techniques and optimise mineral recovery rates.
- The **Technology** Program uses a combination of traditional and cutting-edge technological developments to improve the understanding and, subsequently, advance the exploration and exploitation of minerals.

These five programs, together with a team-based approach, have formed the foundations of CODES' ability to provide a seamless transition between fundamental and applied research.

Opposite page: Top: A swath bathymetry image of the NW corner of Batavia Knoll. **Centre:** Helicopter carrying participants in the Volcanology and Mineralisation in Volcanic Terrains short course comes in to land on White Island, NZ. **Bottom:** Core samples from Program 4.

New Mineral Research Facility

Work commenced late in 2012 on a new mineral research laboratory that will focus on ore deposit characterisation. Newcrest Mining is the foundation client for the new initiative, contributing $1.2 million towards its initial development, with a further $1.3 million in ongoing support over five years. The new facility will use priority micro-analytical techniques developed at CODES to solve some of the complexities associated with defining an ore body prior to mining. Further information can be found under Highlights – Program 5.

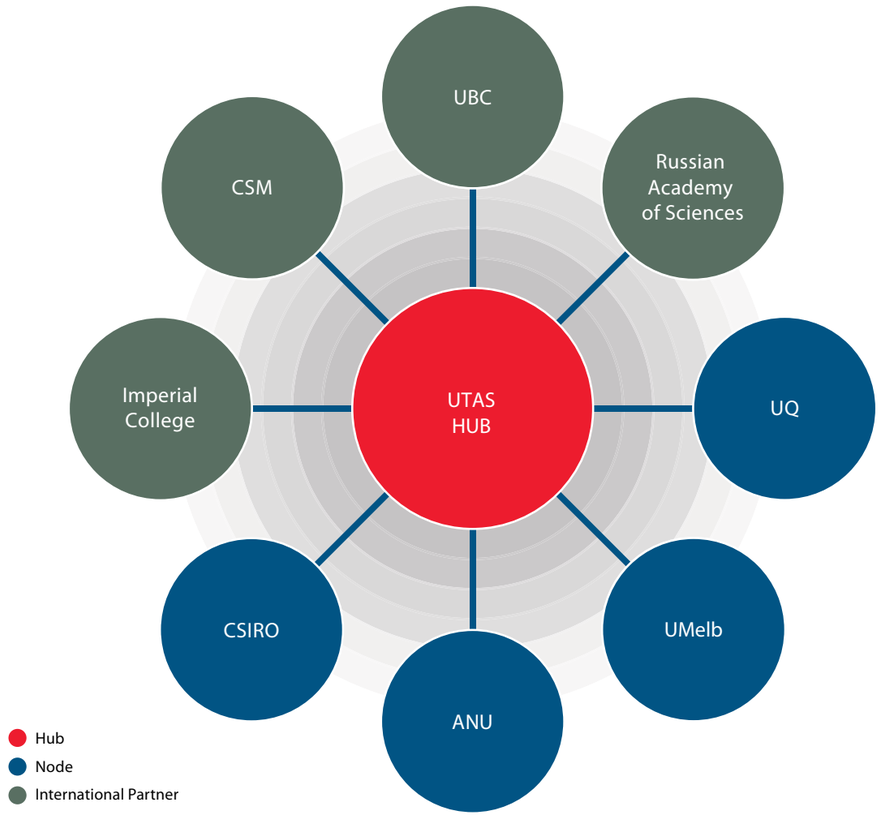
When completed in mid-2013, this facility will significantly extend CODES' R&D capabilities, which already includes three cutting-edge laboratories catering for LA-ICP-MS, ICP-MS, and XRF analysis. In addition, it has access to an extensive range of equipment via the UTAS Central Science Laboratory, including Raman spectroscopy.

Hub, Nodes and International Partners

CODES is based at the University of Tasmania, with satellite facilities, known as nodes, at the University of Queensland, University of Melbourne, Australian National University, and CSIRO. This structure provides an exceptionally strong mix of skills and facilities by combining the research strengths of CODES' UTAS Hub with the diverse range of expertise available through the nodes. The nodes' strengths include:

- Metallurgy and mineral processing (University of Queensland).
- Structure of ore deposits (Australian National University).
- Isotope geochemistry (University of Melbourne).
- Micro-beam analytical techniques (CSIRO).

The strengths of these Australian nodes are complemented by four strong partnerships with the University of British Columbia, the Colorado School of Mines, Imperial College London and the Russian Academy of Sciences, which provide an ideal platform for international research projects and augment the Centre's access to the latest technology.



Opposite page: Participants in the Volcanology and Mineralisation in Volcanic Terrains short course hiking the Tongariro Crossing, NZ.

Staff & Management

Centre Director

Centre Director, Professor Bruce Gemmell, is responsible for the scientific leadership and operational management of the Centre. He is supported in these duties by David Cooke (Deputy Director), the Advisory Board and the Executive Committee. Professor Gemmell, who was previously Deputy Director, was appointed to the position during October, taking over from Professor Ross Large, who remains actively involved with CODES in various research capacities.

Advisory Board

The Advisory Board meets at least once a year to review the progress of the Centre and to advise on future directions. The Board is composed of representatives from major industry partners, University of Tasmania senior management, and key national geoscience organisations. It is chaired by Dr Paul Heithersay, who has extensive experience in the minerals industry and the public service. Dr Heithersay took over from John Dow, who stepped down from the role in November after seven highly competent years at the helm.

Science Planning Panel

The Science Planning Panel meets annually for a one-day forum of presentations relating to the Centre's scientific research progress and to discuss potential new research projects. The membership is wider than that of the Advisory Board and includes a representative from all partner companies. The Panel is designed to provide industry with an opportunity to influence future research directions of the Centre.

Centre Research Committee

The Centre Research Committee includes all collaborating partner chief investigators. It meets annually to discuss research progress, new research opportunities and particularly to focus on effective collaborative activities across all Centre partners.

Executive Committee

The Executive Committee consists of the Centre Director, Deputy Director, Graduate Research Co-ordinator, five program leaders and administrative managers. It meets approximately six times a year, working closely with the Director to develop the Centre's goals, strategies and performance indicators.

Staff Movements 2012

Appointments

Dr Daniel Bombardieri has been appointed as a research fellow in geophysics, working in a collaborative study with Mineral Resources Tasmania (MRT). Daniel works three days per week at CODES, and two days at MRT.

Mr Keith Dobson has been appointed as IT Officer.

Dr Chun-kit Lai was appointed as a research fellow working on the Ore Deposits of SE Asia Project. Dr Lai, more commonly known as 'Kit', completed his PhD at CODES during the year.

Elena Lounejeva has been appointed as a Laboratory Analyst.

Dr Abhisit Salam was appointed as a research fellow working on the Ore Deposits of SE Asia Project. Dr Salam, more commonly known as 'Masoe', completed his PhD at CODES during the year.

Dr Aleksandr (Sasha) Stepanov has been appointed as a mineralogist.

Departures

Three academic staff and one professional staff member left CODES during the year.

Academic Staff: Huayong Chen, Jeff Foster, Janina Micko.

Professional Staff: Shaun Inglis.

CODES Staff

Staff and Management

Name		%
Director, Professor J Bruce Gemmell, BSc (UBC), MA, PhD (Dartmouth)	VHMS deposits and epithermal Au-Ag	100
Deputy Director, David Cooke, BSc Hons (Latrobe), PhD (Monash)	Porphyry Cu-Au, fluid-rock geochemistry	50

Name		%
Director (part of year), Professor Ross Large, BSc Hons (UTAS), PhD (UNE)	Volcanic-hosted and sediment-hosted base metal and gold ores	100

Academic/Research Staff at UTAS

Name		%
Dr Sharon Allen, BSc (Massey), MSc (Auckland), PhD (Monash)	Volcanic facies analysis	50
Dr Mike Baker, BSc Hons (Sydney), PhD (UTAS)	Igneous petrology, mineral chemistry	100
Associate Professor Ron Berry, BSc, PhD (Flinders)	Structure of mineralised provinces, CHIME dating, geometallurgy	50
Dr Daniel Bombardieri, BSc Hons, PhD (UTAS)	3D potential field modelling	60
Dr Stuart Bull, BSc Hons, PhD (Monash)	Clastic and carbonate sedimentology and volcanology	85
Dr Rebecca Carey, BSc Hons (UTAS), PhD (U Hawaii)	Volcanology	100
Professor Tony Crawford, BSc Hons, PhD (Melbourne)	Petrology, geochemistry and tectonics of volcanic arcs	50
Professor Leonid Danyushevsky, PhD (Vernadsky Inst.)	Petrology, geochemistry, LA-ICP-MS analysis	100
Dr Garry Davidson, BSc Hons (ANU), PhD (UTAS)	Sulfur isotope geochemistry and Cu-Au ores	50
Dr Paul Davidson, BSc Hons, PhD (UTAS)	Melt and fluid inclusions	Hon
Dr Nathan Fox, MSc Hons (Imperial), PhD (UTAS)	Porphyry Cu-Au and HS epithermal	100
Dr Trevor Falloon, BSc Hons (Canterbury), BTeaching, PhD (UTAS)	Marine geoscience, petrology	Hon
Dr Jacqui Halpin, BSc Hons (Melbourne), PhD (Sydney)	Metamorphic petrology, geochronology	75
Dr Julie Hunt, MSc (UBC), PhD (JCU)	Geometallurgy, IOCG deposits	100
Dr David Hutchinson, HND (Camborne, Sch of Mines), BSc Hons, PhD (Cardiff)	Ni-Cu/PGE mineralisation, geometallurgy	100
Dr Nic Jansen, BSc Hons (St Mary's), PhD (UTAS)	Porphyry Cu-Au and HS epithermal	100
Dr Maya Kamenetsky, PhD (UTAS)	MLA-SEM, geometallurgy, petrology	80
Professor Vadim Kamenetsky, BSc Hons (Moscow), PhD (Vernadsky Inst.)	Petrology and geochemistry of melt inclusions	50
Professor Khin Zaw, BSc (Rangoon), MSc (Queen's), PhD (UTAS)	Fluid inclusions, SE Asian metallogenesis	100

Name		%
Dr Lyudmyla Koziy, PhD (UTAS)	Fluid flow modelling	50
Dr Chun-kit Lai, BSc, MPhil (HKU), PhD (UTAS)	Petrology, geochemistry and tectonics of SE Asia	100
Dr Peter McGoldrick, BSc Hons, PhD (Melbourne)	Ore deposits and their halos	50
Associate Professor Andrew McNeill, BSc Hons, PhD (UTAS)	Petrology, VHMS deposits, mineral exploration	100
Professor Jocelyn McPhie, BA Hons (Macquarie), PhD (UNE)	Volcanic facies architecture and volcanic textures	50
Dr Sebastien Meffre, BSc Hons, PhD (Sydney)	Petrology and tectonics of the SW Pacific	100
Dr Karin Orth, BSc Hons (Monash), PhD (UTAS)	Volcanology	100
Dr Anya Reading, BSc Hons (Edinburgh), PhD (Leeds)	Geophysics, seismology, computational methods	50
Dr Michael Roach, BSc Hons (Newcastle), PhD (UTAS)	Geophysical responses of ore deposits	50
Dr Abhisit Salam, BSc Hons (Aligarh), MSc (Chulalongkorn), PhD (UTAS)	LS epithermal Au and mineral exploration	100
Dr Ralf Schaa, MSc (Cologne), PhD (UTAS)	Remote sensing, approximate modelling and inversion of TEM	100
Dr Rob Scott, BSc Hons, PhD (Monash)	Structural geology, gold deposits / MTEC Senior Lecturer and Masters Program Coordinator	50
Dr Aleksandr Stepanov, MSc (Novosibirsk), PhD (ANU)	Geochemistry of rare metals	100
Dr Helen Thomas, MSc (Leicester), PhD (Manchester)	LA-ICP-MS trace elements	100
Dr Lejun Zhang, BSc, PhD (HFUT)	Porphyry Cu-Au and HS epithermal	100

Opposite page: David Cooke addressing the Science Planning Panel.

Academic/Research Staff Based at Collaborative Institutions

Name		%
Dr Grant Ballantyne	JKMRC, University of Queensland	11
Dr Stacey Borg	CSIRO	100
Professor Deirdre Bradshaw	JKMRC, University of Queensland	10
Professor Alice Clark	JKMRC, University of Queensland	29
Mr Alan Cocker	WH Bryan Mining Geology Research Centre, University of Queensland	20
Professor Stephen Cox	Node Leader: Australian National University	30
Professor Mark Hannington	University of Ottawa	Hon
Professor Peter Hollings	Lakehead University	Hon
Associate Professor Janet Hergt	Node Leader: University of Melbourne	10
Dr Luke Keeney	JKMRC, University of Queensland	4
Mr Harri Kokkonen	Australian National University	20
Dr Jamie Laird	CSIRO	100

Name		%
Dr Weihua Liu	CSIRO	10
Dr Roland Maas	University of Melbourne	15
Dr Angus McFarlane	JKMRC, University of Queensland	20
Dr Simon Michaux	JKMRC, University of Queensland	19
Dr Khoi Ke Nguyen	JKMRC, University of Queensland	63
Dr Italo Onederra	WH Bryan Mining Geology Research Centre, University of Queensland	5
Dr Bence Paul	University of Melbourne	100
Dr Chris Ryan	Node Leader: CSIRO	20
Mr Patrick Walters	JKMRC, University of Queensland	34
Dr Yicai Wang	JKMRC, University of Queensland	40
Dr Noel White	Consultant	Hon

Technical/Administrative Staff

Name		%
Mr Steve Calladine	Communications Manager	100
Mrs Michele Chapple-Smith	Lapidary Technician	40
Mr Peter Cornish	Laboratory Manager	50
Mr Alex Cuison	Lapidary Technician	80
Mr Keith Dobson	IT Officer	50
Ms Sarah Gilbert, BSc Hons (UTAS)	Laboratory Manager ICP-MS	100
Ms Christine Higgins, Grad. Cert.Management (UTAS)	Finance Manager	50
Mr Ian Little, BSc Hons (UTAS)	Laboratory Analyst	100
Ms Elena Lounejeva	Laboratory Analyst	100
Mrs Deborah Macklin	Personal Assistant to the Director	100
Mrs Katie McGoldrick	Laboratory Assistant	40

Name		%
Mrs Karen Mollross	Finance Officer	100
Ms Caroline Mordaunt, BA Hons (King's College London)	Administrative Assistant	20
Ms June Pongratz	Publications	15
Mrs Claire Rutherford	Finance Officer	70
Miss Helen Scott, BSc Hons (UTAS), BEd (QUT)	Finance Officer	85
Mr Jay Thompson, BSc Hons, MSc (U Iowa)	Laboratory Analyst	100
Mrs Jennifer Thompson, BSc (OSU), MSc (U Iowa)	Laboratory Analyst	100
Ms Isabella von Lichtan, BSc Hons (UTAS)	Curator / Website support	45

Full house at the Science Planning Panel meeting in August.

Advisory Board

Name	
Chair (until November): John Dow	Consultant
Paul Agnew	Rio Tinto
Steve Beresford	MMG
Ron Berry	CODES, UTAS
Margaret Britz	UTAS
Graham Carr	CSIRO
Dean Collett	Newcrest Mining
David Cooke	CODES, UTAS
Stephen Cox	Australian National University
Kim Creak	Mineral Resources Tasmania
Joe Cucuzza	AMIRA International
Leonid Danyushevsky	CODES, UTAS
Cathy Dickins	St Barbara
Kathy Ehrig	BHP Billiton
Bruce Gemmell	CODES, UTAS

Name	
Paul Heithersay (Chair from November)	DMITRE-Geological Survey of SA
Janet Hergt	University of Melbourne
John Holliday	Consultant
Allan Kneeshaw	Anglo American
Ross Large	CODES, UTAS
Craig McEwan	Barrick Gold
Jocelyn McPhie	CODES, UTAS
Paddy Nixon	UTAS
Ian Sandl	Teck Resources
Donna Sewell	AngloGold Ashanti
Steve Turner	Newmont Exploration
Andrew Wells	UTAS
Noel White	Consultant

Executive Committee

Name	
Chair: Bruce Gemmell	Director, CODES
Chair: Ross Large*	Director (part of year), CODES
Ron Berry*	Recovery (4) Program Leader
Steve Calladine	Communications Manager
David Cooke	Formation (2) Program Leader / Deputy Director, CODES
Tony Crawford	Location (1) Program Leader
Leonid Danyushevsky	Technology (5) Program Leader
Jeff Foster*	Recovery (4) Program Leader (part of year)
Christine Higgins	Finance Manager

Name	
Bernd Lottermoser*	Environmental Geochemistry
Andrew McNeill	Discovery (3) Program Leader
Jocelyn McPhie	Co-ordinator Graduate Research
Helen Scott	Finance Officer

*Committee members for part of the year.

Science Planning Panel (also includes the Executive Committee and all CODES research staff and students)

Name	
Chair: Ross Large*	CODES
Paul Agnew	Rio Tinto
Steve Beresford	MMG
Stacey Borg	CSIRO
Graham Carr	CSIRO
Kim Creak	Mineral Resources Tasmania
Cathryn Dickins	St Barbara
John Dow	Consultant
Mark Doyle	AngloGold Ashanti
Martin Fairclough	DMITRE-Geological Survey of SA
Geoff Green	Mineral Resources Tasmania
Nick Hayward	Teck Resources
Janet Hergt	University of Melbourne
John Holliday	Consultant

Name	
Tony Hope	GHD
Carl Jackman	Bluestone Mines Tasmania
Jamie Laird	CSIRO
Angela Lorrigan	Unity Mining
Lee Sampson	Barrick Gold
Adele Seymon	AMIRA International
Steve Turner	Newmont Exploration
David Wallace	MMG
Mike Whitbread	BHP Billiton
Noel White	Consultant
Ian Willis	Anglo American

*Bruce Gemmell takes over as Chair for future meetings.

Graduate Research and Training

Students enrolled in the UTAS Higher Degree by Research (HDR) Program make a major contribution to the research activities of the Centre of Excellence. Ninety per cent of HDR projects are integrated into the Centre's five research programs and about two-thirds of the projects involve collaborations with the minerals industry – where many of the students progress to take senior roles. In addition to the main HDR Program, the Centre also plays a key role in up-skilling industry-based employees through courses such as those offered by the Master of Economic Geology Program.

HDR Program

There were 46 students enrolled in the HDR Program during 2012 (42 PhD and 4 MSc), which included eight new PhD students – Olga Apukhtina (Russia), Margy Hawke (Australia), Qiuyue Huang (China), Sean Johnson (UK), Erin Lawlis (Canada), Charles Makoundi (Republic Congo), Francisco Testa (Argentina), and Richelle Pascual (Philippines). Myall Hingee (Australia) began as an MSc student. Thirteen PhD students and two MSc students had theses under examination, eight of whom graduated: Fiona Best, Natalee Bonnici, Nathan Fox, Nic Jansen, Martin Jutzeler, Chun-kit Lai, Charles Makoundi (MSc), and Anita Parbhakar-Fox.

Two students (one PhD, one MSc) withdrew from candidature, two suspended their candidature for part of the year, and two chose to study part-time. This reduced the effective PhD workforce to 42, which was lowered further to 27 by the number of thesis submissions and graduations.

The 2012 HDR cohort included 37 international students representing 20 nationalities, 12 of whom were at least partly funded by Centre of Excellence scholarships. CODES' success in attracting HDR students from overseas is underpinned by its international reputation as a research training centre, and ability to invest ARC Centre funds in scholarships. In addition, the program is generously supported by UTAS in the form of international student tuition fee scholarships. It is also worth noting that only two of the new students were Australian, and CODES is dependent on ongoing UTAS support to recruit internationally.

SEG Student Chapter

Many of CODES' students are members of the UTAS Student Chapter of the Society of Economic Geologists (SEG). Dan Gregory was president of the chapter for the first part of the year, with Francisco Testa taking over the role in October. Supported by an enthusiastic group of committee members, they organised a wide range of events that encompassed both professional development and recreational activities.

The highlight of the year was the field excursion in April to southern Africa, which included visits to the world-renowned gold fields of South Africa's Witwatersrand Basin, the platinum-rich Bushveld Igneous Complex, plus various mines in Botswana. Two short courses were included in the itinerary – one covering the geology of southern Africa, with a focus on gold deposits, held in Johannesburg, and the second on the geology of Botswana, in Francistown. The trip was organised by the Student Chapter, led by Ross Large, Chris Large and Dave Hutchinson, and sponsored by AngloGold Ashanti, Barrick Australia, CODES, Data Metallogenica, the SEG, and Teck Resources. Industry personnel from AngloGold Ashanti, First Quantum Minerals and Rio Tinto also participated in the excursion.

Other professional development events organised by the Chapter included a short course on the geology and mineral deposits of Tasmania, plus a successful speaker series that included Jim Mortensen, UBC; Ian Willis, formerly Anglo

Left: Graduates Charles Makoundi (MSc) and Natalee Bonnici (PhD). **Right:** PhD graduates (L-R) Fiona Best, Chun-kit Lai and Nic Jansen.

American; Andrea Agangi, University of Johannesburg; and John Bishop, Riverside Energy. Another highlight was the Mike Solomon Lecture, which is held annually in honour of the popular and highly respected teacher and researcher who passed away in 2009. The Chapter always try to get one of Mike's former students as the guest speaker, and this year they were able to secure the services of Professor David Groves, who has built an outstanding research record since attaining his PhD at UTAS in 1969.

The recreational program is far more than being simply a break from studies. It also plays an essential role in generating camaraderie and helping people from a wide variety of cultural backgrounds feel at home at the Centre and a part of their adopted local community. Even though the committee is continually evolving as students graduate and move on, the quality and diversity of the recreational program always seem to remain as constants. The past year was certainly no exception, as the group once again did an outstanding job in organising a broad range of activities that covered a variety of tastes and interests. Activities included dragon boat racing, ice hockey, a quiz night, wine and cheese tasting, barbecues and holiday parties – and even participation in the annual Zombie Walk through the streets of Hobart.

Heidi Berkenbosch and Selina Wu were successful in gaining SEG Student Research Grants, and Evan Orovan received an SEG Fellowship Award.

Honours Program

There were 14 Honours enrolments at the beginning of the year, which took the total number of students to 18, including the four mid-year starters from 2011. This figure represented a 50% increase compared with the first semester of the previous year, resulting in the necessity to open a third Honours room to cater for the numbers. The cohort effectively decreased to 16 at the start of the second semester, when the four mid-year starters completed their studies. However, this was partially offset by two new students joining the group. These new mid-year starters will officially be counted in the 2013 Annual Report.

Andrew Beattie and Andrew Kleeman both joined the program from the University of Queensland, while Renee Birchall, who completed her degree at UTAS, returned after several years in industry. The intake also included two international students: Kian Chee Goh from Malaysia, and Dilani Jayathilaka, who hails from Sri Lanka.

Most of the projects were conducted within Australia, representing an excellent cross section of exploration activity within the country. There were five projects in South Australia, five in Tasmania, four in Western Australia and one in New South Wales. This year's most unusual field location was chosen by Joe Knight, who was the first CODES' Honours student to work in Myanmar. There were also projects in Malaysia and Indonesia. The projects were again spread amongst the disciplines, as follows: geophysics (5), economic geology (4), igneous petrology (3), sedimentology (2), environmental geology (2), structural geology, and hydrogeochemical exploration. The projects were sponsored by Anglo American, Barrick, BHP Billiton, Copper Mines of Tasmania, Grange Resources, MMG, Newcrest, Olympus Pacific Minerals, and OZ Minerals.

The Honours year was administered by Garry Davidson, with Peter McGoldrick supervising the coursework aspects. Primary supervision loads were widely shared between Michael Roach (4), Garry Davidson (2), Vadim Kamenetsky (2), Khin Zaw (2), Stuart Bull, David Cooke, Tony Crawford, Bernd Lottermoser, Peter McGoldrick, Andrew McNeill, Anya Reading, and Rob Scott. Additional co-supervision was provided by Stuart Bull, Garry Davidson, Bruce Gemmell, Nic Jansen, Andrew McNeill, Jocelyn McPhie, Anya Reading, and Michael Roach.

The Exploration and Skills Mapping Course was held twice during the year, as scheduled. Once again, this popular course attracted a high number of students from UTAS and mainland universities.

Opposite page: Examining samples of UG2 and Merensky Reef at Marikana, South Africa – SEG Student Chapter field trip.

Master of Economic Geology Program

The coursework based Master of Economic Geology degree at CODES forms part of the national Minerals Geoscience Masters (MGM) program – a collaboration between UWA, JCU and UTAS, financially supported by the Minerals Tertiary Education Council (MTEC) of the Minerals Council of Australia (until the end of 2012). The MGM remains the course of choice for industry-based geoscientists, attracted by the opportunity of studying for an internationally recognised degree, while still being able to pursue their careers in the minerals industry.

The Centre's Master of Economic Geology Program has had one of its busiest and most successful years, which included a very full program of courses, record student enrolments for some units, and the introduction of a new course on Geometallurgy – the first of its kind in the world. There is an increasing focus on geometallurgy in the mining industry, because of the significant impact of ore variability on the long-term profitability of mining operations. Geometallurgy contributes to ore delineation by measuring factors, other than grade, that influence ore processing behaviour and the cost of environmental management in the mine plan. CODES recognised this trend and, using the substantial knowledge and experience it had gained through the AMIRA-funded GeM^{III} project, developed a 12-day course tailored to fit within the MGM program.

The first Geometallurgy course was held in March, led by Julie Hunt and Ron Berry from CODES, and assisted by presenters Dee Bradshaw, Toni Kojovic, Dave Lawie, Bernd Lottermoser and Jeff Foster. In a packed schedule, the team managed to cover most aspects of this highly specialised field, including rock properties, sample selection, mineralogy, comminution and mineral processing, statistical analysis and modelling, environmental issues, and financial aspects. They even squeezed in excursions to the Rosebery Zn-Cu-Ag-Au mine mill and a geochemical/metallurgical testing laboratory in Burnie.

In April, Jocelyn McPhie, Bruce Gemmell and Andrew McNeill led a group to New Zealand's North Island as part of the ever-popular Volcanology and Mineralisation in Volcanic Terrains course. The second part of this field-based unit was led by Jocelyn and Andrew, who took the participants to the west coast of Tasmania to examine the well mineralised and altered Cambrian Mt Read Volcanics. This very hands-on course provides an excellent introduction to the processes and products of different eruption styles, contrasts in scale and structure of volcanoes, identification of key volcanic facies associations, and interpretation of facies variations. Mineralisation and alteration processes related to hydrothermal systems in subaerial and submarine volcanic environments and implications for mineral exploration are also addressed.

In June, Andrew McNeill, assisted by expert teaching staff from CODES and the minerals industry, led the Exploration in Brownfield Terrains course, which is designed to bring participants up-to-date with the latest exploration techniques and approaches to compiling and working with historical datasets. Exploration in data-rich environments, close to existing mines, has become a preferred method of increasing company resources in recent years. This trend has led to an increased interest in this course, which covers cutting-edge technologies in geophysics, geochemistry and 3D visualisation, and uses real data from world-class mineralised districts. Presentations from leading minerals industry consultants, Scott Halley, Jun Cowan, Dave Lawie and Ian Willis were highlights of this year's course.

The final course for the year, Ore Deposit Models and Exploration Strategies, was held in October. It began with the four-day Red Metal Symposium, which attracted over 60 participants. The Symposium, conceived and organised by Garry Davidson, David Cooke and Bruce Gemmell, addressed recent developments in research and exploration in relation to copper and copper-gold deposits, and included presentations from leading academic and industry geologists, as well as expert teaching staff from CODES. Deposit-types covered in the symposium included Archean Cu-Au-rich VHMS, sediment-hosted Cu of the Central African Copper Belt, Olympic Dam Cu-Au-U, and porphyry and epithermal Cu-Au of the SW Pacific region. In the main body of the course, following the symposium, deposit types covered included VHMS, sediment-hosted Cu-Pb-Zn, orogenic Au, Carlin-type Au, Witwatersrand Au, magmatic Ni sulfide and PGE, IOCG and U.

On a disappointing note, the Minerals Tertiary Education Council (MTEC) ended its long-running association with the MGM program at the end of the year. While the loss of MTEC funding presents significant challenges for the long-term financial viability of the national Masters program, MTEC's key role in establishing the program is gratefully acknowledged.

Notwithstanding the loss of funding support, overall it has been an excellent year for the program at CODES. Eleven new people joined the program, bringing the total number of UTAS-based students active in the national program to 41 for the year. It was also a good year for completions, with eight CODES students completing their degrees: Abdul Arbi, Mark Burdett, Brian Kay and Anna Price have already graduated, while Yungu Lim, Linda Sprigg, Yong Zhang and Stanley Zutah are eligible to graduate in 2013. These positive trends are set to continue in 2013, further cementing the popularity of the Master of Economic Geology degree with industry-based geoscientists – and UTAS (CODES) as the institute of choice for its completion.

The program for 2013:

- 9–23 March: Ore Deposits of South America (KEA706)
- 24 June–5 July: Ore Deposit Geochemistry, Hydrology and Geochronology (KEA704)
- 21 October–1 November: Geometallurgy (KEA702)

Opposite page: Top: Practical exercises being conducted during the new Geometallurgy short course. **Centre:** White Island, New Zealand. **Bottom:** Participants in the Ore Deposit Models and Exploration Strategies short course.

Student Projects

In Australia

Project locations are shown in capitals. Unless marked otherwise, student projects shown here are field and lab-based PhD projects.

1. Apukhtina, Olga. SA
Stable isotopes (C, S and O) and halogens (Cl, F) in gangue and ore minerals at Olympic Dam: Evaluation of mantle and crustal contributions to mineralisation.

2. Baker, Wayne. TAS (GDipSci)
The correlations and exploration significance of the Natone Volcanics, Rosebery Group, western Tasmania.

3. Beattie, Andrew. NSW (Hons)
Geology and geochemistry of the Gooleys alkalic Cu-Au porphyry prospect, Cadia District, New South Wales.

4. Best, Fiona. QLD
The petrogenesis and Ni-Cu-PGE potential of the Dido Batholith, north Queensland, Australia.

5. Birchall, Renee. WA (Hons)
Seismic characteristics of Plutonic Gold Mine.

6. Braniff, Victoria. TAS
The structure and deformational history of the Savage River magnetite orebodies and host rocks, NW Tasmania.

7. Cotterill, Jesse. SA (Hons)
Mafic magmatism at the Wirrda Well prospect, Olympic Domain, Gawler Craton, South Australia: Implications for IOCG mineralisation.

8. Diemar, Glen. SA (Masters)
Geochronology of hydrothermal REE minerals and their relationships with economic mineralisation at the Olympic Dam breccia complex, South Australia.

9. Dolan, Andrew. SA (Hons)
Petrology and electrical properties of key lithologies at Prominent Hill, SA.

10. Ellis, Margaret (Meg). WA (Hons)
Geology and enrichment of the Sharpnose Prospect, WA.

11. Ferguson, Matthew. WA (Hons)
Mineral paragenesis and geometallurgical characteristics of the Karlawinda Deposit, Western Australia.

12. Fox, Nathan. NSW
Controls on alteration and mineralisation at the Cadia East alkalic porphyry Au-Cu deposit, NSW.

13. Gilmore, Phil. NSW (Masters)
An aspect of the geology of the Koonenberry Belt, NSW.

14. Gregory, Daniel. WA
Gold trace metal accumulation in diagenetic pyrite, from a present and Archean perspective.

15. Hawke, Margy. WA (Masters/PhD)
Geology of the DeGrussa VMS deposit, WA.

16. Hennessy, Sean. SA (Hons)
Petrography, geochemistry and lead isotopes of the Upper Gawler Range Volcanics, South Australia.

17. Huang, Qiuyue. SA
Mafic dykes at Olympic Dam.

18. Jayathilaka, Dilani Singappuli. TAS (Hons)
Experimental study on the prevention of acid mine drainage from Mt Lyell mine, Tasmania.

19. Jimenez Torres, Carlos Andres. VIC
Genesis of epithermal and porphyry deposits.

20. Kay, Brian. VIC (Masters)
Combined economic and geologic evaluation of eastern Australian gold projects – selection of acquisition targets.

21. Kleeman, Andrew. SA (Hons)
The petrology and trace element geochemistry of the Carrapateena deposit, Olympic IOCG Province, South Australia.

22. Kyne, Roisin. NSW
Structural controls on mineralisation, including sulfide mineralogy, at the CSA mine, Cobar NSW.

23. Lower, Chantelle. SA (Masters)
An aspect of the geology of the Olympic Dam deposit.

24. Lygin, Alexey. TAS
The geology, geochemistry and genesis of the Avebury Ni deposit, Tasmania.

25. McGuire-Febey, Michael. TAS (Hons)
Stratigraphy, structure and correlations of the Rosebery Group west of the Rosebery fault, Rosebery district, western Tasmania.

26. Memish, Chris. TAS (Hons)
Hydrogeochemistry as an exploration method in the Mount Read Volcanics (MRV), western Tasmania.

27. Morris, Eddie. TAS (Hons)
Structural relationship of the Oonah Formation near the Arthur Lineament, Savage River, NW Tasmania.

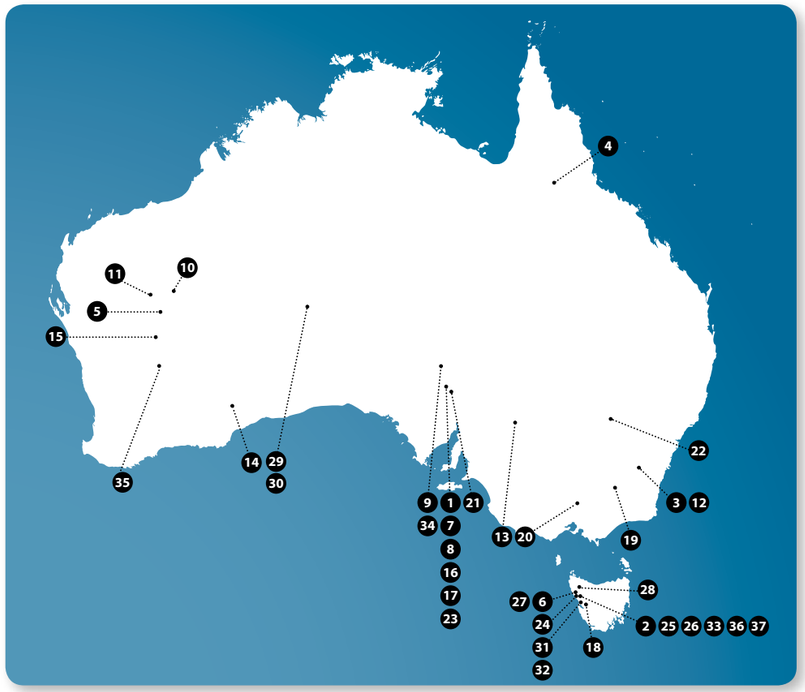
28. Ostberg, Max. TAS (Hons)
Architecture of the Parrawe Basalt Province, and its hydrogeological implications, Tasmania.

29. Ostersen, Tom. WA (Hons)
Electrical response of the Latitude Hill West Prospect (West Musgraves), Western Australia.

30. Pascoe, Ariel. WA (Hons)
The geochemistry and petrogenesis of the Giles Intrusions at Latitude Hill, West Musgrave province, Western Australia.

31. Pascual, Richelle. TAS
The characteristics and role of colloidal silica fluids in the formation of the Grieves Siding Pb-Zn prospect, western Tasmania.

32. Pereira da Fonseca, Pedro. TAS
Facies analysis and correlations in complex submarine volcanic successions: Mount Read Volcanics, western Tasmania.



33. Richardson, Steven. TAS (Masters)
The Fossey Zone, Hellyer Mine.

34. Smith, Nicholas. SA (Hons)
A trial of the MMSPAC passive seismic for mineral exploration in remote inland Australia.

35. Steadman, Jeffrey. WA
The source of gold in banded iron formation (BIF)-hosted gold deposits.

36. Winter, Craig. TAS (Hons)
Stratigraphy, structure and correlations of the Hangingwall Sequence, Rosebery, western Tasmania.

37. Wu, Selina. TAS
Volcanic hosted massive sulphide deposits of the Que-Hellyer Volcanics, western Tasmania.

Lab-based Projects

Bonnici, Natalee
The mineralogical and textural characteristics of Cu-Au deposits related to mineral processing attributes.

Chauhan, Mitesh [JKMRC]
Application of small scale flotation testing.

Cracknell, Matthew
Innovative data inference from spatial datasets in earth science.

Gilbert, Sarah
Development of analytical methods and standard reference materials for the determination of trace element concentrations and isotopic ratios in sulphur-rich minerals and silicate glasses.

Hingee, Myall (Masters)
Approximate Inverse Mapping (AIM) inversion of Transient Electromagnetic (TEM) data.

McMahon, Claire
Distribution of, and controls upon, pyrite trace element content of hydrothermal alteration zones at Hercules VHMS ore deposit, Tasmania and NICO IOCG ore deposit, Northwest Territories, Canada.

Parbhakar-Fox, Anita
Establishing the value of an integrated geochemistry-mineralogy- texture approach for acid rock drainage prediction.

Parra Galvez, Hector Ivan [BRC]
Quantifying the impact of blast induced fragment conditioning on leaching performance.

Opposite page: New PhD student, Sean Johnson.

Outside Australia

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

1. Ageneau, Mathieu. PNG
Geology of the Kapit ore zone and comparative geochemistry with Minifie and Lienetz ore zones, Ladolam Gold Deposit, Lihir Island, Papua New Guinea.

2. Basori, Mohd Basril Iswadi Bin. MALAYSIA
Geology of volcanic hosted massive sulfide (VHMS) deposits in Central Belt, Peninsular Malaysia.

3. Berkenbosch, Heidi. NEW ZEALAND
Geochemistry of hydrothermal mineral chimneys from Brothers volcano, Kermadec Arc.

4. Calderon-Tipiani, Cesar. PERU (Masters)
Geochemical halo to intermediate sulfidation epithermal veins, Azuca Project, Peru.

5. Clark, Lindsey. INDONESIA
The geology and genesis of the Kencana epithermal Au-Ag deposit, Gosowong Goldfield, Halmahera Island, Indonesia.

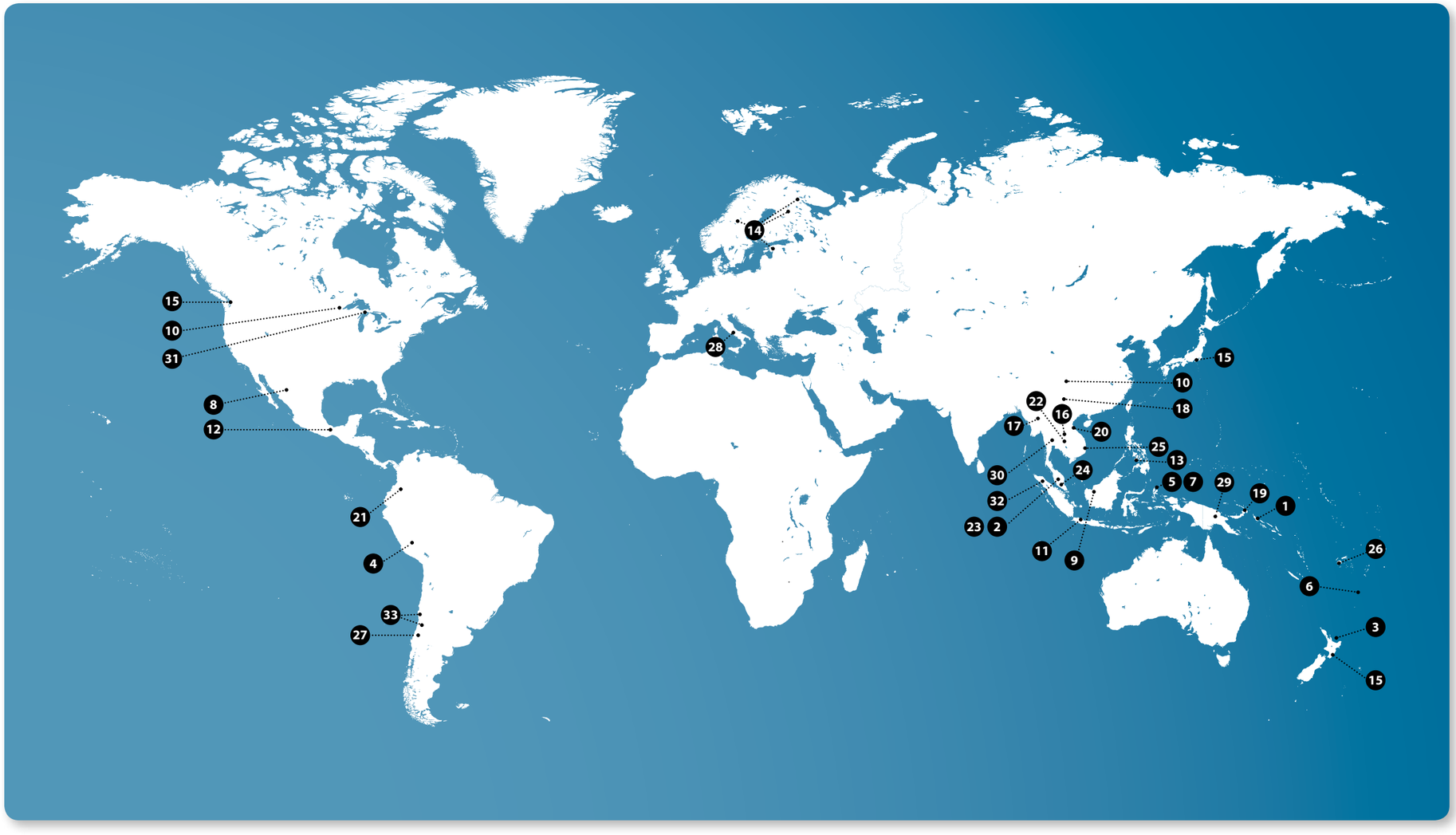
6. Cobenas Benites, Gisela. SW PACIFIC
The behaviour of metals during differentiation of subduction-related lavas: A case study of active submarine volcanoes on the Hunter Ridge, SW Pacific.

7. Dunne, Michael. INDONESIA (Hons)
The magnetic and radiometric character of the Gosowong Goldfield, Halmahera Island, Indonesia.

8. Galván-Gutiérrez, Víctor Hugo. MEXICO
Palmarejo carbonate-base metal epithermal Ag-Au district, Chihuahua, México.

9. Goh, Kian Chee. MALAYSIA (Hons)
Geological and mineralisation characteristics of the Jugan Au Deposit, Bau, Malaysia.

10. Guan, JianXiang. CHINA, USA
Origin of associated magnetite and sulfide mineralisation in large gabbroic intrusions: A LA-ICP-MS study of minerals and melt inclusions from the Panzhihua and Taihe intrusions in Emeishan LIP and Duluth Complex.



11. Harrison, Rachel. INDONESIA (Masters)
Tujuh Bakit Cu-Au porphyry-epithermal deposit, Java Indonesia.

12. Jansen, Nicholas. MEXICO
Geology and genesis of the Cerro la Mina porphyry – high sulfidation prospect, Mexico.

13. Jimenez Torres, Carlos Andres. PHILIPPINES
Genesis of epithermal and porphyry deposits.

14. Johnson, Sean. FINLAND, ESTONIA, SWEDEN, RUSSIA
The effect of metamorphic grade on trace element mobility in black shales.

15. Jutzeler, Martin. NZ, JAPAN, USA
Characteristics and origin of subaqueous pumice-rich pyroclastic facies: Ohanapecosh Formation (USA) and Dogashima Formation (Japan).

16. Kamvong, Teera. THAILAND
Geology and genesis of porphyry-skarn Cu-Au deposits at the Northern Loei and Truong Son Fold Belts, Thailand and Laos.

17. Knight, Joe. MYANMAR (Hons)
The geochemical and geochronological framework of the Monywa high sulphidation Cu and low sulphidation Au – epithermal deposits, Myanmar.

18. Lai, Chun-Kit. CHINA
Tectonic evolution of the Ailaoshan Fold Belt and its SE Asia connection.

19. Lawlis, Erin. PNG
Au-bearing Fe-sulfide ore of Lihir, PNG: Its physiochemical character and nature of the causative fluids.

20. Le, Xuan Truong. VIETNAM (Masters)
Mineralisation of Me Xi Gold Deposit, Vietnam.

21. Leichliter, Stacey. COLOMBIA (Masters)
Gold deportment and geometallurgical recovery model for the La Colosa, porphyry gold deposit, Colombia.

22. Lim, Yungu. CAMBODIA (Masters)
Geological setting and mineralisation characteristics of the Steung Nambrai-Elephant Au-base metal system, eastern Cambodia.

23. Makoundi, Charles. MALAYSIA (Masters)
Geology, geochemistry, and metallogenesis of selected sediment-hosted Au deposits in the Central Gold Belt, Peninsular Malaysia.

24. Makoundi, Charles. MALAYSIA
Trace element variation in Phanerozoic shale sequences in Malaysia: implications for gold metallogeny of Sibumasu terrane.

25. Manaka, Takayuki. VIETNAM
Geology and mineralisation characteristics of the Phuoc Son Goldfields, central Vietnam.

26. Orovan, Evan. FIJI
Geology, geochemistry and genesis of the Namosi porphyry Cu-Au deposits, Fiji.

27. Piquer Romo, Jose Meulen. CHILE
Structural geology of the Andes of Central Chile: Evolution, controls on magmatism and the emplacement of giant ore deposits and implications for exploration.

28. Redi, Daniele. [U Naples] ITALY
A contribution to the understanding of the eruptive behaviour of Somma-Vesuvius: a mineral chemistry perspective.

29. Rinne, Marc. PNG
Geology and genesis of the contrasting Wafi-Golpu porphyry-epithermal deposit, Papua New Guinea.

30. Salam, Abhisit. THAILAND
A geological, geochemical and metallogenic study of the Chatree epithermal deposit, Phetchabun Province, central Thailand.

31. Steadman, Jeffrey. USA, CANADA
The source of gold in banded iron formation (BIF)-hosted gold deposits.

32. Sutopo, Bronto. INDONESIA
The Martabe Au-Ag high-sulfidation epithermal mineralisation in the Tapanuli Selatan district, North Sumatra Province, Indonesia: Implications for ore genesis and exploration.

33. Testa, Francisco. ARGENTINA, CHILE
Tourmaline Breccia Pipes: San Francisco de los Andes, Argentina and Rio Blanco-Los Bronces, Chile.

Program One
Location

Objective

To better understand the links between tectonic setting, magmatism, basin evolution and ore deposit formation in modern and ancient settings.

Introduction

The Location Program hosts the majority of fundamental research being carried out in CODES, with a strong emphasis on magmatic petrology and geochemistry, tectonics, and volcanology. Researchers within this program work across the scales from microscopic to mountain belt, and from laboratory- to field-based studies, attempting to better understand the major controls on the location, timing and size of key ore deposits, particularly those in arc-backarc settings and in continental rift basins. Current projects cover a diverse range of themes, from fundamental to more strategic in nature, and team members with a more fundamental science background are strongly encouraged to become involved in at least one industry- or mineralisation-related project.

Highlights

- The Program One team published thirty-nine refereed papers in 2012.
- Five papers published, and four in press, related to the 'felsic magmas' project – P1B1.
- Peter McGoldrick, Noah Planavsky and Tim Lyons convened a session at Goldschmidt 2012 in Montreal titled: 'Between the O_2 steps: life and the environment between the GOE and the Late Neoproterozoic rise of ice and animals.' This highly successful session included 22 oral presentations and 10 posters, over two days.
- New project initiated to better constrain the depositional age of major units within the Rocky Cape Group.
- Basaltic glasses from the Macquarie Island ophiolite (SW Pacific) provided evidence for effects of partial melting of the mantle peridotite, and subsequent magma crystallisation and degassing on the systematics of metals and volatiles.
- New U-Pb zircon data from the Mogok Metamorphic Belt (MMB) reveals at least five magmatic/metamorphic phases.

Renewed volcanic activity (late 2012) on White Island, NZ.
Image courtesy of Brad Scott (GNS).

Leader
Tony Crawford

Team Members

Sharon Allen, Mike Baker, Ron Berry, Stuart Bull, Rebecca Carey, Leonid Danyushevsky, Paul Davidson, Trevor Falloon, Sandrin Feig, Jeff Foster, Karsten Goemann, David Green, Jacqui Halpin, Janet Hergt, Maya Kamenetsky, Vadim Kamenetsky, Ross Large, Chun-kit Lai, Roland Maas, Peter McGoldrick, Andrew McNeill, Jocelyn McPhie, Sebastien Meffre, Karin Orth, Bence Paul, Anya Reading, Michael Roach, Abhisit Salam, Khin Zaw

PhD Students

Olga Apukhtina, Mohd Basril Iswadi Bin Basori, Fiona Best, Gisela Cobenas, Pedro Fonseca, JianXiang Guan, Qiuyue Huang, Martin Jutzeler, Teera Kamvong, Alexey Lygin, Charles Makoundi, Takayuki Manaka, Daniele Redi

Masters Students

Glen Diemar, Xuan Truong Le, Yungu Lim

Honours Students

Jesse Cotterill, Meg Ellis, Sean Hennessy, Joe Knight, Ariel Pascoe, Craig Winter

Collaborators

AMERICAN MUSEUM OF NATURAL HISTORY, USA James Webster

ANGLO AMERICAN EXPLORATION Allan Kneeshaw, Javier Ortuzar, Paul Polito

AUSTRALIAN NATIONAL UNIVERSITY Greg Yaxley, Hugh O'Neill, Jorg Hermann, Kate Kiseeva

BHP BILLITON Kathy Ehrig

BRITISH GEOLOGICAL SURVEY Mike Crow

CHIANG MAI UNIVERSITY, THAILAND Phisit Limtrakun, Sampan Singharajwarapan, Weerapan Srichan

CHINESE ACADEMY OF GEOLOGICAL SCIENCE Zengqian Hou

COLORADO STATE UNIVERSITY, USA Holly Stein

CONSULTANT, THAILAND Clive Burrett

CSIRO (WA) Adam Bath, Katy Evans

DEPARTMENT OF MINERAL RESOURCES, THAILAND Pol Chaodumrong, Somboon Khositanont

FROGTECH Nick Direen

GEOLOGICAL SURVEY OF JAPAN Kenzo Sanematsu

GEOSCIENCE AUSTRALIA David Huston, Terry Mernagh

GFZ GERMAN RESEARCH CENTRE FOR GEOSCIENCES Rainer Thomas

GNS, NEW ZEALAND Chris Adams

GUANGZHOU INSTITUTE OF GEOCHEMISTRY, CHINA Weidong Sun

HANOI UNIVERSITY OF GEOLOGY AND MINING, VIETNAM Hai Thanh Tran

IFM-GEOMAR, GERMANY Armin Freundt

IMPERIAL COLLEGE LONDON, UK Andrew Berry

INSTITUTE FOR FRONTIER RESEARCH ON EARTH EVOLUTION, JAPAN Yoshihiko Tamura

INSTITUTE OF GEOLOGY AND MINERALOGY, RUSSIA Alexander Golovin, Viktor Sharygin, Lyudmila Zhitova

INSTITUTE OF GEOLOGY OF ORE DEPOSITS, PETROGRAPHY, MINERALOGY AND GEOCHEMISTRY, RUSSIA Alexander Borisov

INSTITUTE OF TECHNOLOGY, INDONESIA Andri Subandrio

JAMES COOK UNIVERSITY Bob Henderson

JAMSTEC, JAPAN Kenichiro Tani

KAGOSHIMA UNIVERSITY, JAPAN Kazuhiko Kano

LAURIN TECHNIC Michael Shelley

MACQUARIE UNIVERSITY Elena Belousova, Nathan Daczko, Bill Griffin

MAX PLANCK INSTITUTE FUR CHEMIE, GERMANY Dmitry Kuzmin

MINERAL RESOURCES TASMANIA Clive Calver, John Everard

MMG Kim Denwer

MONASH UNIVERSITY Reid Keays, Massimo Raveggi

MOSCOW STATE UNIVERSITY, RUSSIA Pavel Plechov

MURORAN INSTITUTE OF TECHNOLOGY, JAPAN Yoshi Goto

NATIONAL LABORATORY OF ENERGY AND GEOLOGY, PORTUGAL Carlos Rosa

NATIONAL TAIWAN UNIVERSITY Sunlin Chung

PRIMARY INDUSTRIES AND RESOURCES SOUTH AUSTRALIA Martin Fairclough

SMITHSONIAN INSTITUTION, USA Richard Fiske

UNITED STATES GEOLOGICAL SURVEY Poul Emsbo

UNIVERSIDAD NACIONAL DE LA PATAGONIA, ARGENTINA Marcelo Marquez

UNIVERSITI KEBANGSAAN, MALAYSIA Wan Fuad Wan Hassan, Mohd Rozi Umor

UNIVERSITY COLLEGE OF SCIENCE, SCHOOL OF GEOLOGY, IRAN Mirsaleh Mirmohammadi

UNIVERSITY OF ADELAIDE Cristiana Ciobanu, Nigel Cook

UNIVERSITY OF BONN, GERMANY Chris Ballhaus, Raul Fonseca

UNIVERSITY OF CALIFORNIA RIVERSIDE, USA Tim Lyons, Noah Planavsky

UNIVERSITY OF CENTRAL MISSOURI, USA John Nold

UNIVERSITY OF JOHANNESBURG, SOUTH AFRICA Andrea Agangi

UNIVERSITY OF LISBON, PORTUGAL Jorge Relvas

UNIVERSITY OF MALAYA Azman Ghandi, Teh Guan Hoe

UNIVERSITY OF MELBOURNE Andrea Giuliani, David Phillips, Jon Woodhead

UNIVERSITY OF NAPLES, ITALY Benedetto De Vivo

UNIVERSITY OF NEW CALEDONIA Dominique Cluzel, Christine Laporte-Magoni

UNIVERSITY OF OREGON, USA Kathy Cashman, Emily Johnson, Paul Wallace

UNIVERSITY OF PADJAJARAN, INDONESIA Mega Rosa

UNIVERSITY OF QUEENSLAND Sue Golding, Paulo Vasconcelos

UNIVERSITY OF SCIENCE & TECHNOLOGY, CHINA Yuling Xie

UNIVERSITY OF SYDNEY Geoff Clarke

UNIVERSITY OF WESTERN SYDNEY Lin Sutherland

UNIVERSITY OF TASMANIA Donna Satterthwait

UNIVERSITY OF TOULOUSE, FRANCE Anastassia Borsisova, Georges Ceuleneer

UNIVERSITY OF THE WITWATERSRAND, SOUTH AFRICA Allan Wilson

UNIVERSITY OF WOLLONGONG Chris Fergusson

VERNADSKY INSTITUTE, RUSSIA Alexey Ariskin, Galina Barmina

VIRGINIA POLYTECHNIC INSTITUTE & STATE UNIVERSITY, USA Robert Bodnar, Rosario Esposito

WOODS HOLE OCEANOGRAPHIC INSTITUTION, USA Andrey Gurenko

Opposite page: Jacqui Halpin at the Holy Grail of Horodyskia – fossil locality near Balfour, NW Tasmania.

Core Projects

Theme 1A
Geodynamic Controls on the Fertility of Foldbelts, Cratons and Sedimentary Basins

P1A2 Mafic magmatism in modern submarine SW Pacific settings

P1A3 Global ocean chemistry, marine basins and mineralisation

P1A4A Ore deposits of SE Asia

P1A6 Tectonic significance and mineralisation potential of volcano-plutonic belts and ophiolites at the northern end of the Tasman Line, N Queensland

P1A7 Geochronology of the Rocky Cape Group*

Theme 1B
Magmas, Volatiles and Metals

P1B1 Felsic magmas in volcanic arcs and intraplate volcanic provinces – eruption style, degassing processes, fluid evolution and links to mineralisation

P1B2 Ni-PGE potential of mafic and ultramafic magmas – a combined melt inclusions and numerical modelling approach (AMIRA P962)

P1B3B Melt-melt immiscibility and the origin of magnetite-apatite deposits

*New initiative

Project Summaries

Theme 1A
Geodynamic Controls on the Fertility of Foldbelts, Cratons and Sedimentary Basins

P1A2 Mafic magmatism in modern submarine SW Pacific settings

Leader: Leonid Danyushevsky

Team members: Tony Crawford, Trevor Falloon

Student: Gisela Cobenas

Collaborators: Andrew Berry, Robert Bodnar, Benedetto De Vivo, Hugh O'Neill, Pavel Plechov, Jon Woodhead

This project aims at improved understanding of magma generation and evolution processes in the complex settings of convergent plate margins in the Southwest Pacific and other regions worldwide. These tectonic settings are likely modern analogues of the geodynamic environments that existed during formation of paleo-magmatic sequences in the orogenic volcanic belts along eastern Australia, which host numerous types of ore deposits.

During the year, Gisela Cobenas completed her PhD thesis, which was aimed at gaining a better understanding of the behaviour of metals during evolution of calc-alkaline and adakitic arc magmas. The main finding of the research was that the behaviour of Cu is closely related to the history of magma saturation with an H_2O-rich fluid. The onset of degassing leads to a rapid decrease in Cu contents in the fractionating melt, thus preventing Cu concentration in the residual liquids. It is inferred that magma evolution at depth below fluid saturation for a given magma is essential for generating Cu-rich evolved fluids capable of forming porphyry style deposits. Gisela's thesis will be submitted early in 2013.

This project has now concluded.

P1A3 Global ocean chemistry, marine basins and mineralisation

Leader: Peter McGoldrick

Student: Meg Ellis

Collaborators: Tim Lyons, Noah Planavsky, Donna Satterthwait

This project aims to decipher processes that controlled the sulfur chemistry and redox state of oceans that existed in northern Australia approximately 1.65 billion years ago; understand how coeval ocean water interacted with hydrothermal fluids responsible for forming the giant northern Australian Proterozoic SEDEX Zn-Pb-Ag deposits; and elucidate the role played by (micro-) organisms during seafloor venting of fluids responsible for forming Proterozoic sedimentary Zn mineralisation.

The main activities in 2012 included:

- Peter McGoldrick, Noah Planavsky and Tim Lyons convened a session at the Goldschmidt Conference in Montreal entitled: 'Between the O_2 steps: life and the environment between the GOE and the Late Neoproterozoic rise of ice and animals'.
- Additional geochemical analyses conducted of fine-grained Rocky Cape Group sediments, aimed at characterising the redox state of a Tasmanian Mesproterozoic marine shelf. A draft paper based on these results is in progress.
- An Honours study was conducted by Meg Ellis of 1.8 Ga iron formations from the Earaheedy Basin of Western Australia. This work was supported by Anglo American Exploration (Australia).
- Noah Planavsky has measured Cr isotopes on samples obtained by Peter McGoldrick from 1.45 Ga granular iron formations from the Northern Territory. A paper is planned that will address the implications of the Cr isotope results for hypergene versus supergene origin of the Sherwin Formation iron ores.

P1A4A Ore deposits of SE Asia

Leader: Khin Zaw

Team members: Tony Crawford, Chun-kit Lai, Ross Large, Sebastien Meffre, Abhisit Salam

Students: Mohd Basril Iswadi Bin Basori, Teera Kamvong, Joe Knight, Xuan Truong Le, Yungu Lim, Charles Makoundi, Takayuki Manaka

Collaborators: Clive Burrett, Pol Chaodumrong, Mike Crow, Wan Fuad Wan Hassan, Azman Ghandi, Sue Golding, Teh Guan Hoe, Somboon Khositanont, Phisit Limtrakun, Mega Rosana, Mohd Rozi Umor, Sampan Singharajwarapan, Weerapan Srichan, Holly Stein, Andri Subandrio, Hai Thanh Tran, Paulo Vasconcelos

This extension of the SE Asia project is building on the methods and techniques developed during previous work in the region, while expanding the research in terms of its geological scope and geographical footprint, which now includes the whole of mainland SE Asia and Sumatra.

Key aims are to: a) Undertake a regional tectonic and metallogenic analysis of the mineralised fold belts in mainland SE Asia. b) Perform deposit-scale studies to characterise important ore deposits. c) Provide sponsor companies with an increased understanding of ore deposit location, formation and evolution in the region. d) Gain a new understanding of the geological and tectonic events that formed ores deposits in SE Asia. e) Establish a new, well-constrained, dated, and documented geological framework to enable better exploration targeting in the area.

Highlights of 2012 included:

- New U-Pb zircon data from the Mogok Metamorphic Belt (MMB) reveals at least five magmatic/metamorphic phases, including the Chaung Magyi Group schists (east of the Mogok gneiss and granitoids) and newly dated Ordovician magmatism in Myanmar. Regionally, many of the Mogok and Chaung Magyi rock units can be correlated and are coeval with the rock units in the Tengchong Block in western Yunnan.
- It was found that three arc-related magmatic belts in the southern part of the Indochina Terrane (i.e., SE Laos, Cambodia-Southern Vietnam) include Triassic (260–230 Ma), Jurassic (200–170 Ma) and Cretaceous (120–75 Ma) ages. Deposit types associated with the magmatic events include porphyry-related Cu-Mo-Au skarn, Jurassic magmatism, intrusion-related gold deposits, and Cretaceous magmatism.
- Extensive occurrences of pillow basalt and other ultramafic-mafic plutonic rocks in a mélange in Northern Vietnam have been found to be similar to many mélanges in South China. Preliminary geochemical investigations suggest that these ultramafic-mafic complexes may have been formed in an island arc, or MOR-like tectonic settings, instead of within-plate settings as previously suggested. The restoration of pre-Cenozoic regional tectonic configuration shows that the Early Mesozoic tectonic setting of northern Vietnam is consistent with a back-arc basin setting that is related to the northward subduction of Sibumasu Terrane during Late Paleozoic-Early Mesozoic. This back-arc basin was linked with Paleotethys and formed the northern margin of the Indochina Block.
- At least two generations of magmatism were identified in eastern Thailand and western Cambodia – i.e. Late Permian-Early Triassic, plus Late Triassic-Early Jurassic ages. They are comparable to the early and late stage magmatism of the Loei Fold Belt, which is associated with subduction and post-collisional events between the Sibumasu and Indochina Terranes. However, existence of the Sukothai Fold Belt in the southern part of this area cannot be ruled out (timing of magmatism of the Sukhothai Fold Belt is 250–180 Ma).

From left, Taka Manaka, Joe Knight and Khin Zaw during field work at the Monywa Cu mine, central Myanmar.

Khin Zaw (second from right) visiting the Chinkuahih Au deposit, Taiwan.

- Granitoids in southern Myanmar have a range of emplacement age from 85 to 45 Ma, and geochemical data indicate they have I-type affinity. They can also be divided into early magnetite-series (85–60 Ma; oxidised) and late ilmenite-series (60–45 Ma; reduced) groups. The granites are commonly associated with Sn-W (-REE) and Au deposits in southern Myanmar.

P1A6 Tectonic significance and mineralisation potential of volcano-plutonic belts and ophiolites at the northern end of the Tasman Line, N Queensland

Leader: Tony Crawford

Student: Fiona Best

Collaborators: Chris Fergusson, Bob Henderson, Reid Keays, Paul Polito

This project was completed in 2012 with the submission of Fiona Best's PhD thesis on the Dido Tonalite. The project component covering the geology, geochronology and geochemistry of the northern end of the Tasman Line around Greenvale, N Queensland, was completed in 2011 with publication of a paper (Henderson et al. *Australian Journal of Earth Sciences*).

Fiona's thesis on the petrogenesis and mineralisation potential of the Dido Batholith, showed that the complex, formerly considered to be a single Late Silurian intrusive unit, also includes diorites and associated rocks of Early Ordovician age. Mafic and ultramafic rocks in the core of this mainly tonalitic batholith have been shown to include both strongly Fe-enriched cumulates, and more typical, relatively Fe-poor cumulates. High precision PGE data and Nd isotope data were used to decipher relationships between the two cumulate packages and the more abundant dioritic rocks, and to evaluate the PGE prospectivity of this unusual ultramafic rock occurrence.

P1A7 Geochronology of the Rocky Cape Group

Leaders: Peter McGoldrick, Jacqui Halpin

Collaborators: Clive Calver, John Everard

The project has a single aim: to better constrain the depositional age of major units within the Rocky Cape Group.

The main activities in 2012 were:

- Zircon and monazite dating was extended to parts of the Rocky Cape Group not covered by Tortsen Jensen's 2011 Honours project, in which he dated these minerals from two locations in the Balfour Subgroup.

- Jacqui Halpin has successfully obtained authigenic monazite and detrital zircon ages from several stratigraphic levels, including Pedder River Siltstone, Lagoon River Quartzite, Cowrie Siltstone, Detention Subgroup and the Jacob Quartzite. Results were presented at the Strahan 'Science Meets Exploration' meeting on December 6th and 7th. Jacqui is preparing a paper based on this work for *Precambrian Research*.

Theme 1B
Magmas, Volatiles and Metals

P1B1 Felsic magmas in volcanic arcs and intraplate volcanic provinces – eruption style, degassing processes, fluid evolution and links to mineralisation

Leaders: Jocelyn McPhie, Vadim Kamenetsky

Team members: Sharon Allen, Rebecca Carey, Karsten Goemann, Maya Kamenetsky, Sebastien Meffre, Karin Orth

Students: Olga Apukhtina, Jesse Cotterill, Glen Diemar, Pedro Fonseca, Sean Hennessy, Qiuyue Huang, Martin Jutzeler

Collaborators: Andrea Agangi, Kim Denwer, Kathy Ehrig, Richard Fiske, Yoshi Goto, Emily Johnson, Kazuhiko Kano, Roland Maas, Marcelo Marquez, Jorge Relvas, Carlos Rosa, Yoshi Tamura, Kenichiro Tani

This project concentrates on volatiles and metals in felsic magmas, using a combination of melt inclusion research and physical volcanology. One of the aims is to determine how degassing of felsic magmas affects eruption styles and products, as well as the influences of magmatic volatiles on related hydrothermal systems. The research is being conducted in the Gawler Range Volcanics (South Australia), the Mount Read Volcanics (Tasmania), Taupo Volcanic Zone (New Zealand), Izu-Bonin arc (Japan), and Cascade Range (Washington, USA).

Outcomes for the year included:

- Emily Johnson has shown that metals potentially available from felsic magmas are sequestered by crystallising mineral phases in the absence of appropriate ligands, such as S or Cl. These results were presented in a paper accepted by the *Journal of Petrology*.

Qiuyue Huang, Olga Apukhtina and Vadim Kamenetsky study core samples at Olympic Dam.

- The importance of fluorine as a modifier of eruption behaviour in the Gawler SLIP was the subject of a paper published in *Precambrian Geology*.
- PhD candidate Martin Jutzeler graduated and had the first paper directly related to his PhD research published in the *Journal of Volcanology and Geothermal Research*. Martin submitted two additional manuscripts for review, one to the *Geological Society of America Bulletin* and one to *Geology*.
- Recent PhD graduate, Carlos Rosa, submitted a manuscript to the *Bulletin of Volcanology* on the misidentification of peperite.
- Another recent PhD graduate, Olga Vasyukova, had part of her PhD research on quartz in porphyry environments accepted for publication in the *American Mineralogist*.
- Long-term CODES collaborator, Associate Professor Yoshi Goto, and Jocelyn McPhie published a paper in the *Bulletin of Volcanology* on submarine pillow lavas.
- CODES and the School of Earth Sciences have a world-class suite of submarine silicic volcanic samples that have been collected over the past decade from the modern seafloor and young successions. The collection was expanded in 2012 through a collaboration with Professor Kazuhiko Kano, Kagoshima University, Japan, and Rebecca Carey's participation in a JAMSTEC research cruise with Dr Kenichiro Tani and other international scientists. These submarine samples have micro- to macroscopic textures that reflect eruption intensity.
- Sharon Allen and Rebecca Carey have generated a data set comprising image analysis of SEM photomicrographs, vesicle size and number distribution analysis, permeability measurements and synchrotron FTIR analysis of matrix glass using the Australian Synchrotron. Sharon and Rebecca submitted two manuscripts (*Geology* and the *Bulletin of Volcanology*) using these data to clarify submarine explosive eruption mechanisms; they also have two other manuscripts in preparation.
- Rebecca Carey has also been actively processing data from the 2008 eruptions on Kilauea volcano, Hawaii. One of Rebecca's papers was published in the *Journal of Geophysical Research*, and two others were accepted by *Geology* and the *Journal of Volcanology and Geothermal Research*.

Olympic Dam Project

CODES' recognition of the connection between high-fluorine rhyolites and granites in the Gawler SLIP and the giant Olympic Dam Cu-U-Au-Ag deposit published in *Geology* (McPhie et al., 2011) attracted a Comment (Manning, 2012). A Reply has been offered that clarifies the conditions under which fluorine-rich fluids may have operated.

Two new PhD students joined the project – Olga Apukhtina and Qiuyue Huang, both working on different aspects of the Olympic Dam Cu-U-Au-Ag deposit. Karin Orth left the Olympic Dam project to take up a Research Fellow position funded by the Geological Survey of Western Australia.

Jesse Cotterill and Sean Hennessy completed their Honours projects. Jesse produced new data on the age and composition of mafic dykes associated with the Wirrda Well prospect, southeast of Olympic Dam. Sean studied rare-earth-element minerals in the upper Gawler Range Volcanics.

P1B2 (AMIRA P962) Ni-PGE potential of mafic and ultramafic magmas – a combined melt inclusions and numerical modelling approach

Leader: Leonid Danyushevsky

Team members: Tony Crawford, Andrew McNeill

Students: JianXiang Guan

Collaborators: Alexey Ariskin, Allan Wilson

During 2012, activities focussed on the preparation of several manuscripts based on project outcomes that are no longer restricted by confidentiality arrangements. Subsequently, one manuscript has been submitted to *Economic Geology*, and two more will be submitted in 2013.

PhD student JianXiang Guan is in the final stages of writing his PhD thesis, which is aimed at understanding the interplay between magnetite and sulfide crystallisation during solidification of large gabbroid intrusions. His research has focussed on the Panzhihua Intrusion in China, which is one of the world's largest magmatic magnetite deposits. The main finding is that the intrusion was an open magma chamber, with minerals deposited from passing melts of similar compositions. This outcome could explain the accumulation of large amounts of magnetite.

A collaboration with Allan Wilson from the University of the Witwatersrand on the nature of primitive melts for the Bushveld and Great Dyke intrusions in southern Africa has been suspended indefinitely due to the extensive commitments of both parties.

This project has now concluded.

P1B3B Melt-melt immiscibility and the origin of magnetite-apatite deposits

Leader: Paul Davidson

Collaborators: Mirsaleh Mirmohammadi, John Nold, Rainer Thomas, James Webster, Yuling Xie

The ongoing melt inclusion study of the concentrically zoned Fanshan alkaline intrusion has shown considerable evidence of melt/melt immiscibility with silicate, carbonate, sulfide, and Fe-Ti oxide components observed in various combinations of melt inclusions. Further progress depends on accessing more samples from this unusual occurrence.

A new project on a magnetite-apatite deposit at Zanjan, Iran, will fully commence in 2013. The project group will include Garry Davidson from CODES and a collaborating student, Ghasem Nabatian, from Iran.

A paper with John Nold on the Pilot Knob magnetite-apatite occurrence (which invokes the involvement of an immiscible Fe-Ti oxide melt) is being revised following a review.

The collaboration with Rainer Thomas on the origin and evolution of pegmatites has continued to be productive, with four papers published in 2012, and another one in press. A review paper on granitic pegmatites is also in preparation for publication in 2013.

Outlook

- Publish two papers related to the collaboration with Rainer Thomas on the origin and evolution of pegmatites.
- Conduct field work and sampling in southern and central Myanmar, eastern Thailand, and Sumatra.
- Prepare papers on the geochronology of the Rocky Cape Group, the marine redox conditions during Mesoproterzoic in western Tasmania, and the origin of northern Australian sedimentary zinc deposits.
- Commence new project on a magnetite-apatite deposit at Zanjan, Iran.
- Gisela Cobenas to submit her PhD thesis aimed at gaining a better understanding of the behaviour of metals during evolution of calc-alkaline and adakitic arc magmas.
- Submit six manuscripts for publication related to the 'felsic magmas' project – P1B1.

Program Two
Formation

Objective

To develop practical, process-based models for the formation of hydrothermal and magmatic ore deposits that will help increase discovery rates for Australia's deep earth resources.

Introduction

Ore deposits form when chemical and physical processes cause dramatic changes in metal solubilities in hydrothermal fluids or magmas. These processes vary between deposit classes, and also between individual deposits. Evaluating the relative and absolute effectiveness of different ore-forming processes is essential for the development of new, process-based exploration models.

The Formation Program has two major research themes. Ore-Forming Processes investigates fundamental problems in ore genesis, taking advantage of CODES' unparalleled access to world-class ore deposits, well-constrained sample suites and data sets, and cutting-edge technologies. These technologies are accessed via Program 5, the nodes, and international collaborators. This theme aims to generate high profile publications, targeting high impact journals such as *Science*, *Nature*, *GCA*, *EPSL* and *Geology*.

The second research theme is Ore Deposit Characterisation. In order to understand how ore deposits form, it is essential that alteration and mineralisation features are carefully documented, both in the field and in the laboratory. This applied research activity generates essential data for understanding deposit formation and refining mineral exploration models, which makes this theme strongly linked to Program 3. One of the aims is to publish key papers and special issues describing and interpreting world-class ore deposits in *Economic Geology* and *Mineralium Deposita*.

Highlights

- Indications that episodic breaching of overpressured magmatic-hydrothermal systems is associated with swarm seismicity, leading to ore deposit formation in episodic flow regimes on timescales as little as 10^4–10^5 years.
- Evidence for processes of magmatic-hydrothermal fluid exsolution from Tasmanian Sn granites is being investigated through textural and geochemical analyses of USTs, miarolitic cavities, tourmaline orbicules and veins as part of a new PhD study.
- First public release of research results on Wafi-Golpu, Namosi and Lihir deposits, through presentations by CODES' students and Newcrest staff at the 34th International Geological Conference (IGC), held in Brisbane.
- A session at the 34th IGC entitled 'IOCG deposits: the unhappy family' included several CODES' presentations and attracted a large audience.
- Links identified between diorite-hosted metasomatic Fe deposits and shallow level high-sulfidation style hydrothermal activity.
- Paper on 'Mineralogy and formation of black smoker chimneys from Brothers submarine volcano, Kermadec arc' was published in *Economic Geology*.

Tomorocho porphyry copper mine, Peru.

Leader
David Cooke

Team Members

Mike Baker, Stuart Bull, Huayong Chen, Stephen Cox, Tony Crawford, Garry Davidson, Nathan Fox, Bruce Gemmell, Wei Hong, Julie Hunt, Nic Jansen, Ross Large, Andrew McNeill, Sebastien Meffre, Janina Micko, Karin Orth, Bence Paul, Khin Zaw, Lejun Zhang

PhD Students

Mohd Basril Iswadi Bin Basori, Heidi Berkenbosch, Margy Hawke, Carlos Jimenez, Erin Lawlis, Brendan McGee, Claire McMahon, Evan Orovan, Marc Rinne, Shiwei Wang (Hefei University), Selina Wu, Dayu Zhang (Hefei University), Guoxiong Zhong (Hefei University)

Masters Students

Jo Condon, Linghong Ge (Hefei University), Fengjie Lin(Hefei University), Yuzuo Lu (Hefei University), Hong Qiu (Hefei University), Yanduan Ren (Hefei University), Zhi Ren (Hefei University), Nathan Steeves (University of Ottawa)

Honours Students

Andrew Beattie, Andrew Kleeman

Collaborators

AUSTRALIAN NATIONAL UNIVERSITY Charlotte Allen, Ian Campbell

BARRICK GOLD Paul McInnes

CHINESE ACADEMY OF SCIENCES Chengbiao Leng

COLORADO SCHOOL OF MINES, USA Thomas Monecke

CSIRO Adam Bath, Charles Butt

EMMERSON RESOURCES Hamish Johns, Grant Osborne

GEOLOGICAL SURVEY OF CANADA Wayne Goodfellow, Jan Peter

GEOSCIENCE AUSTRALIA Geoff Fraser, Roger Skirrow

GNS, NEW ZEALAND Cornel de Ronde, Kevin Faure

GOLD FIELDS Jacqueline Blackwell

HARMONY GOLD Mawson Croaker, Russell Dow

HEFEI UNIVERSITY OF TECHNOLOGY, CHINA Yu Fan, Feng Yuan, Taofa Zhou

IMPERIAL COLLEGE LONDON, UK Clara Wilkinson, Jamie Wilkinson

IMPERIAL METALS Patrick McAndless, Chris Rees

IOGLOBAL Heidi Pass

IVANHOE AUSTRALIA Florinio Lazo, Rohan Wolfe

LAKEHEAD UNIVERSITY, CANADA Peter Hollings

MAWSON WEST Wojciech Zukowski

MEMORIAL UNIVERSITY, CANADA Steve Piercy

MOROBE MINING JOINT VENTURE Doug Menzies, Betty Tekeve

NEWCREST MINING Benjamin Ackerman, Will Clarke, Dean Collett, Mike Erceg, Dave Finn, Warwick Fortune, Stephanie Grabovickic, Anthony Harris, John Holliday, Fiona Karaut, Gustav Nortje, Jon Rutter, Geoff Smart

NORTHERN TERRITORY GEOLOGICAL SURVEY Masood Ahmad

OZ MINERALS Hamish Freeman, Mick Sawyer, Bruce Whittaker

QUEEN'S UNIVERSITY, CANADA Dan Layton-Matthews

TARBIAT MOALLEM UNIVERSITY, IRAN Zahra Bonyadi, Behzad Mehrabi

TECK Kevin Byrne, Amber Henry

UNIVERSITY OF ALBERTA, CANADA Robert Creaser

UNIVERSITY OF BRITISH COLUMBIA, CANADA Thomas Bissig, Greg Dipple, Jim Mortensen, Dick Tosdal

UNIVERSITY OF OTTAWA, CANADA Mark Hannington

Core Projects

Theme 2A
Ore-forming Processes

P2A2A Fracture arrays in intrusion-related ore systems – controls on the dynamics of fluid flow, vein formation and the generation of giant deposits

P2A3 Efficiency of ore-forming processes

Theme 2B
Ore Deposit Characterisation

P2B1A Exploring the porphyry environment

P2B1B Polymetallic mineralisation and associated magmatic and volcanic activity in Cretaceous volcano-sedimentary basins of eastern China

P2B1D Shallow and deep-level alkalic mineral deposits

P2B3B Genesis of volcanic-hosted copper-lead-zinc-silver-gold massive sulfide deposits

P2B3C Hydrothermal event recognition and target vectoring in volcano-sedimentary strata

P2B3D Active base- and precious-metal-rich massive sulfide depositions

P2B4 Iron oxide copper-gold and related deposit types

Opposite page: Tin granites, western Tasmania.

Project Summaries

Theme 2A
Ore-forming Processes

P2A2A Fracture arrays in intrusion-related ore systems – controls on the dynamics of fluid flow, vein formation and the generation of giant deposits

Leader: Stephen Cox

Earthquake hypocentre datasets are being used to explore the nature of seismogenic permeability enhancement associated with fluid-driven swarm seismicity, in order to understand fluid pathway architectures, flow dynamics, and scale of flow in fault-related magmatic-hydrothermal systems. Overpressured fluid reservoirs are typically breached by episodic sequences of swarm seismicity, as demonstrated by Hakone caldera, Japan, and Long Valley caldera, California. The behaviour of swarm-like, fluid-driven rupture sequences in fluid injection experiments into low permeability rocks, and recurrent swarm activity associated with natural fluid migration away from deep crustal, distal reservoirs, provides additional insights into fluid migration dynamics and fluid pathways in low permeability rocks. Fluid-driven failure processes in overpressured magmatic-hydrothermal systems favour episodic bursts of fluid migration and ore formation at potentially severe chemical disequilibrium conditions. Swarm recurrence and moment release rates in contemporary fluid-driven rupture sequences indicate that fault-hosted ore deposits can form in as little as 10^4–10^5 years.

P2A3 Efficiency of ore-forming processes

Leader: David Cooke

Team members: Mike Baker, Nathan Fox, Wei Hong, Lejun Zhang

Students: Carlos Jimenez

Collaborators: Chengbiao Leng

Two sub-projects were initiated in 2012. The first was a PhD study that is investigating the spectacular tourmaline ± quartz tourmaline orbicules and veins, as well as quartz ± magnetite unidirectional solidification textures (UST) that occur in granitic plutons in western Tasmania. The granites have associated Sn-W-Pb-Zn mineralisation but tourmaline alteration and USTs are not always spatially associated with the various types of mineralisation. Initial field work was undertaken, and samples were collected for LA-ICP-MS analyses of minerals and fluid inclusions. These analyses will help advance the understanding of metal and boron partitioning between brines and vapours in the USTs, and veins associated with these granites. The second sub-project

is being conducted by Chengbiao Leng, a visitor from the Chinese Academy of Sciences, who commenced EMP and LA-ICP-MS analyses of apatite, garnet and sulfides from selected Chinese porphyry and skarn deposits in December.

Theme 2B
Ore Deposit Characterisation

P2B1A Exploring the porphyry environment

Leaders: David Cooke, Nic Jansen

Team members: Tony Crawford, Janina Micko

Students: Andrew Beattie, Erin Lawlis, Evan Orovan, Marc Rinne

Collaborators: Benjamin Ackerman, Charlotte Allen, Ian Campbell, Will Clarke, Dean Collett, Robert Creaser, Mawson Croaker, Russell Dow, Mike Erceg, Kevin Faure, Dave Finn, Warwick Fortune, Stephanie Grabovickic, Anthony Harris, John Holliday, Fiona Karaut, Doug Menzies, Gustav Nortje, John Rutter, Geoff Smart, Betty Tekeve

The team is working in close collaboration with Newcrest Mining in order to maximise opportunities for the discovery of new porphyry-related gold resources in Australia and the South West Pacific region.

A combination of university-based research and in-house training has led to an improved understanding of Newcrest's porphyry and epithermal deposits in Australia, Papua New Guinea and Fiji, and advanced the conceptual models and exploration techniques applied at the relevant deposits and districts.

The close working relationship with Newcrest has resulted in the rapid uptake of knowledge arising from research activities, as well as the continued support from the company's leadership, both logistically and financially. Due to this, the company's exploration teams are now able to capitalise on epithermal and porphyry vectors developed in AMIRA research projects, past and present (P588, P765, P765A, and P1060), the findings of which have helped the team to develop sampling and analytical protocols. In most cases, these are now being routinely applied to exploration and advanced projects.

Rock from Golpu porphyry deposit containing quartz-orthoclase-biotite-magentite-calcopyrite.

The postdoctoral research fellows are focussing on techniques developed at CODES for exploration in the lithocap and green rock environment through the AMIRA P765, P765A, and P1060 projects. Nic Jansen is testing and refining lithocap exploration at the Wafi lithocap. He is also studying the Lihir gold deposit to determine whether the same lithocap vectors can be applied to the steam-heated clay blanket. Janina Micko recently completed a study on the Cadia district using green rock exploration vectors utilising whole-rock geochemistry and LA-ICP-MS analysis of chlorite and epidote. Unfortunately, Janina has left the team to follow other opportunities in Canada. A replacement is expected to be appointed in the new year.

Current student research activities include PhD studies by Erin Lawlis, Evan Orovan, and Marc Rinne. Their projects are aimed at gaining a better understanding of the geology of the Kapit NE ore body at the Lihir gold deposit, Wafi-Golpu porphyry-epithermal deposits, and the Namosi porphyry deposits in Fiji, respectively. In addition, an Honours study was completed this year by Andrew Beattie on the Gooleys porphyry prospect in the Cadia district.

P2B1B Polymetallic mineralisation and associated magmatic and volcanic activity in Cretaceous volcano-sedimentary basins of eastern China

Leaders: Taofa Zhou, David Cooke

Team Member: Lejun Zhang

Students: Linghong Ge, Fengjie Lin, Yuzuo Lu, Hong Qiu, Yanduan Ren, Zhi Ren, Shiwei Wang, Dayu Zhang, Guoxiong Zhong

Collaborators: Yu Fan, Feng Yuan

This project is investigating polymetallic mineralisation and associated magmatic and volcanic activity in the Luzong, Ningwu, Fanchang and Huaining basins, in the middle and lower Yangtze River regions of eastern China. Early Cretaceous magmatic rocks (135 ~123 Ma) formed during subduction of the paleo-Pacific plate, and generated a series of Fe deposits related to diorite intrusions (endo and exoskarn), together with massive pyrite, anhydrite and alunite deposits. Fe mineralisation was controlled by intra-basinal structures. Halite from the basal Triassic strata is also implicated in mineralisation. High sulfidation epithermal-style alteration appears to have formed above the diorite-related iron deposits. Research results from 2012 were presented at six conferences in China, one in the USA and one in Australia. Three PhD and six MSc students at Hefei University are working on this research project. One of these PhD students will spend 2013 at CODES, collaborating with David Cooke and Lejun Zhang.

Helicopter supported drilling at the Palmer VHMS deposit,southeast Alaska.

P2B1D Shallow and deep-level alkalic mineral deposits

Leaders: David Cooke, Thomas Bissig

Team member: Janina Micko

Collaborators: Adam Bath, Jacqueline Blackwell, Kevin Byrne, Greg Dipple, Amber Henry, Patrick McAndless, Paul McInnes, Heidi Pass, Chris Rees, Jon Rutter, Dick Tosdal, Wojciech Zukowski

This project has been concluded, except for the publication of the special alkalic issue of *Economic Geology*, which has been postponed until late 2013 or early 2014, due to delays in finalising several manuscripts.

The alkalic project aimed to document the characteristics and determine the genesis of alkalic porphyry deposits of British Columbia and alkalic epithermal deposits of PNG and Australia. The project involved collaboration with the University of British Columbia and was supported by nine industry sponsors. Additional financial support derived from grants from the Natural Sciences and Engineering Research Council of Canada (NSERC) and Geoscience BC.

P2B3B Genesis of volcanic-hosted copper-lead-zinc-silver-gold massive sulfide deposits

Leader: Bruce Gemmell

Team members: Ross Large, Andrew McNeill, Khin Zaw

Students: Mohd Basril Iswadi Bin Basori, Jo Condon, Margy Hawke, Brendan McGee, Nathan Steeves, Selina Wu

Collaborators: Charles Butt, Cornel de Ronde, Jim Mortensen

This project is investigating the spectrum of massive sulfide deposit types – from typical seafloor VHMS (zinc-lead-copper-silver-gold) deposits, through to sub-seafloor shallow-water, replacement gold-rich epithermal, and deep sub-volcanic intrusion-related copper-gold-rich styles.

In 2012, research was undertaken on deposits at Fossey-Hellyer-Que-River-Mt Charter (Tasmania), DeGrussa (Western Australia), Palmer (Alaska), Duc Bo (Vietnam), Tsik Chini (Malaysia) and Tala Hamza (Algeria). Developments included:

Selina Wu continued her PhD study on the VHMS deposits in the Que-Hellyer Volcanics, western Tasmania. Selina is specifically investigating the geologic setting and genetic relationships of the Fossey-Hellyer-Que-River-Mt Charter deposits.

Nathan Steeves, an MSc student at the University of Ottawa, completed his investigation of the Palmer VHMS deposit in southeast Alaska. This is a collaborative study with Mark Hannington of the University of Ottawa.

Mohd Basril Iswadi Bin Basori continued his PhD work on the geochemical, isotopic and genetic aspects of the Bukit Botol and Bukit Ketaya deposits at Tsik Chini, and related VHMS hydrothermal systems in Malaysia.

Brendan McGee discontinued his geologic and genetic study of the unusual Tala Hamza Zn-rich VHMS deposit in Algeria and withdrew from the PhD program.

Two student thesis projects continued at Sandfire Resources' new VHMS discovery at DeGrussa, WA. The first is a PhD project by Margy Hawke that is investigating the geologic, structural and geochronological setting of the deposits. The second project is a thesis by Jo Condon that focuses on the ore and gangue mineralogy, textures, paragenesis, mineral chemistry and sulfur isotopes of the prospects.

The first phase of a project aimed at improving the age and geochronological constraints on the development of the Mount Read Volcanic Belt (MRV) was completed. U-Pb dating of zircons proceeded, with many new dates obtained that have helped constrain the timing of the development of the MRV and associated VHMS mineralisation. The project is being conducted in collaboration with Jim Mortensen (UBC). A manuscript was submitted for publication in *Economic Geology* and was accepted for publication in 2013, with minor revisions.

Lejun Zhang, Chengbiao Leng and Wei Hong at the tin granites, western Tasmania.

P2B3C Hydrothermal event recognition and target vectoring in volcano-sedimentary strata

Leader: Bruce Gemmell

Team member: Ross Large

Collaborators: Wayne Goodfellow, Mark Hannington, Dan Layton-Matthews, Thomas Monecke, Jan Peter, Steve Piercy

This CAMIRO (Canadian Mining Industry Research Organization-Exploration Division)-funded project aims to provide an improved understanding of the concentrations and behaviour of trace metals associated with volcanic-hydrothermal processes in marine sedimentary and volcano-sedimentary successions, and develop new tools (mineralogical, geochemical, isotopic) to discriminate potentially mineralised versus unmineralised horizons in many mineralised districts. A sponsors meeting was held at the PDAC meeting in Toronto in March where Bruce Gemmell gave a presentation on the research at Greens Creek, Alaska.

P2B3D Active base- and precious-metal-rich massive sulfide depositions

Leader: Bruce Gemmell

Team member: Andrew McNeill

Student: Heidi Berkenbosch

Collaborators: Cornel de Ronde

This project is investigating the ore and gangue mineralogy, textures, paragenesis, mineral chemistry and sulfur isotopes of the sulfide-sulfate chimneys in modern seafloor hydrothermal systems.

Heidi Berkenbosch's PhD project at Brothers volcano, in the Tonga-Kermadec arc, continued in 2012. This is a collaborative project with GNS, New Zealand (Cornel de Ronde). A paper detailing the mineralogy, textures and mineral chemistry of the chimneys was published in *Economic Geology*.

P2B4 Iron oxide copper-gold and related deposit types

Leader: Garry Davidson

Team members: Mike Baker, Stuart Bull, Huayong Chen, David Cooke, Julie Hunt, Sebastien Meffre, Karin Orth, Bence Paul

Students: Andrew Kleeman, Claire McMahon

Collaborators: Masood Ahmad, Zahra Bonyadi, Geoff Fraser, Hamish Freeman, Hamish Johns, Florinio Lazo, Behzad Mehrabi, Grant Osborne, Mick Sawyer, Roger Skirrow, Bruce Whitaker, Rohan Wolfe

IOCG deposits remain one of the most controversial ore deposit types of the past decade, and this project aims to contribute data and ideas to this debate.

Achievements in 2012 included:

- Project leader Garry Davidson, together with Murray Hitzman from the Colorado School of Mines, convened a session at the 34th IGC in Brisbane entitled: IOCG deposits: the unhappy family. The session attracted a strong audience, and CODES contributed three of the twelve papers presented.
- Honours student Andrew Kleeman undertook a project studying the ore petrology and LA-ICP-MS trace element geochemistry of the Carapateena deposit.
- Continuation of a sulfur isotope investigation to determine the 3D variability of the Prominent Hill deposit continued in the Gawler Craton (see also P3B7A in Program 3).
- Through funding by Emmerson Resources, new data was obtained to refine the age of U mineralisation on Northern Star and Warrego deposits at Tennant Creek.
- Collaboration between UTAS and Tarbiat Moallem University, Iran, produced a Discussion and Reply (Bonyadi et al. 2012) on a 2011 paper in *Chemical Geology*, which enabled elaboration of mineral geochemistry detail not previously released.

Outlook

- Commence modelling the dynamics of fracture-controlled flow and stress regimes relevant to formation of porphyry Cu-Au systems, in collaboration with Beck Engineering.
- Conduct stable isotope, fluid inclusion and LA-ICP-MS analyses of USTs, veins and tourmaline orbicules from the Heemskirk granite.
- Initiate new MSc study at Lihir, a PhD study at Wafi-Golpu and Honours studies at Marsden and Gosowong.
- Complete PhD study at Wafi-Golpu, and appointment of new postdoctoral research fellow.
- Conduct two field trips to Middle-Lower Yangtze River Valley mineralisation belt, after conferences in Chengdu and Hefei, China.
- Publication of the alkalic special issue of *Economic Geology*.
- Publication of several articles dealing with IOCG and related deposits.
- Initiate PhD projects on the VHMS deposits of Greens Creek, Alaska, USA and Myra Falls, British Columbia, Canada.

Program Three **Discovery**

Objective

To develop techniques for the acquisition and interpretation of ore deposit geophysical and geochemical data that will assist in the discovery of Australia's deep earth resources.

Introduction

The Discovery Program leverages off CODES' extensive, broad-based research expertise to enhance the development of geophysical, geochemical and geological models for specific world-class ore deposits. The program is structured around two key themes: innovative techniques for discovery, and integrated exploration models for discovery.

CODES has built on its traditional strengths in ore deposit geology and geochemistry by expanding its geophysics capability, which employs a comprehensive suite of geophysical and mathematical techniques in a diverse mix of projects around the world.

Highlights

- Rapid inversion software implemented for homogeneous, heterogeneous and geometric inversion of airborne, downhole and fixed and moving loop TEM data.
- Successful completion of a proof of concept study using ambient seismic methods to determine depth to basement for mineral exploration under cover.
- Studies of data inference methods have led to the development of a semi-automated approach to geological mapping, including the identification of previously unknown sub-units.
- AMIRA P1060 continued with field campaigns in the USA, Chile, Peru, Panama, and Argentina. A successful sponsors' review meeting as well as an AMIRA P765A workshop for new sponsors were held in Salt Lake City, USA, during July. Activities included associated field trips.
- In September, a paper by Ross Large, Stuart Bull and Valeriy Maslennikov on Carlin-type and orogenic gold deposits was awarded the Brian J Skinner Award for the best paper published in *Economic Geology* during the previous year (2011).
- A team, led by David Cooke and Bruce Gemmell, received the inaugural AMIRA International Award for Geoscience Research Excellence. The award was presented in recognition of research related to AMIRA projects P765, P765A and P1060.
- PhD theses submitted by Mathieu Ageneau, Lindsey Clark and Hugo Galvan.
- New PhD study initiated at Ladolan, Lihir Island, PNG

Leader
Andrew McNeill

Team Members

Mike Baker, Ron Berry, Stuart Bull, David Cooke, Leonid Danyushevsky, Garry Davidson, Jeff Foster, Nathan Fox, Bruce Gemmell, Sarah Gilbert, Leon Graham, Dave Hutchinson, Shaun Inglis, Vadim Kamenetsky, Ross Large, Elena Lounejeva, Sebastien Meffre, Anya Reading, Ralf Schaa, Rob Scott, Helen Thomas, Jennifer Thompson, Lejun Zhang

PhD Students

Mathieu Ageneau, Victoria Braniff, Lindsey Clark, Matt Cracknell, Hugo Galvan, Dan Gregory, Carlos Jimenez, Sean Johnson, Erin Lawlis, Alexey Lygin, Adam Pacey (Imperial College London), Jose Piquer, Jeff Steadman, Bronto Sutopo, Francisco Testa

Masters Students

Ayat Baig (Lakehead University), Djohanne Celiz, Myall Hingee, Wes Lueck (Lakehead University), Neil Macaladad, Daud Silitonga, Leo Subang

Honours Students

Michael Dunne, Edward Morris, Nicholas Smith

Collaborators

ANGLOGOLD ASHANTI Rob Burnett, Mark Doyle

AUSTRALIAN NATIONAL UNIVERSITY Nicholas Rawlinson, Malcolm Sambridge

BHP BILLITON Tony Webster

CLUMP MOUNTAIN GEOSCIENCE Pat Williams

CONSULTANT Noel White

EPIGENESIS CONSULTING Marcus Tomkinson

FULLAGAR GEOPHYSICS Peter Fullagar

GEOLOGICAL SURVEY OF FINLAND Peter Sorjonen-Ward

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA Peter Haines, Arthur Hickman

GUANGZHOU INSTITUTE OF GEOCHEMISTRY, CHINA Huayong Chen

IMPERIAL COLLEGE LONDON, UK Jamie Wilkinson, Clara Wilkinson

LAKEHEAD UNIVERSITY, CANADA Peter Hollings

MINERAL RESOURCES TASMANIA Ralph Bottrill, Jafar Taheri

MONASH UNIVERSITY Michael Asten, Chris Wilson

MMG Steve Beresford, Todd McGilvray

NEWCREST MINING Kylie Braund, Dean Collett, Anthony Harris, Cam Mackay

OZ MINERALS Mark Allen, Jorge Benavides, Hamish Freeman, Charles Funk, Kerrin Gale, Marcel Van Eck

RUSSIAN ACADEMY OF SCIENCES Valeriy Maslennikov, Svetlana Maslennikova

UNIVERSITY OF CALIFORNIA RIVERSIDE, USA Tim Lyons

UNIVERSITY OF JOHANNESBURG, SOUTH AFRICA Bradley Guy

UNIVERSITY OF OTAGO, NEW ZEALAND David Craw

YUKON GEOLOGICAL SURVEY, CANADA Patrick Sack

Core Projects

Theme P3A
Innovative Techniques for Discovery

P3A1C The rapid approximate inversion of TEM data (P1022)

P3A2A Ambient seismic energy techniques

P3A3A Data inference techniques applied to diverse geoscientific datasets

Theme P3B
Integrated Exploration Models for Discovery

P3B1B Enhanced geochemical targeting in magmatic-hydrothermal systems (AMIRA P1060)

P3B1C Low- and high-sulfidation epithermal mineral deposits

P3B2A Sediment-hosted gold-arsenic-tellurium deposits: genesis & exploration models (includes part of AMIRA P1041)

P3B3A Shales and carbonates – improved vectors for Rosebery and Hercules style VHMS

P3B5C The geology and genesis of the Avebury Ni deposit – implications for exploration

P3B6A Structure and formation of the Savage River magnetite deposit

P3B7A Iron oxide copper-gold and related deposit types

Project Summaries

Theme P3A
Innovative Techniques for Discovery

P3A1C (AMIRA P1022) The rapid approximate inversion of TEM data

Leader: Peter Fullagar

Team members: Jeff Foster, Ralf Schaa

Student: Myall Hingee

The aims of this project are to build on the results of Ralf Schaa's PhD research and further advance the development of rapid approximate 3D inversion of TEM data. During 2012, VPem3D was advanced to a trial evaluation stage with all targeted inversion options (homogeneous property inversion, heterogeneous property inversion and geometric inversion for moving-loop, fixed-loop, airborne and downhole TEM data) implemented.

A new MSc project commenced, involving Myall Hingee, who is investigating approximate inverse mapping (AIM) inversion of TEM. This will involve validation of VPem3D inverted conductivity models, using 3D TEM forward modelling and cross-validation of the 3D TEM modelling programs.

Significant progress has been made with the graphical user interface (VPview). Outcomes include the newly acquired ability to display:

- Drill hole data, both for locations and measured values.
- TEM moments as line-profiles.
- Model inversion weights and cell constraints on vertical sections, and increased implementations of small details.

Research in the last quarter focussed on preliminary data interpretation from Rio Tinto and Gold Fields' sponsor site studies involving airborne, downhole and fixed and moving loop TEM data.

Fig. 1

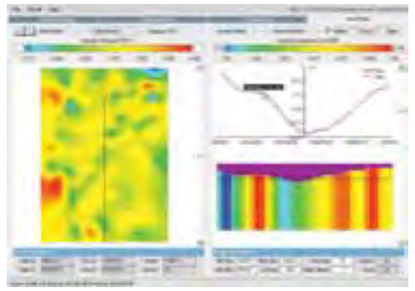
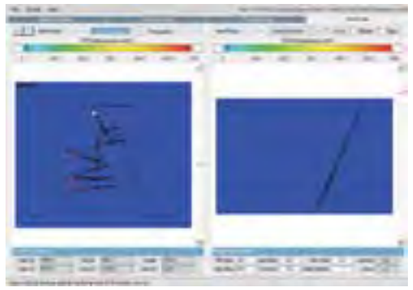


Fig. 2



Opposite page: Northparkes, NSW. **Above Fig. 1:** Interpolated profile from observed and calculated magnetic data along the North-South mid-section of the model. The left-hand-side shows the data residuals after inversion; the right-hand-side shows the associated vertical section of the model after basement-inversion, where the top-panel displays interpolated observed and calculated data profiles for the selected section-line. **Fig. 2:** Projected downhole TEM stations in plan (left) and on a vertical section (right) through a VPem test model. The red triangles on the left image denote the positions of the drill-collars.

P3A2A Ambient seismic energy techniques

Leader: Anya Reading

Team member: Leon Graham

Student: Nicholas Smith

Collaborators: Michael Asten, Charles Funk, Nicholas Rawlinson

In 2012, the proof of concept study, using ambient seismic techniques to constrain the depth to basement in the context of exploration under cover, was completed and results submitted to the major international journal, *Geophysics*. The collaboration with Michael Asten (Monash University) and Charles Funk (OZ Minerals) has been a resounding success. A key factor in using the method in low-noise environments in inland Australia is the enhancement of the available ambient seismic energy using an off-road vehicle. There is considerable industry interest in the method which, used in tandem with high-resolution gravity, significantly improves exploration targeting for locations with between 50 and 500m of cover sediment.

P3A3A Data inference techniques applied to diverse geoscientific datasets

Leader: Anya Reading

Team member: Andrew McNeill

Student: Matt Cracknell

Collaborator: Malcolm Sambridge

Matt Cracknell's PhD project on data inference work, applied to geological mapping and uncertainty estimation, has progressed and is now being used for knowledge discovery in key regions, such as western Tasmania. As well as being able to create credible geological maps in a semi-automated process, previously unidentified sub-units are being revealed.

Anya Reading has carried out a successful trial of the use of trans-dimensional change-point modelling as a data-driven appraisal of uncertainty in geophysical borehole data.

The results of the work carried out under this project have been submitted for publication in international journals and presented at the American Geophysical Union meeting in San Francisco.

Theme P3B
Integrated Exploration Models for Discovery

P3B1B (AMIRA P1060) Enhanced geochemical targeting in magmatic-hydrothermal systems

Leaders: David Cooke, Bruce Gemmell, Mike Baker

Team members: Nathan Fox, Elena Lounejeva, Jennifer Thompson, Lejun Zhang

Students: Ayat Baig, Djohanne Celiz, Carlos Jimenez, Wes Lueck, Neil Macaladad, Adam Pacey, Jose Piquer, Leo Subang, Francisco Testa

Collaborators: Huayong Chen, Peter Hollings, Noel White, Clara Wilkinson, Jamie Wilkinson

This initiative commenced in June 2011, building on research carried out within AMIRA P765A, which concluded in late 2010. The project is being conducted in collaboration with Lakehead University and Imperial College London, and has the support of 21 industry sponsors, making it the largest exploration-based research project in AMIRA's history.

The aims are to develop and refine new geochemical and geological tools that will help explorers to determine the locations of porphyry and epithermal deposits, discriminate between different styles of mineralisation, and assess the fertility of individual districts. These techniques will assist explorers to detect the subtle hypogene geochemical dispersion halos that extend for kilometres away from the intrusive centre; thereby enhancing their ability to discover new deposits more quickly and at less cost. An additional aim is to develop cost-effective, field-based methods that can be applied by explorers who do not have access to suitable laboratory facilities for LA-ICP-MS geochemical analysis.

The two main environments (lithocap and green rock) that are being explored in porphyry-epithermal districts are being further investigated, with the objective of developing new tools for exploration in these areas through the analyses of pre-existing and new sample suites. Blind site testing is being used to validate the findings.

Tools developed by the P765A team have proven to work effectively in volcanic terrains, but have not been tested effectively in other environments. Therefore, an important component of the research is to investigate the effects on various protoliths (limestones, sandstones, granite, etc.).

Since project commencement, field campaigns have been conducted in the USA, Canada, Indonesia, Chile, Peru, Panama, Colombia, the Philippines and Argentina.

In the past year, a successful sponsors' review meeting and an AMIRA P765A workshop for new sponsors were held in Salt Lake City, USA, during July. Activities included associated field trips. A sponsors' review meeting was also held at CODES during December.

Lejun Zhang and Jennifer Thompson sampling the Little Cottonwood Stock in the Wasatch Mountains, Utah, USA.

P3B1C Low- and high-sulfidation epithermal mineral deposits

Leaders: Bruce Gemmell, David Cooke

Team member: Michael Roach

Students: Mathieu Ageneau, Lindsey Clark, Michael Dunne, Hugo Galvan, Bronto Sutopo, Erin Lawlis, Daud Silitonga

Collaborators: Kylie Braund, Dean Collett, Anthony Harris, Cam Mackay

The geology and genesis of low- and high-sulfidation epithermal deposits are being investigated in Australia and in the southwest Pacific region. Research has concentrated on determining the geological and geochemical constraints on the formation of these deposits, which will lead to improved genetic and exploration models.

Low sulfidation deposits

- Research continued on the Newcrest-funded deposit to district-scale study of the Gosowong goldfield, Halmahera Island, Indonesia. Lindsey Clark completed her PhD thesis, investigating the geology and genesis of the Kencana epithermal Au-Ag deposit at Gosowong. This research provided the first detailed study of the deposit via geological, structural, mineralogical and geochemical investigations. Masters of Economic Geology student, Daud Silitonga, continued his investigation of the Toguraci epithermal veins that crosscut the low grade Bora porphyry Cu-Au prospect in the district. Michael Dunne completed an Honours thesis on the geophysical response of epithermal and porphyry alteration/mineralisation in the Gosowong goldfield.
- Hugo Galvan completed his PhD project investigating the geological and geochemical evolution of carbonate-base-metal Ag-Au epithermal veins in the Palmarejo District, Chihuahua, Mexico. The study, funded by Coeur d'Alene, developed a more detailed understanding of the geological evolution of the district, and included investigations of the mineralisation history, geochemistry and relationships to grade distribution. It also documented the vein stratigraphy, paragenesis, spatial and temporal distribution of the alteration assemblages and geochemistry of the mineralising fluids.
- PhD student, Mathieu Ageneau, completed his PhD thesis on the low-sulfidation Ladolam Au deposit in Papua New Guinea. This research, which was supported by Newcrest, focused on the mineralogy of the Lienetz and Minifie ore bodies and, more specifically, the geochemistry of the main ore mineral – refractory pyrite. The study also investigated the geology, alteration, and metal zoning of the Kapit ore body.
- PhD student, Erin Lawlis, initiated her PhD thesis on the modern geothermal system associated with the low-sulfidation Ladolam Au deposit in Papua New Guinea. This research is also supported by Newcrest.

High sulfidation deposits

Bronto Sutopo undertook corrections to his PhD thesis on the high- and low-sulfidation mineralisation in the Martabe district, Indonesia. His thesis significantly improved the understanding of the geologic setting and ore genesis, as well as developing criteria for enhanced exploration in the district.

Ross Large (L) and an AngloGold Ashanti geologist 3.5 km underground at the Mponeng mine in South Africa's Witwatersrand Basin, studying the gold reef.

P3B2A Sediment-hosted gold-arsenic-tellurium deposits: genesis & exploration models

Leaders: Ross Large, Stuart Bull

Team members: Leonid Danyushevsky, Garry Davidson, Sarah Gilbert, Dave Hutchinson, Shaun Inglis, Sebastien Meffre, Robert Scott, Helen Thomas

Students: Dan Gregory, Sean Johnson, Jeff Steadman

Collaborators: Rob Burnett, Dave Craw, Mark Doyle, Bradley Guy, Peter Haines, Arthur Hickman, Tim Lyons, Valeriy Maslennikov, Svetlana Maslennikova, Patrick Sack, Peter Sorjonen-Ward

This project focuses on aspects of gold deposits that relate to mineral processing, genesis and exploration. The work includes gold mineralogy, characterisation of refractory (invisible) gold, pyrite textures, geochemistry and isotopes in a wide range of gold deposits. The project utilises LA-ICP-MS analyses and laser mapping of sulfides to determine gold deportment and mineralogical relationships. A portion of this work forms AMIRA project P1041: The application of new technologies to gold deposits, which includes six industry-based research partners: AngloGold Ashanti, Newcrest, Newmont, G Resources, Sipa and Issara.

The following deposits were studied as part of the overall project in 2012:

- Witwatersrand Carbon Leader Reef (CLR) in the West Wits district (part of AMIRA P1041) – Research is addressing the question: What are the potential sources of the various pyrite types and related gold? Evidence for both a detrital component of gold and a significant hydrothermal component has been revealed by detailed laser mapping of CLR samples. A paper on this work has been accepted for publication in *Economic Geology*.
- The Geita BIF-hosted gold deposit group in Tanzania – Research is focused on gold mineralogy and deportment at a number of deposits across the district.
- The Wiluna orogenic gold deposit in the Yilgarn of Western Australia (where the gold zone is hosted in altered mafic rocks) – This research is aimed at determining the proportion of refractory (invisible) gold in pyrite and arsenopyrite, compared to free gold hosted in sulfides and silicates.

- The Martabe high sulfidation gold deposit in Sumatra, Indonesia – Research indicates a very complex paragenesis, with the highest grade parts of the deposit dominated by a rare cavity fill mineral association with pyrobitumen.
- The Chatree epithermal gold deposit in Thailand – Focus was on research to assist exploration and targeting of further high grade zones.
- The giant Lihir epithermal gold deposit in PNG – Studies have evaluated the relationships between pyrite texture and paragenesis compared with gold grade for different zones of the orebody.

Research on a range of gold deposits has highlighted the controls of both chemistry, in particular arsenic and tellurium, and mewtamorphic grade, on the mineralogy, deportment of gold and ore grade in sediment-hosted, volcanic-hosted and greenstone-hosted deposits.

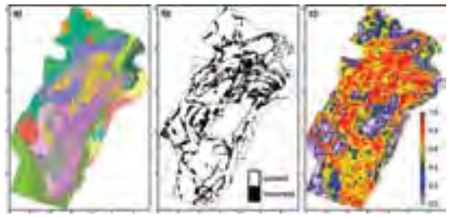
P3B3A Shales and carbonates – improved vectors for Rosebery and Hercules style VHMS

Leaders: Andrew McNeill, Bruce Gemmell

Collaborator: Todd McGilvray

Exploration for VHMS deposits in the Mt Read Volcanics (MRV) is based on the concepts that all economic mineralisation occurs at a particular time horizon and that this horizon has been adequately tested to a depth of 150–200m. Therefore, from the exploration perspective, it is important to define the location and down-dip extent of the prospective horizon and to locate alteration envelopes that may be associated with VHMS mineralisation.

All analytical work for this project has been completed and the results are being prepared for publication, which will conclude this project.



Spatial distribution of lithology predictions generated by Random Forests for the Hellyer–Mt Charter region of western Tasmania. a) provides the predictions of ~ 20 different lithology classes of the Que-Hellyer Volcanics and nearby units, b) represents the location of misclassified samples, and c) shows estimated uncertainty based on the distribution of posterior class probabilities.

P3B5C The geology and genesis of the Avebury Ni deposit – implications for exploration

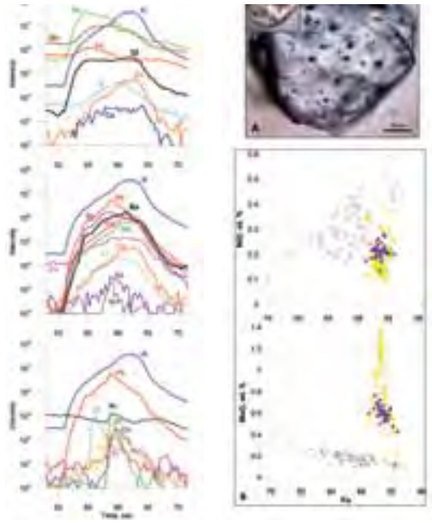
Leaders: Jeff Foster, Vadim Kamenetsky

Team member: Andrew McNeill

Student: Alexey Lygin

Collaborator: Steve Beresford

A new genetic model of the Avebury Ni sulfide deposit was developed during the year as part of Alexey Lygin's PhD project. It is fundamentally different to existing views on the origin of this unconventional mineralisation in that a precursor Ni sulfide deposit of magmatic origin is not required. New data obtained



Left: In situ LA-ICP-MS analysis of a metal-rich brine inclusion in hydrothermal olivine. **Right:** a) Hydrothermal olivine with abundant metal-rich brine inclusions; b) Composition of Avebury olivine, samples A193-653.1 (circles), U066-12 (rhombi) and magmatic olivine (crosses) from Heazlewoodite River Complex (data from Peck, 1990).

from the study of fluid inclusions trapped in olivine (together with mineralogy, petrology, whole-rock geochemistry, dating, and isotopic studies) support the concept of a metasomatic (hydrothermal) origin for Avebury.

Olivines at Avebury are compositionally different from magmatic olivines found in Cambrian ultramafic rocks in western Tasmania, as they are characterised by a wide range of NiO, and unusually high MnO abundances, as well as a lack of the typical correlation between Ni and forsterite content. The Avebury olivines contain many hundreds of metal-rich brine inclusions, which are characterised by multiphase composition and high temperature of homogenisation. Laser ablation study of inclusions revealed they are enriched in Cl, Na, K, Ca, Fe and Mn, and base, alkaline and alkaline-earth metals. Heating experiments on these inclusions confirmed the highly concentrated, viscous nature of the entrapped fluid. First transformations among daughter phases occurred at 150–200°C, followed by continual re-arrangement of phase boundaries and gradual shrinking of the vapour bubble, which did not change its original position and disappeared at ~620–700°C.

P3B6A Structure and formation of the Savage River magnetite deposit

Leaders: Ron Berry, Rob Scott

Students: Victoria Braniff, Edward Morris

Collaborators: Ralph Bottrill, Jafar Taheri, Tony Webster, Chris Wilson

The primary aim of this collaboration with Grange Resources is to gain an understanding of the structure of high strain rocks of the Arthur Lineament in the vicinity of the company's Savage River Mine. In 2012, this project involved the ongoing PhD study by Victoria Braniff, and an Honours project by Edward Morris. The findings of these studies will help deal with pit wall stability issues and resource definition.

Key findings in 2012 include:

- Pit mapping by Victoria Braniff indicates the presence of at least two generations of mylonite at the mine. The foliation orientation is similar for both generations of mylonite (i.e. steeply dipping, N-striking), however the older, higher P-T condition mylonites (inferred Cambrian) have a sub-horizontal stretching lineation, while the younger mylonites (Devonian from monazite dating) record dip-slip movement.
- Edward Morris investigated the structure of Neoproterozoic turbidites of the Oonah Formation to the east of the mine. The earliest folds recognised are downward facing, suggesting the sequence in this area was inverted during an earlier episode of recumbent folding. Strain increases abruptly across a 100–300 m wide zone that defines the eastern margin of the Arthur Lineament. However, studies of the illite crystallinity index revealed no significant variation of metamorphic conditions across the eastern boundary of the lineament.
- To help clarify relations between rock packages comprising the Arthur Lineament near the Savage River Mine, Edward also dated detrital zircons from samples of high- and low-strain Oonah Formation and several units closer to, and within, the mine area. This study identified detrital zircons as young as ca. 740 Ma in the Bowry Formation (host to the Savage River magnetite deposits), which is a sequence that was previously interpreted to be older than 777 Ma, based on the U-Pb zircon age of an interpreted cross-cutting granitic intrusive to the south of the mine. Additionally, a sample of an albite-rich rock (albitite) from the Bowry Formation at the mine yielded a dominant ca. 777 Ma zircon population, indistinguishable from those of the previously dated 'granitic intrusive'. These new data suggest that the 'granitic intrusive' is actually albitically altered Bowry Formation, and the Bowry Formation is similar in age to the adjacent, and compositionally similar, Eastern Ahrberg Group.

P3B7A Iron oxide copper-gold and related deposit types

Leader: Stuart Bull

Team members: Garry Davidson, Sebastien Meffre

Collaborators: Mark Allen, Jorge Benavides, Hamish Freeman, Kerrin Gale, Marcus Tomkinson, Marcel Van Eck, Pat Williams

Phase two of the project was completed in 2012, and involved applying the chrono-stratigraphic framework developed for the mine area to some of the regional prospects in the Mount Woods Inlier. This task required the acquisition of new U-Pb zircon and monazite dates for host rocks and sulfide mineralisation at each site. Phase two also saw the commencement of a sulfur isotope zonation study, and a pilot evaluation of the mineral geochemistry of oxide phases using LA-ICP-MS.

Outcomes of the regional geochronology included highly significant new insights into the architecture of the region. The sulfur isotope work on one geological section illustrated the value of careful, paragenetically constrained analysis – because of complex intergrowths and replacement among the sulfide minerals. Results of phases one and two cannot be further detailed due to the confidential nature of the project.

Further support is being sought from OZ Minerals for several aspects of the study.

Outlook

- Complete the interpretation of sponsor data to validate VPem3D rapid TEM inversion software by the end of the project in August 2013.
- Development of AMIRA project proposal to further develop and apply ambient seismic methods to mineral exploration.
- Preparation of open-source computing tools for the use of Random Forests in Geological Mapping.
- Completion of all field work for AMIRA P1060.
- AMIRA P1041 will finish in mid-2013. A new AMIRA gold project will be proposed to continue some aspects of this research.
- Garry Davidson to take over as Program Leader from the beginning of 2013. Garry replaces Andrew McNeill, who has taken up a position with Mineral Resources Tasmania.

Program Four Recovery

Objective

To create and develop a series of small-scale, low-cost, and practical geometallurgical tools, protocols, proxies and processing indices for the purpose of ore-body domaining and mine planning.

Introduction

Over the past decade, the extent of research conducted within the field of geometallurgy has significantly increased. Industry recognition of this growing discipline, and the subsequent need for new large-scale, integrated geometallurgical research, resulted in the development of the AMIRA P843 (Geometallurgical Mapping and Mine Modelling) project, which has commonly become known as GeM^{III}.

The project commenced in July 2005, in collaboration with the University of Queensland (UQ), with a vision to establish a collaborative, cross-discipline research platform to support the emerging role of geometallurgy in providing predictive inputs into mine planning, economic optimisation and sustainability. During its initial four-year lifespan, GeM^{III} became the fastest growing and largest foundation project in AMIRA's 50-year history, which led to an extension of the project (AMIRA P843A) in 2009. Over the project's lifespan, it has been highly successful in developing an array of geometallurgical methods and protocols in areas of comminution and flotation. It has incorporated aspects of mining, liberation, recovery (flotation and leaching) and environmental impact, and carried out important larger scale, site-specific case studies aimed at evaluating these methods in active mines – paying careful attention to the potential for integration of the findings into resource models, mine planning and optimisation studies. AMIRA P843A is to be completed in 2013 and planning is underway for an AMIRA continuation project.

With significant support from CODES' collaborating team members at UQ and CSIRO, the GeM^{III} project has successfully delivered a number of key benefits to industry partners, including improved forecasting, reduced technical risk, enhanced economic optimisation of mineral production, and more efficient use of the resource.

Highlights

General

- A joint CRC ORE / GeM^{III} Masters level, two-week short course was run as part of the Master of Economic Geology Program at CODES. Other geometallurgy courses were prepared for delivery through UQ (JKTech).
- Associate Professor Jeff Foster left CODES in the latter part of the year to take up an industry position, and Associate Professor Ron Berry was appointed as the new leader of the Recovery Program.

Theme 1 (P4A1)
Predictive Environmental Indices

- Critical testing of established rinse and paste pH procedures completed.

Theme 2 (P4A2)
Integrated Blast Modelling

- Major advances made in the structure and documentation of iFragX software, especially in terms of providing links to measurement while drilling (MWD) data and DomAIn (GeM^{III} software) results.

Theme 3 (P4A3)
Deterministic Comminution Modelling

- Interactive CD developed to document comminution test methods previously reported in this theme.

Theme 4 (P4A4)
Texture-based Liberation and Recovery Modelling

- Validation of small scale flotation tests on sieved material.

Theme 5 (P4A5)
Predictive Leaching Indices

- Significant advances made in establishing selective leaching protocols for the determination of copper mineralogical deportment (oxides, chalcocite, covellite, bornite and chalcopyrite).

Theme 6 (P4A6)
Specialist Analytical and Support Software

- Manual produced on designing and building a core photography system.
- Software programs, STORC and SupLCore, reach test stage.

(P4A7) Case Studies and Technology Transfer

- Five case studies completed.

Oktocopter, which is used to survey dangerous pit faces.

Leader
Ron Berry

Team Members

CODES Julie Hunt, Dave Hutchinson, Maya Kamenetsky, Lyudmyla Koziy

CRC ORE/UTAS School of Earth Sciences Bernd Lottermoser (partly CODES), Taryn Noble, Anita Parbhakar-Fox

CSIRO Minerals Down Under Flagship/Process Science and Engineering Nicole Chapman, Laura Kuhar, Rachael Martin, Angus McFarlane, Rebecca Meakin, Patrick Merrigan, Dave Robinson, Nicole Turner

UQ SMI Dee Bradshaw, Alice Clark, Alan Cocker, Mansour Edraki, Louisa Groves, Luke Keeney, Toni Kojovic, Simon Michaux, Khoi Nguyen, Italo Onederra, Pat Walters, Steve Walters, Yicai Wang

PhD Students

CRC ORE/UTAS School of Earth Sciences Ashish Sadhu

UQ Hector Parra Galvez, Mitesh Chauhan

Masters Students

CODES/UTAS School of Earth Sciences Stacey Leichliter

Core Projects

Project P4A (AMIRA P843A) **GeM^{III} Geometallurgical Mapping and Mine Modelling** – is split into the following six themes, plus a sub-project covering case studies and technology transfer.

Theme 1 (P4A1)
Predictive Environmental Indices

Theme 2 (P4A2)
Integrated Blast Modelling

Theme 3 (P4A3)
Deterministic Comminution Modelling

Theme 4 (P4A4)
Texture-based Liberation and Recovery Modelling

Theme 5 (P4A5)
Predictive Leaching Indices

Theme 6 (P4A6)
Specialist Analytical and Support Software

(P4A7) Case Studies and Technology Transfer

Project Summaries

Theme 1 (P4A1)
Predictive Environmental Indices

Leaders: Ron Berry, Bernd Lottermoser

Team members: Mansour Edraki, Taryn Noble, Anita Parbhakar-Fox

Student: Ashish Sadhu

This theme provides early predictive information on intrinsic rock characteristics likely to impact on environmental performance and management during mineral processing, product manufacture and waste disposal.

It was originally intended for this theme to continue as an integral part of AMIRA P843A. However, due to funding restrictions, it has been transferred to CRC ORE, of which the UTAS School of Earth Sciences is a participant. For a transition period, the theme's results will be reported to AMIRA P843A sponsors.

Significant outcomes during 2012 include the completion of a major literature review on micro-analytical technologies for mineral mapping and trace element deportment, and testing of established rinse and paste pH procedures. A microwave-assisted thermal excitation (MATE) pH test is near finalisation.

Opposite page: Headframe at Telfer.

Theme 2 (P4A2)
Integrated Blast Modelling

Leaders: Italo Onederra, Alan Cocker

Team members: Ron Berry, Toni Kojovic, Angus McFarlane, Simon Michaux (early part of year), Khoi Nguyen, Steve Walters

Student: Hector Parra Galvez

This theme is divided into three parts. In the first part of the theme, integration of high-resolution bulk rock properties into advanced blast models, the IfragX software has been extended to interact with both the DomAIn software and data relating to measurements taken while drilling. Final adjustments are being made to the documentation for the IfragX software. However, there are a number of IP issues to solve with this software, which is built around a pre-existing blast modelling module.

The second part of the theme, blast induced fragment conditioning on leaching performance, is being advanced by trials on an artificial rock analogue, blasted in barrels. Samples taken at various positions in relation to the blast centre are being tested for comminution strength and leaching behaviour. These tests will be completed by mid-2013.

The final part of the theme, the STORC (structure from oriented core) program, was made available as a beta release to sponsors during the year; and a larger scale trial, based on sponsor data, has begun. The orientation of discontinuities and other structural data is scheduled to be analysed on 500 metres of oriented core. STORC was developed in collaboration with the team on Theme 6.

Theme 3 (P4A3)
Deterministic Comminution Modelling

Leader: Toni Kojovic

Team members: Alice Clark, Julie Hunt, Luke Keeney, Simon Michaux (early part of year), Pat Walters, Steve Walters

During the past year, the research team has primarily worked on validating pre-existing protocols in three areas: improvement to the GeM^{III} comminution index, use of non-core drilling products, and comminution blend response.

A comminution testing manual has been completed to the draft stage, which is complemented by an interactive CD that includes details on testing methodologies, videos of testing practices, relevant background technical reports, and other information for use in the application of the selected tests. The documents on the CD are searchable and a general index has been developed to assist with researching the application of each test. The team has completed its objectives and needs only to put the finishing touches to the documentation.

Theme 4 (P4A4)
Texture-based Liberation and Recovery Modelling

Leader: Dee Bradshaw

Team members: Ron Berry, Louisa Groves, Julie Hunt, Maya Kamenetsky, Khoi Nguyen, Steve Walters, Yicai Wang

Student: Mitesh Chauhan

The objective of this theme is to develop appropriate methodology to populate deposit block models with recovery predictions that incorporate inherent geological variability, both from mineralogical predictions (particularly those focused on obtaining texture indicators) and the development of a suitable small-scale test. Textural analysis for prediction of liberation and the grade recovery curve have continued during the year, and software development has provided new capability in the analysis of unclassified images.

There have also been major developments in terms of small-scale flotation testing, through both the MSI approach and with 1.5 litre batch flotation systems. Tests were conducted using a sieve fraction from a comminution test to ensure their practicality in a geometallurgy survey. The MSI has been validated on porphyry Cu deposits, while the small-scale batch flotation cell has wider applications and is in the process of validation.

Theme 5 (P4A5)
Predictive Leaching Indices

Leaders: Dave Robinson, Laura Kuhar

Team members: Nicole Chapman, Lyudmyla Koziy, Rachael Martin, Angus McFarlane, Rebecca Meakin, Patrick Merrigan, Nicole Turner

This theme comprises five parts:

- Development of small-scale tests (diagnostic leaching, selective leaching, agglomeration, rheology).
- Integrated mineralogical feed characterisation.
- Texture-based leaching simulation.
- Use of pre-conditioning for leach optimisation (with Theme 2).
- Class-based modelling of leaching performance and use of blend response curves.

Selective leaching test work has been completed on 182 samples from a copper-gold deposit, and an additional 238 samples are to be processed in 2013. A standard operating procedure manual has been compiled for the small-scale tests and is to be circulated to sponsors for comment. The diagnostic and selective leaches have undergone a number of iterations, and protocols are nearing finalisation. The hydrology model for a leach pad, using multiple porosity models, is well advanced. The protocol for agglomeration has been developed and the first validation tests are in progress. In excess of 450 leach tests and 5,000 porosity measurements have been conducted on samples from a controlled blast experiment to test the significance of blast energy on leach behaviour. Leach tests will be correlated with blasting model predictions, once they are available.

Opposite page: Mill, OZ Minerals.

Theme 6 (P4A6)
Specialist Analytical and Support Software

Leader: Ron Berry

Team members: Julie Hunt, Dave Hutchinson, Maya Kamenetsky, Luke Keeney, Khoi Nguyen, Steve Walters, Yicai Wang

This theme provides technical support for various areas of the GeM^{III} project. In the area of micro-analytical technology, the major emphasis during the reporting period was on testing the Renishaw laser Raman fast mapping system (at UTAS) for applications of geometallurgical interest, including mapping of carbonaceous material and various polymorphic minerals.

The work on improving core-scale imaging and analysis was largely completed, with a manual being produced on design concepts in core photography systems. Stereophotography of drill core was tested using twin cameras to produce 3D images of the core. The two software programs, STORC (structure from oriented core) and SupLCore (support for core logging), are being tested in larger scale trials.

(P4A7)
Case Studies and Technology Transfer

Leader: Steve Walters

Team members: Ron Berry, Dee Bradshaw, Julie Hunt, Maya Kamenetsky, Luke Keeney, Toni Kojovic, Pat Walters, Steve Walters

Student: Stacey Leichliter

Site-based case studies are a feature of the GeM^{III} project. The aim of these studies is large scale validation and comparative benchmarking, mainly of tools and methodologies developed in AMIRA P843. The studies are designed to support technology transfer through validation, enhancement and demonstration of outcomes.

From the original 12 case studies put forward, five are complete. Four current projects are in Chile and these are on track to be completed by the end of the project in June 2013. The Frieda River case study was delayed and will now be carried out by CRC ORE. The remaining two projects did not proceed beyond a scoping stage.

The most effective case study was at AngloGold Ashanti's La Colosa gold mine in Colombia, where the sponsor provided extra staff for the study in the form of two Masters students. This assistance helped the work run more efficiently and provided an effective technology transfer mechanism at the end of the case study.

Outlook

- Plan for an extension of the AMIRA project.
- Measure the pre-conditioning effect of blast energy on leaching.
- Finish interactive CD on comminution testing.
- Major review of texture relevant to liberation.
- A significant work program on over 400 copper samples will be completed in 2013. This test work will serve as validation of the selective leaching tests.
- Large scale trial of STORC (structure from core) and SupLCore (support for core logging) software.
- Finalise SupLCore software and release to sponsors.
- Finalise the remaining four case studies.

Program Five Technology

Objectives

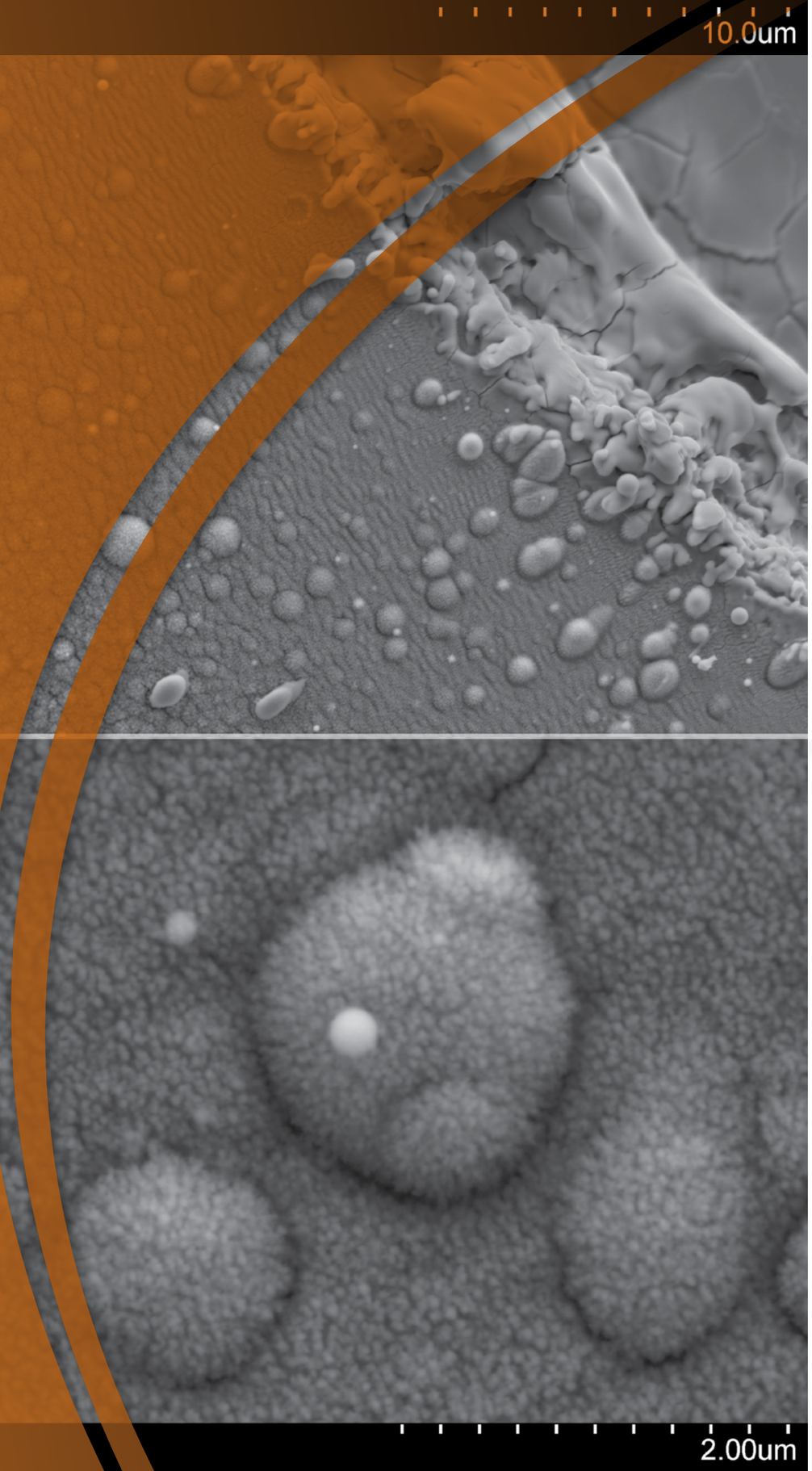
Research activities within the Program are aimed at developing new analytical techniques, ensuring that research is driven by innovative technology, and the Centre is at the cutting edge of analytical developments of relevance to ore deposit research.

The program also aims to provide CODES' research staff and students with access to the state-of-the-art micro-analytical equipment within Australia and overseas, and maintain their awareness of new analytical developments.

Introduction

The Technology Program explores and develops novel analytical and data interpretation techniques based on the latest technological developments, such as a number of high spatial resolution microprobes. This helps in the understanding, exploration and exploitation of deep earth resources.

Current research projects focus mainly on expanding the capabilities of in-situ multi-element analysis by laser ablation (LA), inductively-coupled plasma mass-spectrometry (ICP-MS), in-situ isotope analysis by LA multi-collector (MC) ICP-MS, non-destructive multi-element analysis using nuclear (PIXE) and synchrotron-based X-ray microprobes (XFM), and development of new stable-isotope solution-based analytical techniques. Research activities also develop data interpretation tools, such as new algorithms and new user-friendly scientific software packages. These are used primarily for modelling the deep earth processes that lead to ore formation, and processing of analytical data. Many of the projects include close collaborations with Node partners, such as the University of Melbourne, CSIRO and the Australian National University.



Highlights

Work began on the expansion of the LA-ICP-MS facilities entailing a new laboratory that will house a Resonetics RESOlution S-155 laser probe coupled to an Agilent 7700s quadrupole mass-spectrometer. This significant expansion of CODES' LA-ICP-MS facility has been made possible through funding of $2.5 million, over five years, from Newcrest Mining, and is scheduled to be fully operational by mid-2013. Newcrest funding also supports an R&D program within the facility, which is aimed primarily at developing calibration standards for sulfide analysis and LA-ICP-MS data reduction software for multi-standard calibrations and image quantification, including identification and size determination of micro-inclusions.

Other highlights include:

- Installation, testing and modification completed for the new S-155 large format sample cell for the Resonetics RESOlution laser probe.
- The team working on the Maia detector was awarded a CSIRO Medal for Research Achievement.
- New MicroDAQ data collection system implemented on the CSIRO Nuclear Microprobe. This system acquires PIXE data at a high rate, and over long periods of time, by simultaneously controlling detector data collection and ion beam transport in the beam line.
- MinMapper developed, which is an innovative LA-ICP-MS approach to imaging samples containing multiple minerals.
- Correlation of micro-junctions in metal sulfide assemblages with gold accumulation hot-spots in Arsenian pyrite completed.
- A new project funded by Agilent Technologies Foundation has developed a technique for S isotopic analysis in sulfide minerals by LA-Q-ICP-MS.

Top: FeSEM image of localised melting on the edge of a laser crater ablated in pyrrhotite. **Bottom:** High magnification FeSEM image of melt droplets and fine particulate deposit surrounding a laser ablation crater.

Leader
Leonid Danyushevsky

Team Members

Stacey Borg, David Cooke, Garry Davidson, Sandrin Feig, Janet Hergt, Jamie Laird, Ross Large, Ian Little, Weihua Liu, Elena Lounejeva, Sebastien Meffre, Bence Paul, Chris Ryan, Aleksandr Stepanov, Helen Thomas, Jay Thompson

PhD Student

Sarah Gilbert

Masters Students

Ross Aston, Lloyd Grills

Collaborators

AGILENT TECHNOLOGIES David Death, Fred Fryer, Toshiaki Matsuda, Paul Perry

AUSTRALIAN SYNCHROTRON Martin de Jonge, Daryl Howard, David Paterson, Kathryn Spiers

BROOKHAVEN NATIONAL LABORATORY, USA Gianluigi De Geronimo, Tony Kuczewski, Zhi Yong Li, Peter Siddons

CSIRO James Cleverley, Paul Dunn, Rob Hough, Simon James, Murray Jensen, Robin Kirkham, Mel Lintern, Gareth Moorhead, David Parry

ETH ZURICH, SWITZERLAND Detlef Gunther

INSTITUT NEEL AND EUROPEAN SYNCHROTRON RADIATION FACILITY, FRANCE Jean-Louis Hazemann, Denis Testemale

IOGLOBAL Heidi Pass

LAURIN TECHNIC Michael Shelley

MOSCOW STATE UNIVERSITY, RUSSIA Pavel Plechov

NEWCREST MINING Dean Collett, Kathryn Stewart

NORRIS SOFTWARE Ashley Norris

UNIVERSITY OF ADELAIDE Joel Brugger, Barbara Etschmann

UNIVERSITY OF MELBOURNE Jeff McCallum, Roland Szymanski, Jon Woodhead

UNIVERSITY OF SOUTH AUSTRALIA Erica Donner, Enzo Lombi

VICTORIA UNIVERSITY OF WELLINGTON, NEW ZEALAND John Creech

Core Projects

Theme 5A
Advancing Spatially Resolved Mass Spectrometry

P5A1 LA-Q-ICP-MS analysis development

P5A2 New LA-Q-ICP-MS applications

P5A3 New LA-MC-ICP-MS applications

P5A4 New stable isotope MS applications

P5A4A Cracking the sulfate isotopic composition problem in ancient hydrothermal systems: Application of the Carbonate-Associated Sulfate (CAS) method

P5A5 Pyrite metallurgy*

P5A6 Laser-ablation ICP-MS analysis of spatial variations of sulfur isotopic composition: Advancing applications in the field of ore deposit research*

Theme 5B
Advancing Non-destructive Focused-Beam Spectroscopy

P5B1 Ion beam analysis development

P5B2 New ion beam applications

P5B3 Synchrotron X-ray probe development

P5B4 New synchrotron-based applications

Theme 5C
Data Interpretation Tools

P5C3 Modelling of crystallisation and melting processes

P5C5 LA-ICP-MS data reduction software*

*New initiatives

Project Summaries

Theme 5A
Advancing Spatially Resolved Mass Spectrometry

P5A1 LA-Q-ICP-MS analysis development

Leaders: Sebastien Meffre, Leonid Danyushevsky

Team members: Ian Little, Elena Lounejeva, Jay Thompson

Student: Sarah Gilbert

Collaborators: Fred Fryer, Michael Shelley

This project designs and develops new instrumentation to ensure continuing advances in geological LA-Q-ICP-MS applications. Example developments include ablation cells, the interface between the laser and the mass-spectrometer, and testing new types of laser microprobes and mass-spectrometers.

The focus during the year was on improving the sensitivity, reliability and versatility of the LA-ICP-MS instrumental set-ups at the CODES analytical facility, as well as designing and planning for the expansion of the LA-ICP-MS facilities, funded by Newcrest Mining. The expansion entails a new laboratory that will house a Resonetics RESOlution S-155 laser probe coupled to an Agilent 7700s quadrupole mass-spectrometer.

Specific activities and successes during the year included:

- Installation, testing and modification of the new S-155 large format sample cell for the Resonetics RESOlution laser probe. This work was carried out in collaboration with the sample cell designers, Laurin Technic, and included developing a protocol for sample exchange and designing a new He introduction system. The new cell is now fully operational, resulting in increased sample throughput and reduced instrument drift.
- Expansion of CODES' sulfide imaging capabilities through the installation and testing of a second New Wave UP213 laser probe, and building a new in-house constant geometry ablation cell for the UP platform.
- Addition of nitrogen in the argon carrier gas for U-Pb dating of zircon analysis, resulting in reduced instrument drift.
- Analysis of robust plasma conditions for a range of laser probes equipped with lasers of different physical parameters.

P5A2 New LA-Q-ICP-MS applications

Leaders: Leonid Danyushevsky, Sebastien Meffre

Team members: Ian Little, Elena Lounejeva, Jay Thompson

Student: Sarah Gilbert

Collaborators: Fred Fryer, Detlef Gunther, Michael Shelley

New geological LA-Q-ICP-MS applications are being developed in the fields of ore deposit geology, igneous petrology, hydrothermal fluid chemistry and U-Pb dating of zircons and other minerals.

The main outcomes in the past year were:

- An investigation into the ablation characteristics and fractionation processes of different sulfide minerals, using imaging and analysis of ablated material from the FE-SEM at the UTAS Central Science Laboratory, has shown that ablation of pyrite generates particles of a different Fe/S ratio to that contained in the mineral. This investigation is part of Sarah Gilbert's PhD project.
- A published paper from the LA-ICP-MS laboratory at ANU has suggested that the accuracy of U-Pb LA-ICP-MS dating is strongly affected by the radiation dose that the zircons were

Opposite page: Top: Laser ablation cell. **Middle:** Bence Paul, University of Melbourne Node, working in the chemical laboratory. **Bottom:** Sebastien Meffre addressing the Science Planning Panel.

Laboratory Analyst, Elena Lounejeva, operating the New Wave UP213 laserprobe.

subjected to through geological time. A set of experiments was conducted at CODES to test this theory, with the results showing less of an effect than was proposed in the paper. Most of the ages determined in the past ten years were well within levels of analytical uncertainty, leading to the conclusion that the variation between results from the two laboratories is likely to be due to the different laser beam fluence used.

- Work has continued on U-Pb dating of sphene, apatite and uraninite. All these minerals can now be dated routinely, and well characterised sets of standards have been established.
- In a project co-funded by the DET CRC, experiments were performed, using LA-ICP-MS, investigating rapid trace element determination on powdered rock samples. The experiments yielded promising results, indicating that a reliable technique can be developed for analysis of rock powders.
- Further work was undertaken on quantifying LA-ICP-MS images of complex multi-mineral ores, including a detailed comparison of spots to images on the samples. The results indicate that the imaging data reduction techniques are now accurate, and software is currently being developed to make the procedure simple and user friendly.
- In collaboration with ETH Zurich, work has started on the development of new calibration standards for LA-ICP-MS analysis of sulfide minerals.

P5A3 New LA-MC-ICP-MS applications

Leaders: Bence Paul, Janet Hergt

Team members: Leonid Danyushevsky, Sebastien Meffre

Student: Ross Aston

Collaborator: Jon Woodhead

The aim of this project is to develop new analytical techniques for quantitative, in-situ analysis and the imaging of isotopic compositions of key elements in a range of geological materials. This will provide new spatially resolved information to help unravel processes involved in ore formation.

During 2012, MinMapper software was developed, which adopts an innovative approach to measuring samples containing multiple minerals by combining principal component analysis with advanced image analysis to enable researchers to process their data on a mineral-by-mineral basis. Each phase can be reduced using a separate reference material and internal standard value. This method has the potential to be valuable in projects where, for example, the trace element concentrations of sulfides and silicates are required with improved precision. MinMapper builds on, and extends, the CellSpace spatial imaging software developed in 2011. A paper on CellSpace was published in 2012, and a paper on MinMapper is in preparation.

The new procedure for measuring melt inclusions (detailed in the 2011 annual report) is the subject of Ross Aston's MSc thesis, which includes a thorough examination of the achievable precision using this procedure, and an example study using melt inclusions from Hawaii.

P5A4 New stable isotope MS applications

Leaders: Bence Paul, Janet Hergt

Team members: Leonid Danyushevsky, Sebastien Meffre

Collaborator: John Creech, Jon Woodhead

The aim is to develop new analytical protocols for the measurement of non-conventional stable isotope compositions (e.g., Cu, Mo) that can be used to explore ore forming processes.

The Cu isotope and trace element study of hydrothermal sediments from the Rainbow vent field in the Atlantic Ocean requires repeat analyses before publication. These analyses will be conducted in combination with a Cu isotope study by CODES' PhD student Heidi Berkenbosch, who will be analysing samples from black smokers from the Kermadec Arc.

Following the successful measurement of molybdenum isotopes in molybdenite samples from the Merlin deposit, a larger study has commenced. Improvements in the handling of analytical precision using Iolite are also the subject of a manuscript in preparation.

P5A4A Cracking the sulfate isotopic composition problem in ancient hydrothermal systems: Application of the Carbonate-Associated Sulfate (CAS) method

Leader: Garry Davidson

Team members: David Cooke, Sandrin Feig

Collaborators: Heidi Pass

Redox conditions and isotopic sulfur composition are important for understanding ore systems. Sulfur isotopes are also useful in exploring for oxidised hydrothermal systems. Unfortunately, sulfate minerals are often not present and, in those cases, the redox character and S source cannot be reconstructed. However, it is well known that sedimentary carbonate can incorporate an amount of lattice-bound SO_4. This project is evaluating whether the same phenomenon occurs in hydrothermal carbonate and, if so, how it can be applied to ore systems.

Previous work has demonstrated that SO_4 is generally at lower abundances than in sedimentary carbonates, and in higher temperature systems (>350° C) values are too low for even bulk chemical extraction. In 2012, work was delayed while a new instrument was 'bedded down' in the isotope laboratory. The main achievement was the trialling of two modifications to the existing sulfate extraction method to address a recently discovered analytical oxidation phenomenon that affects more reactive pyrite in the presence of HCl and iron oxide (thus producing dissolved SO_4 not derived from primary carbonate). The results of these trials will be reported in the final report in 2013.

P5A5 Pyrite metallurgy

Leaders: Sebastien Meffre, Ross Large, Leonid Danyushevsky

Team members: Aleksandr Stepanov, Helen Thomas

Collaborators: Dean Collett, Kathryn Stewart

This new project, funded by Newcrest Mining, aims to develop techniques to characterise differences in pyrite chemistry by comparing metallurgical composites from ores of various grades. In 2012, the project was focused on the Lihir mine in Papua New Guinea. The precision, accuracy and throughput rate of different analytical strategies were compared on the LA-ICP-MS, and optimum methods to reconcile petrographic, SEM and LA-ICP-MS data were investigated. Pyrite chemistry and petrography from the different ore types and grades at Lihir were compared using the various techniques.

Ultimately, the project will provide a set of petrographic, SEM or LA-ICP-MS-based techniques that can be used to produce ore processing or metallurgic indices for different types of ore.

P5A6 Laser-ablation ICP-MS analysis of spatial variations of sulfur isotopic composition: Advancing applications in the field of ore deposit research

Leader: Leonid Danyushevsky

Student: Sarah Gilbert

Collaborators: David Death, Fred Fryer, Toshiaki Matsuda, Paul Perry

This new project, funded through the Agilent Technologies Foundation, is aimed at developing a technique for the analysis of sulfur isotopes in sulfide minerals by LA-Q-ICP-MS. Outcomes to date include:

- Characterisation of a set of sulfide standards by Secondary Ion Mass Spectrometry at the Woods Hole Oceanographic Institution, USA, and by the new Isotope Ratio Mass Spectrometer at the UTAS Central Science Laboratory.
- Design of the interface between the laser probe and the ICP-MS to minimise S washout time, sample-to-sample cross-contamination, and increase the throughput. It was found that the optimal design is dependent on the type of lasers used. The washout time of sulfur varies between different sulfide minerals.
- Sulfur isotopic fractionation during laser ablation analysis was investigated, looking at the differences between sulfide minerals and ablation patterns (spots versus lines).

Theme 5B
Advancing Non-destructive Focused-Beam Spectroscopy

P5B1 Ion beam analysis development

Leader: Jamie Laird

Team member: Chris Ryan

Student: Lloyd Grills

Collaborators: Robin Kirkham, Jeff McCallum, David Parry, Roland Szymanski

The aim of this project is to better understand the role of metal sulfide semiconductivity on the deposition of precious metals, such as gold.

For large scale mapping on the Nuclear Microprobe (NMP) line, a stable and high throughput data collection system has been developed to cope with simultaneously performing an expanded variety of techniques. PIXE analysis on minerals from various laboratories has been performed with an increased emphasis on large scans over long periods. After initial teething problems, the system is operating in a stable and near ideal manner. Hyper-spectral Ionoluminescence (IL) and Rutherford Back-Scattering (RBS) channels can now be included to make the most of the complementary information these methods provide. The new NMP chamber, to be installed soon, will make the most of the new system.

P5B2 New ion beam applications

Leader: Jamie Laird

Team members: Chris Ryan

Student: Lloyd Grills

Collaborators: Jeff McCallum, Roland Szymanski

Understanding the role of metal sulfide semiconductivity on the genesis of precious metals requires methods for mapping electrical properties, such as the electric field in complex minerals.

In 2012, the remote laser-beam-induced current (LBIC) technique used to map the electric field distribution in minerals has been improved by developing a method for removing artefacts related to laser intensity. Electric field maps on an arsenian pyrite from Otago, New Zealand, have been imaged with this improved method and correlated with PIXE data over the same area. Micro-junctions have been positively identified at the chalcopyrite-As pyrite boundary in agreement with theoretical expectations. Furthermore, the presence of gold on the As-rich side of the junction agrees with the micro-galvanic model. The same sample has also undergone Electron Back-Scattered Diffraction (EBSD) analysis to better understand the role crystal history and pyrite paragenesis may have had on gold accumulation. These results were presented at the IGC conference in Brisbane and are currently being written into several papers.

P5B3 Synchrotron X-ray probe development

Leader: Chris Ryan

Team members: Stacey Borg, Weihua Liu

Collaborators: Joel Brugger, James Cleverley, Gianluigi De Geronimo, Martin de Jonge, Erica Donner, Paul Dunn, Barbara Etschmann, Jean-Louis Hazemann, Rob Hough, Daryl Howard, Simon James, Murray Jensen, Robin Kirkham, Tony Kuczewski, Zhi Yong Li, Mel Lintern, Enzo Lombi, Gareth Moorhead, David Paterson, Peter Siddons, Kathryn Spiers, Denis Testemale

Chris Ryan, CSIRO Node, (second from left) with part of the award-winning Maia team. Photo courtesy of the Australian Synchrotron.

This project is developing new experimental equipment for probing samples of geological interest, using the following synchrotron radiation applications at the Australian Synchrotron (AS):

- The Maia detector – a high throughput, high-definition fluorescence imaging system for the XFM beamline.
- The mAESTRO system – a high pressure-temperature synchrotron spectroscopy cell for solution studies at the XAS beamline.

In 2012, the team working on the Maia detector was awarded a CSIRO Medal for Research Achievement, further enhancing its international reputation, and building on the R&D 100 Award in 2011.

Work has focussed on XANES imaging and statistical image exploration approaches, and analysis issues flowing from the redesign of the Maia detector, which is beginning to deliver better noise suppression and improved energy resolution.

The mAESTRO system was unable to be utilised in 2012, despite assurances that there would be an opportunity to perform at least one experiment in the last quarter of the year. The XAS beamline has been beset with problems, but has undergone some important improvements. Current information suggests operations in the second hutch are on track for the second half of 2013. The mAESTRO system itself has been well maintained, with upgrades to the heating and control systems implemented. Some effort was undertaken by Weihua Liu to establish a collaboration (utilising mAESTRO) with the Shanghai synchrotron (SSRF), but beamtime constraints have held this initiative back for the time being.

P5B4 New synchrotron-based applications

Leader: Stacey Borg

Team members: Weihua Liu, Chris Ryan

Collaborators: Joel Brugger, James Cleverley, Barbara Etschmann, Jean-Louis Hazemann, Rob Hough, Denis Testemale

This project is directed towards continued development of new and existing synchrotron techniques for the study of metals and mineral species.

In 2012, the primary focus was on refinement of procedures for analysis of XANES imaging datasets, in order to provide information relating to the spatial distribution of redox and chemical states of specific elements in a geological matrix. The secondary focus was on further use of synchrotron XAS techniques to understand speciation and reactivity of metal species in aqueous solutions under hydrothermal conditions.

Major outcomes include:

- Development and incorporation of Principal Component Analysis (PCA) tools for XANES stacks into GeoPIXE.
- Publication of manuscripts exploring Mo(VI) chloride, Ni(II) chloride and Zn(II) bromide geochemistry at elevated temperature and pressure.
- Study initiated on apatite mineral transformations, with the aims of improving the understanding of how apatite analogues may be formed, and how this relates to solution composition.

Theme 5C
Data Interpretation Tools

P5C3 Modelling of crystallisation and melting processes

Leader: Leonid Danyushevsky

Collaborators: Pavel Plechov

The aims of this project are to:

- Develop model-independent algorithms for tracking the behaviour of trace elements during magma generation and evolution processes.
- Conduct modelling of post-entrapment modifications in melt inclusions in minerals.
- Simulate processes of mantle and crustal melting, and melt crystallisation.
- Develop a range of general petrological tools. (These algorithms are continuously implemented in the future versions of the 'Petrolog' software package).

In 2012, work has continued on improving the algorithms for modelling the behaviour of trace elements during crystallisation processes, and on developing a new model for plagioclase-silicate melt equilibrium under hydrous conditions at variable pressures. An updated version of the Petrolog3 software was made available on the Petrolog home page (http://petrolog.web.ru)

P5C5 LA-ICP-MS data reduction software

Leader: Leonid Danyushevsky

Team members: Sebastien Meffre, Jay Thompson

Student: Sarah Gilbert

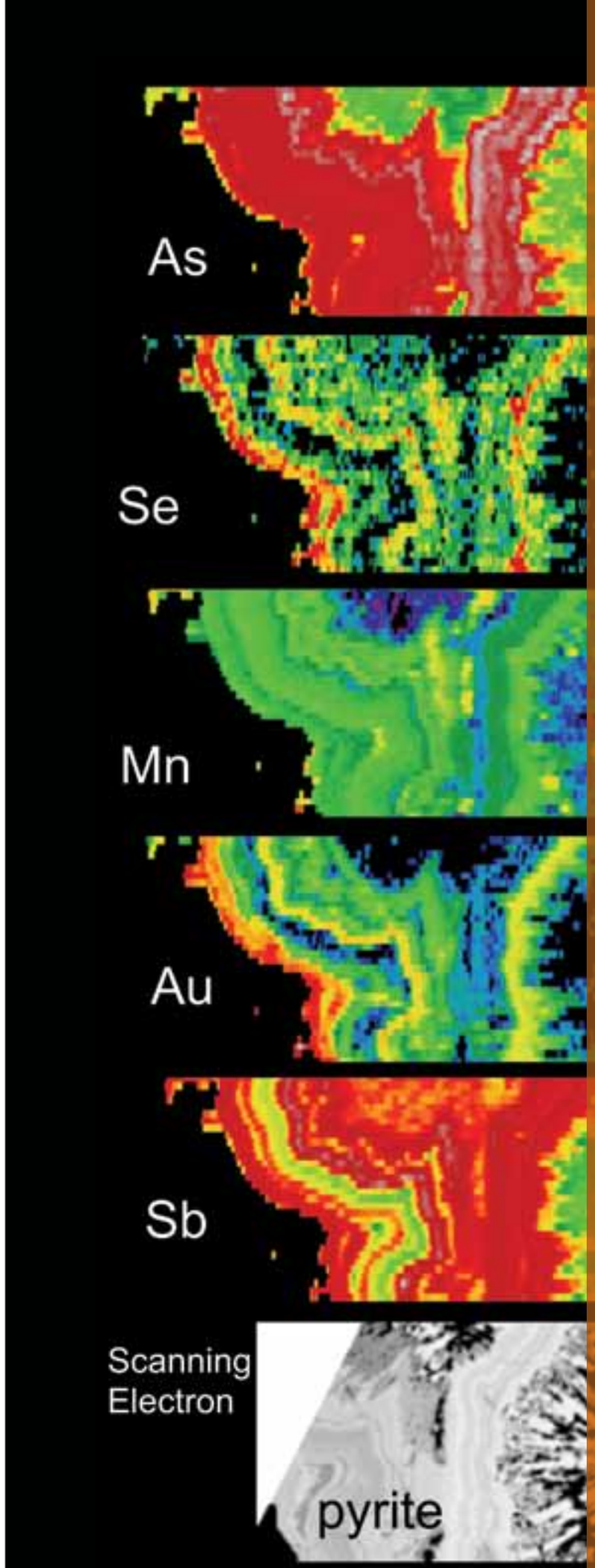
Collaborator: Ashley Norris

This new project is funded by Newcrest Mining as part of its support for the R&D program of the CODES LA-ICP-MS analytical facility at UTAS. The aim is to develop comprehensive, user-friendly LA-ICP-MS data processing software, capable of:

- Quantification of data acquired with multiple calibration standards using a range of internal standard elements.
- Quantification of images depicting distribution of major and trace element concentrations in fine-grained multi-mineral aggregates of sulfides, silicates, phosphates and carbonates.
- Identification of mineral phases in, and sizes of, micro inclusions in minerals.

During the year, the focus was on designing the data structures within the software, the overall concept of data processing, and the basic software interface.

Opposite page: Image of trace element distribution in Lihir pyrite, acquired by LA-CP-MS.



Outlook

- Completion of the new LA-ICP-MS laboratory funded by Newcrest Mining.
- Continue the investigation of the ablation characteristics and fractionation processes of different sulfide minerals.
- Development of LA-ICP-MS data reduction software for quantification of analyses performed using multiple calibration standards.
- Release of MinMapper for the Iolite platform and publication of a paper detailing the advances it represents.
- Publication of the CAS extraction technique, and evaluation of extending its application to ultra-low S samples, and the testing of IOCG carbonate vein samples.
- New NMP chamber and Maia installation will enormously improve PIXE imaging.
- Papers to be published on the results to date and the development of a cryogenic LBIC system for much improved sensitivity in E-field mapping.
- Publication of new method developments for quantitative SXRF imaging using the Maia detector on the Australian Synchrotron.
- XAS experiments into Ni, Zn and Pd speciation at the Australian Synchrotron, following full integration of the mAESTRO system at the XAS beamline.
- Standardisation of the interface design for S isotopic analysis by LA-Q-ICP-MS.

Outreach

Each year, CODES works closely with the UTAS School of Earth Sciences to implement a comprehensive program of outreach activities that caters for a wide variety of sectors within the local community. While a key focus is on ensuring that the geosciences are seen as an attractive option for young people making career choices, the program also reaches a very broad span of age groups, from kindergarten through to retirees.

Fundamental to the program's success is the Centre's participation in national outreach programs, and its long standing relationships with a number of community groups and educational facilities. For example, the Centre continued its participation in the Science Experience initiative by hosting a workshop for year-11 students in January, led by Andrew McNeill. This program aims to inspire students to continue their science studies and is supported by the Science Schools Foundation, Rotary, and the Australian Science Teachers Association.

Support also continued for the Teacher Earth Science Education Program (TESEP). This national program operates under the auspices of the Australian Science Teachers Association, and provides a series of professional development workshops aimed at upper primary / lower secondary school teachers. Michael Roach led a further two workshops at the Centre during the year, which mixed interactive classroom and laboratory sessions with off-site field activities at local sites of geological interest.

Once again, a number of schools visited the Centre, with participants ranging from primary school students through to year-12. In addition, the Centre continued to be popular with local youth groups, such as the 10th Hobart Cub Scouts, who visited in October, and were led by Simon Stephens.

In addition to the full agenda of outreach events held within the Hobart campus, staff participated in a variety of activities out and about in the local community. Andrew McNeill travelled to Deloraine, in the north of the state, to address the Friends of the Great Western Tiers, which is a diverse group of people who share a love for the area's magnificent landscape. Andrew delivered a talk on the geology of the Tiers, providing the perfect counterbalance to a fellow speaker who spoke on how the area provides great inspiration to writers and artists. Andrew has also been a regular speaker with the older age groups. This year he educated and entertained a large audience from the Glenorchy School for Seniors, with a talk entitled 'A geologist's life'. Another staff member that participated in off-campus outreach activities was Sharon Allen, who gave a highly interactive talk on the geological rocks in the Hobart area to Preparatory and grade 1 children at Waimea Heights Primary School.

School teachers getting involved in practical exercises as part of the TESEP workshop.

As foreshadowed in last year's report, an extensive upgrade to the rock, mineral, and seismology exhibits was completed early in the year. Centrepieces of the new display are a bust of the late Professor Sam Carey, together with globe models illustrating his pioneering theory of the Expanding Earth. The new exhibits were launched at a function in late February attended by alumni, family and friends of Professor Carey, together with various invited guests from the local community.

Staff and students continued to accommodate a variety of requests from the community throughout the year. Examples included PhD candidate Dan Gregory providing help to a high school student with a project, through to rock store curator Izzy von Lichtan assisting the Tasmanian Museum and Art Gallery (TMAG) while the facility underwent extensive renovations. During this period, some its geology-based exhibition areas needed to be closed on a temporary basis. Therefore, Izzy agreed that CODES / UTAS could be a referral point for visitors interested in the earth sciences. As a result, she guided a host of local and international visitors through the Centre's extensive collection of rock reference material.

The Centre is also a popular port of call for the media, particularly when a major geoscience-related event, such as an earthquake, landslide, or volcanic eruption occurs. In 2012, a number of media interviews were held via various media outlets, from local and national radio stations through to a PhD student, Jose Piquer, being interviewed by a Chilean television station.

Jose Piquer being interviewed by a Chilean TV station after a local landslide.

Opposite page: Top: A very mixed audience at the function in honour of Professor Sam Carey. **Middle:** The 10th Hobart Cub Scouts were one of the first visiting groups to enjoy the new exhibits. **Bottom:** Year-11 students at the Science Experience workshop.

Industry Links and Research Collaborations

Objectives

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

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

Industry Links and Synergies

CODES has strong, enduring and mutually beneficial links with a large group of major Australian and international mining companies. These links have been critical for funding CODES' research, and for technology transfer to the mining and mineral exploration community.

At the end of 2012, the group of CODES' industry partners comprised of ten Australian and international mining companies: Anglo American, AngloGold Ashanti, Barrick Gold, BHP Billiton, MMG, Newcrest Mining, Newmont Mining, Rio Tinto, St Barbara Mines, and Teck Resources.

Each of the partner companies provides support of $15,000 to $50,000 in cash per year to the core research budget of the Centre. Senior representatives of these companies sit on the Science Planning Panel, along with other government and university researchers. This panel meets annually to discuss the results of CODES' research and the potential directions for new research.

Industry Partnership Opportunities Beyond 2013

At the end of 2013, CODES' tenure as an ARC Centre of Excellence (CoE) comes to an end, after eight highly successful years. Plans are already well advanced for the next phase of CODES' evolution, which include a number of exciting new partnership opportunities that can be tailored to company requirements. Major benefits of an alliance with CODES include enhanced prospects of discoveries, optimisation of existing reserves, first call on geoscience graduates, and access to a world-class research team and state-of-the-art facilities. For further details of partnership opportunities beyond 2013, contact the Director, Bruce Gemmell: Email: bruce.gemmell@utas.edu.au Tel: +61 3 6226 2893.

Role of AMIRA International

AMIRA plays a vital role in facilitating the funding of collaborative research involving university research groups and the minerals industry. AMIRA has agreed to fund a series of research projects within the Centre, which will run over a period of three to four years.

In 2012, AMIRA funded these major projects for CODES:

- P843A (GeM^{III} project) Geometallurgical mapping and mine modelling.
- P1022 The rapid approximate inversion of TEM data.
- P1041 Application of new technologies to gold deposits.
- P1060 Enhanced geochemical targeting in magmatic-hydrothermal systems.

Research Collaborations and International Visitors Program

In 2012, CODES further cemented its reputation for cultivating research collaborations with other Australian and international research organisations. During the year, collaborative research was conducted with 71 international and 17 national organisations.

Collaborative research between international and Australian-based partners is also being facilitated by joint research appointments. The table on the next page details each of the collaborating institutions with the joint researchers and their funding source. These researchers are based at collaborating partner institutions and incorporate research visits to CODES throughout the term of their research projects.

Researchers Who Work Jointly in CODES and the Collaborating Organisations

Institution	COE ARC Grant	Node Matching Funds	Industry / AMIRA Funds	University / CSIRO Funds
University of Queensland-Sustainable Minerals Institute (incl. Julius Kruttschnitt Mineral Research Centre & WH Bryan Centre)	Grant Ballantyne (3%), Dee Bradshaw (3%), Alice Clark (20%), Alan Cocker (5%), Luke Keeney (1%), Angus McFarlane (6%), Simon Michaux (6%), Khoi Ke Nguyen (19%), Italo Onederra (1%), Patrick Walters (9%), Yicai Wang (27%)	Alice Clark (9%), Yicai Wang (13%)	Grant Ballantyne (8%), Dee Bradshaw (7%), Alan Cocker (15%), Luke Keeney (3%), Italo Onederra (4%), Angus McFarlane (14%), Simon Michaux (13%), Khoi Ke Nguyen (44%), Patrick Walters (25%)	
University of Melbourne	Bence Paul			Janet Hergt, Roland Maas
Australian National University				Stephen Cox
CSIRO	Jamie Laird (50%), Stacey Borg (50%)	Jamie Laird (50%), Stacey Borg (50%)		Chris Ryan, Weihua Liu

Technology Transfer

Objectives

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

Technology Transfer Activities

CODES undertakes strategic and applied research into the formation, location, discovery and recovery of ore deposits, and the development of innovative technologies to support these research endeavours. These initiatives create knowledge, processes, methods and solutions for the minerals industry and ore deposit researchers – locally, nationally and internationally.

Research results and technical developments in the applied research programs are transferred to end-users via regular research meetings, research reports, monographs, books, digital presentations and software packages, where appropriate. In 2012, 119 research reports were presented to industry clients, and meetings were held to present and discuss progress and adoption of research results.

Publications Targeted at End-users

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

- Altered volcanic rocks: A guide to description and interpretation (2005). Authors: C Gifkins, W Herrmann and R Large (104 copies sold in 2012).
- Basins, fluids and Zn-Pb ores – CODES Special Publication 2 (1999). Editors: O Holm, J Pongratz and P McGoldrick (3 copies sold in 2012).
- Geophysical signatures of copper-gold porphyry and epithermal gold deposits, and implications for exploration (2011). Author: Terence Hoschke (98 copies sold in 2012).
- Giant ore deposits: Characteristics, genesis and exploration. CODES Special Publication 4 (2002). Editors: D Cooke and J Pongratz (13 copies sold in 2012).
- New developments in Broken Hill-type deposits. CODES Special Publication 1 (1996). Editors: J Pongratz and G Davidson (3 copies sold in 2012).
- Ore Geology Reviews – Special Issue (April 2007): Mineral deposits of South China. Editors: Khin Zaw, S Peters, N Cook and Z Hou (no copies sold in 2012).
- The geology and origin of Australia's mineral deposits (2000). Authors: M Solomon and D Groves (13 copies sold in 2012).
- The geology of the Broken Hill Pb-Zn-Ag deposit, NSW, Australia (2006). Author: A Webster (4 copies sold in 2012).
- 24ct Au workshop. CODES Special Publication 5 (2004). Editors: D Cooke, C Deyell and J Pongratz (10 copies sold in 2012).
- Volcanic environments and massive sulfide deposits (2000). Editors: JB Gemmell and J Pongratz (6 copies sold in 2012).
- Volcanic textures: A guide to the interpretation of textures in volcanic rocks (1993). Authors: J McPhie, M Doyle and R Allen (133 copies sold in 2012).

Commercial Products and Processes

Geometallurgical research in Program 4, in collaboration with the University of Queensland, has the potential to deliver a number of commercial outcomes for industry. Due to the commercial-in-confidence nature of this research, details of the specific outcomes cannot be released at this time.

Short Courses, Workshops and Conferences for End-users

Short courses and workshops continued to play a key role in the Centre's technology transfer activities. Throughout the year, a total of 28 courses were held at various locations around the world. This included venues in thirteen countries on six continents, including Argentina, Chile, and Peru in South America; the USA and Panama in North/Central America; Indonesia, Myanmar, New Zealand and the Philippines in the Asia Pacific region; South Africa and Botswana in Africa, and Italy in Europe.

Total attendance by industry geologists, academic researchers and postgraduate students was 795, with 29 different presenters from the CODES' Hub involved in delivering the lectures.

2012 Short Courses/Workshops/Conferences Led by CODES

Title	Presenters*	No.**	Location	Date
AMIRA P1060 Workshop	**David Cooke**	10	Rancagua, Chile	4 Feb
Geometallurgy Short Course	**Ron Berry,** Dee Bradshaw, Sandrin Feig, David Green, **Dan Gregory, Julie Hunt,** Toni Kojovic, Dave Lawie, Graeme Long, **Bernd Lottermoser, Andrew McNeill,** Thomas Rodemann	21	CODES, Hobart	19–30 March
Volcanology and Mineralisation in Volcanic Terrains Short Course	**Bruce Gemmell, Andrew McNeill, Jocelyn McPhie**	28	New Zealand and western Tasmania	15–29 April
Sediment-hosted Gold Workshop	Nic Beukes, Rob Burnett, **Dan Gregory,** Bradley Guy, **Ross Large,** Morris Viljoen	30	Johannesburg, South Africa	25 April
Geology of Botswana Workshop	Puso Akanyang, Charles Byron, **Chris Large, Ross Large,** Mosimanegape Zibo Pontsho, David Wood, Jerry Sharrock	40	Francistown, Botswana	29 April
VIEPS Ore Deposit Models Short Course	**Stuart Bull, David Cooke, Garry Davidson, Jeff Foster, Bruce Gemmell, Ross Large, Peter McGoldrick, Rob Scott**	13	CODES, Hobart	14–18 May
Geometallurgical Mapping and Mine Modelling Annual Review	**Ron Berry,** Dee Bradshaw, Nicky Chapman, Mitesh Chauhan, **Jeff Foster, Julie Hunt, Dave Hutchinson,** John Jackson, Toni Kojovic, **Lyudmyla Koziy, Bernd Lottermoser,** Angus McFarlane, Simon Michaux, Khoi Nguyen, Taryn Noble, Louisa O'Connor, **Anita Parbhakar-Fox,** Nicole Turner, Steve Walters	70	Mercure Hotel, Brisbane	31 May–1 June
Exploration in Brownfield Terrains Short Course	Jun Cowan, David Green, Scott Halley, Dave Lawie, **Andrew McNeill, Mike Roach,** Tony Webster, Ian Willis	23	CODES, Hobart	4–15 June
AMIRA P765A Workshop	Huayong Chen, **David Cooke, Bruce Gemmell,** Jamie Wilkinson	32	Utah, USA	10 July
Intrusive and Magmatic-Hydrothermal Features of the Central Wasatch Mountains, Utah	**David Cooke, Mike Baker,** Pete Hollings, **Jennifer Thompson,** Jamie Wilkinson, **Lejun Zhang**	30	Utah, USA	11 July
Bingham Canyon AMIRA P1060 Workshop	**Mike Baker, David Cooke, Nathan Fox, Jennifer Thompson,** Clara Wilkinson, Jamie Wilkinson	30	Utah, USA	13 July
Geological Workshop on Myanmar's Mines and Minerals	Margaret Bridges, Hla Kyi, Aung Kyin, Zaw Oo, Stuart Smith, Win Swe, Maung Thein, Kyaw Thu, **Khin Zaw**	46	Yangon, Myanmar	25 July
AMIRA P765A Workshop	**Mike Baker**	3	Cobre Panama, Panama	24 August
Rhyolitic Volcanoes and Their Products	**Jocelyn McPhie**	12	Patagonia, Argentina	13–16 September
AMIRA P1060 Workshop	**Bruce Gemmell**	10	La Zanja Mine, Peru	29 September
Gosowong Low Sulfidation Goldfield, Indonesia	**Bruce Gemmell**	10	La Zanja Mine, Peru	30 September
Structural Processes and Controls on the Formation of Lode Gold Systems	Stephen Cox	35	St Ives Gold Mine, Gold Fields, WA	2 October
AMIRA P765A Workshop	**Mike Baker**	6	Quebrada Blanca, Chile	3 October
Gold Deportment in Low and Intermediate Sulfidation Deposits	**Bruce Gemmell**	10	La Zanja Mine, Peru	5 October
Metal Zoning in Low and Intermediate Sulfidation Deposits	**Bruce Gemmell**	10	La Zanja Mine, Peru	9 October
AMIRA P1060 Project Research at La Zanja and Yanacocha	**Bruce Gemmell**	30	Yanacocha Mine, Peru	10 October
Fluids in the Earth	Robert Bodnar, **Leonid Danyushevsky,** Jim Webster	30	University of Naples, Italy	15–19 October
Red Metals Symposium	**Stuart Bull, David Cooke,** Kathy Ehrig, **Bruce Gemmell,** Anthony Harris, **Rachel Harrison,** Terence Hoshke, **Vadim Kamenetsky, Lyudmyla Koziy, Ross Large,** Adi Maryono, **Jocelyn McPhie,** Patrick Mercier-Langevin, **Rob Scott,** David Selley, Noel White, Carl Young	75	CODES, Hobart	22–25 October
Ore Deposit Models Short Course	**Garry Davidson,** Jeff Foster, **Bruce Gemmell, Margy Hawke, Ross Large, Peter McGoldrick, Karin Orth, Rob Scott,** Andy Tomkins	41	CODES, Hobart	1 November
Structural Processes and Controls on the Formation of Lode Gold Systems	Stephen Cox	25	Kalgoorlie: Silver Lake Gold Mine and Integra Resources	1 November
AMIRA P1060 Workshop	**David Cooke, Lejun Zhang**	15	Manila, Philippines	13 November
Volcanoes and Their Products	**Jocelyn McPhie**	92	Yogyakarta, Indonesia	15–16 November
Volcanoes and Their Products	**Jocelyn McPhie**	18	Toka Tindung, Indonesia	4–8 December

* CODES Hub presenters in bold ** Number of attendees

Performance Indicators

Performance Measure	Target	2012
Research Findings		
Publications in international journals	50pa	62
Percentage of publications in A/A* journals	70%	59%
Reports to industry collaborators	80pa	119
Special Issues and/or research monographs	1 per 2 years	0
Invitations to give keynote conference presentations	10pa	14
Papers at national/ international meetings	70pa	135
Investigators		
Average percentage of CIs research in Centre	70%	80%
Average percentage of PIs research in Centre	15%	32%
Percentage of team-based projects	80%	85%
Percentage of Australian cross institutional projects	30%	49%
Research Training and Professional Education		
Percentage of RHD students attracted from interstate	40%	10%
Percentage of RHD students attracted from overseas	40%	81%
Honours students in Centre programs	10	18
RHD students in Centre programs	45	44 PhD, 4 MSc
Percentage of students in projects linked with industry	50%	80%
Professional short courses/workshops for industry	5pa	28

Participants in the Fluids in the Earth short course, held in Naples, Italy, visiting the Solfatara Volcano. The course was co-presented by Leonid Danyushevsky.

Performance Measure	Target	2012
International, National and Regional Links and Networks		
Centre national or international conferences /workshops	1 per 2 years	1
Registrants at Centre's conferences /workshops	100pa	795
International and national visitors per year	50pa	120
Collaborative projects with other global centres/groups	10pa	15
External collaborators using Centre's equipment	10pa	20
End-user Links		
Frequency of meetings with industry representatives	15pa	25
End-user representatives to Science Planning Panel and Advisory Board	20% / 50%	72% / 57%
Frequency of meetings with AMIRA Research Co-ordinator	10pa	12
Number of industry visitors to Centre	80pa	54
Organisational Support		
Annual cash contributions from UTAS	$1,800,000	$2,358,330
Annual cash support from other collaborating universities & CSIRO	$205,000	$292,500
Annual cash support from industry	$2,000,000	$6,047,010
Number of new organisations recruited to or involved in the Centre	1pa	0
Governance		
Joint post-doctoral appointments between collaborating institutions/organisations	5	6 (2 CSIRO, 1 UMelb, 3 UQ)
Balance and experience of Advisory Board members		Excellent balance
Annual review of strategic and business plans		Yes
Effectiveness of Centre Research Committee		High
Effectiveness of Science Planning Panel		High
Public profile of Centre	High	High
National Benefit		
Centre research has input into a major mineral discovery	1 per 5 years	0
Employment of Centre's graduates by minerals industry	>65%	75%

Finances

ARC Contract and Governance

CODES became the Australian Research Council (ARC) Centre of Excellence (CoE) in Ore Deposits on 1 July, 2005. It was formerly an ARC Special Research Centre. The CoE contract with the Australian Government covers five years' funding from 2005 to 2010. At the mid-term review in November 2008, the ARC awarded an extension of funding for the period 2010 to 2013.

The Centre's financial affairs are conducted within the established procedures, controls and delegations of the University of Tasmania (UTAS) and the CoE's node universities and institutions. CODES has a policy of assigning budget responsibility to Node and Program Leaders, which is overseen by the Finance Manager and the Director.

To ensure the ARC's CoE requirements are met, an inter-institutional agreement was established by the UTAS Research Office, formally binding all participating institutions to the ARC CoE agreement, including funding allocations from the CoE to its nodes and agreed matching contributions made by those nodes.

The tables and figures presented in the following pages demonstrate the CoE is meeting the income and expenditure requirements of the current agreement.

2012 Income

Total CODES income was $13.2 million (see Table 1). This was derived principally from industry (46%), the ARC (22%) and UTAS (18%) (see Figure 1). The main income streams over time are compared in Figure 2, demonstrating that ARC funding continues to be exceeded by other funding at a ratio of more than 2:1 (the original CoE agreement with the ARC was 1:1). Therefore, non-ARC funding has consistently exceeded expectations since the start of the CoE, with industry funding showing the strongest growth.

The CoE Collaborator/Contributor Cash Income Agreement

The CoE funding agreement with the ARC requires that approximately $3 million per annum ARC funding be matched, dollar for dollar, with agreed core funding from collaborators/contributors (N.B. annual ARC funding was reduced from $3 million pa to $2.7 million pa for the extension period, 1.7.2010 to 31.12.2013). This combined cash income is used to fund core research projects at the Centre. It should be noted that, in total, CODES has received $31.8 million more to-date towards CoE projects than was specified in the original agreement. This is mainly due to:

- Annual indexation of the ARC CoE Grant.
- Significantly increased industry and AMIRA International funding.
- Income from book sales, short courses and laboratory analyses.
- Pre-existing funding from UTAS, ARC and AMIRA, which has extended into the CoE period.

All collaborator/contributor funding is paid to CODES annually, in cash, with the exception of funding from the CoE nodes, which is treated differently, as detailed under the heading 'CoE node income'.

In addition to the abovementioned cash income, the CoE receives a considerable amount of in-kind support from its collaborators/contributors, with UTAS providing the most substantial portion.

The following is a summary of the main income streams to the CoE in 2012:

- **ARC income:** ARC income received in 2012 comprised primarily of the CoE ARC Grant ($3.0 million), with the addition of one Discovery Grant ($0.1 million).
- **CoE node income:** The CoE's Australian nodes comprise the University of Queensland (UQ), University of Melbourne (U Melb), Australian National University (ANU) and CSIRO. The CoE agreement requires CODES to transfer an agreed annual portion of its ARC CoE Grant income to each of the above nodes, to be expended at the node institutions. In return, the nodes agree to match this income with an agreed value of their own funds each year. Although these matching funds are counted as income to the CoE (Table 1), they are actually held and expended at the node institutions. Expenditure of both portions of node funding is reported annually to CODES.

  Only two of the nodes received their agreed 2012 ARC income from CODES, due to delays in the finalisation of the CoE Extension Agreement. All nodes, however, contributed their matching funds for 2012 to the Centre, and ANU was able to provide outstanding matching funds that they were previously unable to contribute due to internal policy regarding Extension Agreement finalisation. The Agreement was finalised in early 2013, which will result in the last of the outstanding contracted 2012 transactions being included in the accounts for 2013.
- **State Government income:** The agreed three-year funding from the State Government of Tasmania ceased at the end of 2007.
- **Industry income:** Total industry funding in 2012 was $6.0 million, of which the largest contribution (42%) was in the Industry – pre-existing and new projects category. Approximately half of this was from Newcrest as part of the new R&D laboratory contract.

  Industry funding increased significantly, by 105% ($3.1 million), in 2012, mainly due to the following factors:
  - Late signing of two AMIRA projects, with resultant catch-up payments occurring in 2012.
  - Late signing of contracts for the extension of the SE Asia Project, with catch-up of most payments occurring in 2012.
  - First contracted payment ($1.2 million) from Newcrest for the new R&D laboratory. This large initial payment is to facilitate building refurbishment for the facility, as well as to enable the purchase of required analytical equipment.

  Despite the overall increase in Industry income there is still a shortfall in Industry Partner income caused by the late finalisation of the CoE Extension Agreement. It is anticipated that outstanding Industry Partner commitments will be made up in 2013.
- **Host institution support:** Core cash funding from UTAS was comparable to 2011. This funding relates primarily to research salaries, PhD scholarships and income earned by the Centre from research output. UTAS also provided approximately $2.3 million in in-kind support in 2012.

2013 Income Estimates

As much of the 2012 income figure is anomalous (explained above), it would not be expected for 2013 income to be as high. However, although the income from Industry has these inherent fluctuations, it is not expected to decrease when trends are analysed over the longer term. For example, several new research projects are currently being planned with AMIRA and other industry participants that will bolster income further down the track.

Table 1
Cash Income Financial Statement 2005–2012

	(half year) 2005	2006	2007	2008	2009	2010	2011	2012
ARC - Centre of Excellence Grant								
CoE agreed core funding* – 2005 grant indexation (not received until 2006)	0	31,500	0	0	0	0	0	0
CoE agreed core funding* – ARC grant	1,500,000	3,121,198	3,184,402	3,248,088	3,313,864	3,097,230	2,856,123	2,966,012
	1,500,000	**3,152,698**	**3,184,402**	**3,248,088**	**3,313,864**	**3,097,230**	**2,856,123**	**2,966,012**
CoE nodes matching funds (agreed matching funds held at node institutions)								
CoE agreed core funding*	0	295,000	255,000	250,000	237,500	242,500	190,000	292,500
Additional funding (pre-existing or new)	0	0	0	0	0	0	0	0
	0	**295,000**	**255,000**	**250,000**	**237,500**	**242,500**	**190,000**	**292,500**
Other ARC grants								
CoE agreed core funding*	0	0	0	0	0	0	0	0
Additional funding (pre-existing or new)	328,791	397,325	394,338	471,524	403,889	0	106,655	103,647
	328,791	**397,325**	**394,338**	**471,524**	**403,889**	**0**	**106,655**	**103,647**
Other Commonwealth Government								
CoE agreed core funding*	0	0	0	0	0	0	0	0
Additional funding (pre-existing or new)	7,184	19,649	24,666	62,680	2,046	87,856	4,364	194,988
	7,184	**19,649**	**24,666**	**62,680**	**2,046**	**87,856**	**4,364**	**194,988**
State Government								
CoE agreed core funding*	200,000	200,000	200,000	0	0	0	0	0
Additional funding (pre-existing or new)	68,000	852	4,000	8,000	2,500	2,396	3,556	98,951
	268,000	**200,852**	**204,000**	**8,000**	**2,500**	**2,396**	**3,556**	**98,951**
Local Government								
CoE agreed core funding*	0	0	0	0	0	0	0	0
Additional funding (pre-existing or new)	0	0	0	0	0	0	0	0
	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Industry/private								
CoE agreed core funding*	868,646	1,582,507	1,825,010	2,158,677	2,182,472	1,298,919	716,463	1,312,160
Additional funding (pre-existing or new)	444,803	909,552	938,913	1,487,935	2,268,323	2,117,721	2,230,995	4,734,850
	1,313,448	**2,492,059**	**2,763,923**	**3,646,611**	**4,450,795**	**3,416,640**	**2,947,458**	**6,047,010**
Contracts/consultancies/revenue raising								
CoE agreed core funding*	0	0	0	0	0	0	0	0
Additional funding (pre-existing or new)	143,787	286,675	306,743	368,160	383,012	411,097	841,397	1,137,486
	143,787	**286,675**	**306,743**	**368,160**	**383,012**	**411,097**	**841,397**	**1,137,486**
University of Tasmania – host institution support								
CoE agreed core funding*	343,744	1,334,728	1,147,471	1,128,759	1,430,393	2,107,854	2,366,074	2,358,330
Additional funding (pre-existing or new)	383,623	678,064	566,682	468,267	589,489	0	0	0
	727,367	**2,012,792**	**1,714,152**	**1,597,026**	**2,019,881**	**2,107,854**	**2,366,074**	**2,358,330**
Other income sources/interest								
CoE agreed core funding*	0	0	0	0	0	0	0	0
Additional funding (pre-existing or new)	4,348	60,006	53,000	131,585	25,147	84,795	22,726	20,113
	4,348	60,006	53,000	131,585	25,147	84,795	22,726	20,113
Total annual income	**4,292,926**	**8,917,056**	**8,900,226**	**9,783,674**	**10,838,635**	**9,450,368**	**9,338,352**	**13,219,037**
Grand total of all income to date								**74,740,275**

* Core funding listed in the CoE agreement and matched to the ARC funds

Figure 1
Total Cash Income 2012

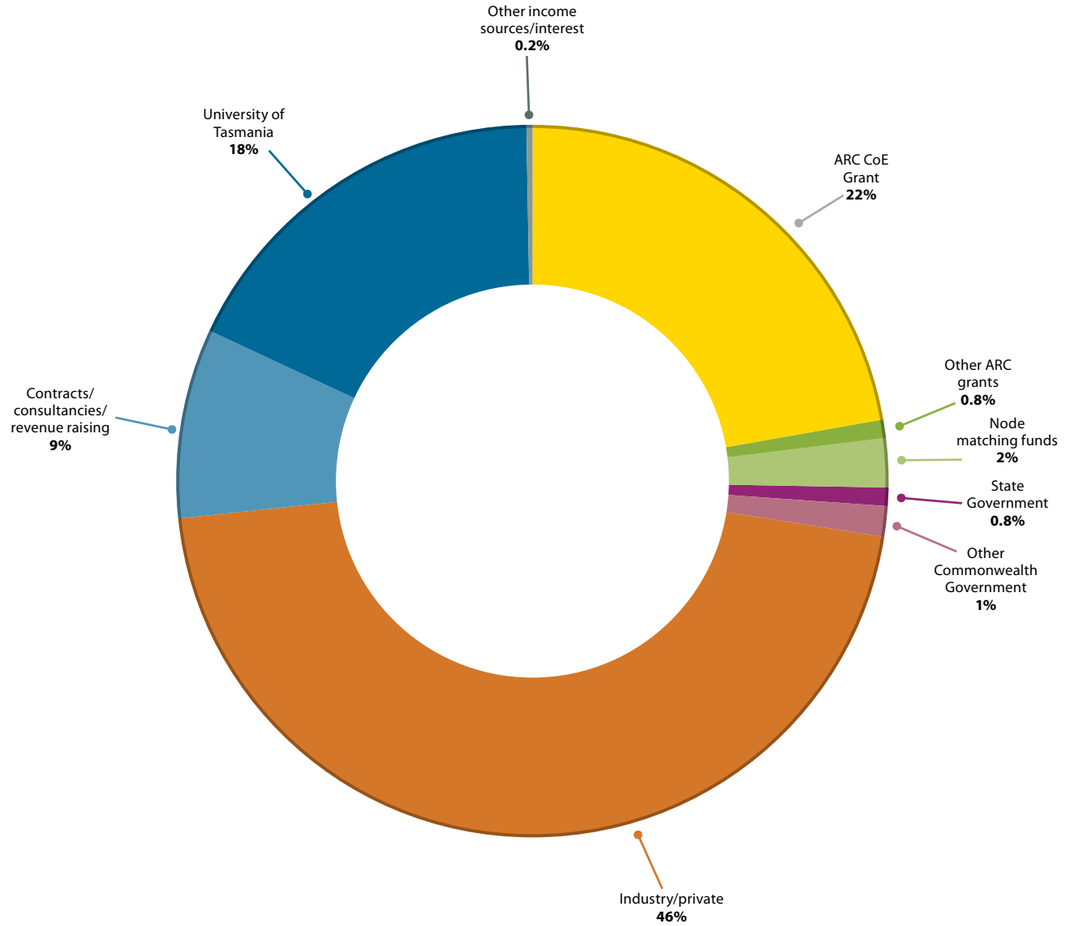
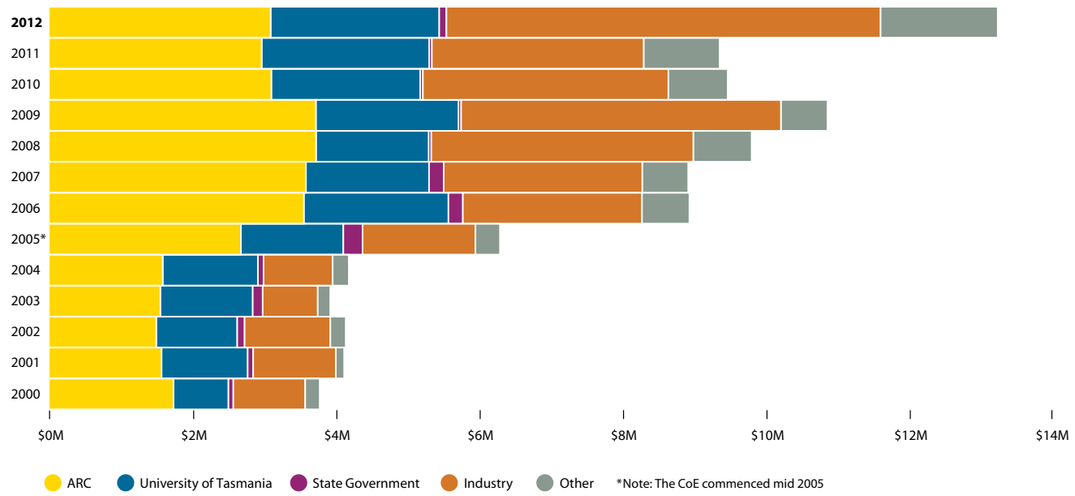


Figure 2
Comparison of CODES Main Income Streams 2000-2012



2012 Expenditure of ARC CoE Grant

Summaries are provided in Table 2 and Figure 3 to show how CODES and its nodes have expended the ARC CoE Grant funds to date. As in past years, the major areas of expenditure in 2012 were salaries, student scholarships, laboratory analyses, and research and field travel. Most areas had similar or lower levels of expenditure when compared to 2011 due to reduced research budget allocations. Salaries, however, increased due to CoE paid positions that were funded from other sources in 2011 moving back to CoE funding in 2012. It should be noted that consultancy payments originally costed to the CoE Grant in 2011 were transferred to an industry-funded research project in 2012, which has resulted in the credit shown in Table 2. Therefore this figure is not represented in Figure 3 (Expenditure pie chart).

The 2012 combined ARC CoE income and carry-forward of $3.6 million was offset by expenditure of $2.9 million. This leaves a carry-forward surplus of $756k. However, it should be noted that the Centre currently owes $180k of 2012 funds to two of its nodes (ANU and CSIRO). This amount was not able to be paid in 2012 due to late finalisation of the CoE Extension Agreement, and will be made up during 2013. The total surplus of ARC funds into 2013 incorporates both surplus and deficit amounts held at the nodes, which will be reconciled to zero by the end of the CoE period (31 December 2013).

2013 Expenditure Estimates

Expenditure in 2013 is expected to be similar to 2012.

Notes to, and Forming Part of, the Financial Statements for 2012

The financial pages of this Annual Report were prepared by Helen Scott (Finance Officer). Data for the financial statements was extracted from the UTAS TechOne Financial System and CODES' financial databases. All Financial Statements shown here have been reviewed and audited by UTAS.

Income Statement Explanations

The income figures in Table 1 represent actual income recorded in the University's finance system or transferred internally from UTAS to CODES during 2012, with the following exceptions:

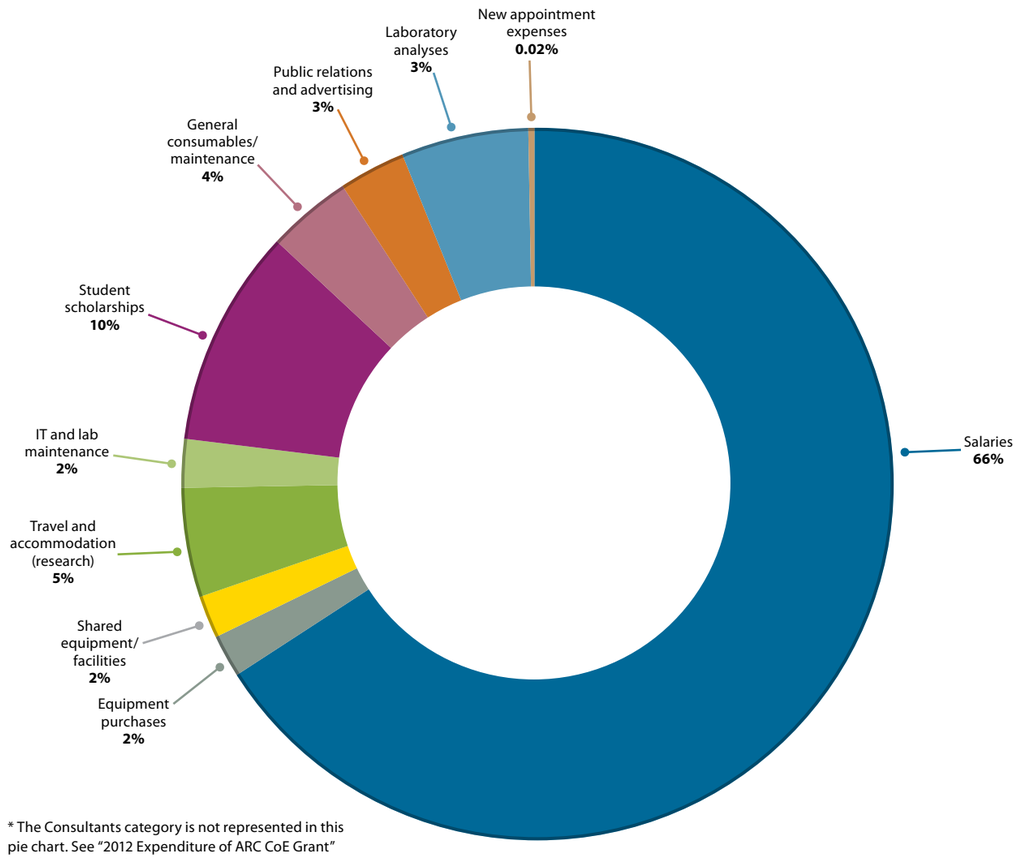
- The CoE node matching funds are listed as cash income in the income statement (Table 1), but are not actually received as cash by the Centre. These matching funds, contributed by the nodes, are held and expended at the node institutions and reported annually to the CoE. They are listed as cash income in Table 1 to demonstrate that the nodes are providing their agreed annual contribution to the CoE.

Table 2
Expenditure of ARC Centre of Excellence Grant 2005–2012 (CODES plus its nodes)

	(half year) 2005	2006	2007	2008	2009	2010	2011	2012
Income								
Balance brought forward from previous year	0	954,886	1,345,188	711,979	55,741	(145,268)	372,323	652,363
Miscellaneous income (refund of expenses)	0	8,497	29,589	43,155	0	18,704	1,271	9,641
ARC income	1,500,000	3,152,698	3,184,402	3,248,088	3,313,864	3,097,230	2,856,123	2,966,012
	1,500,000	**4,116,081**	**4,559,179**	**4,003,222**	**3,369,605**	**2,970,667**	**3,229,717**	**3,628,016**
Expenditure								
Salaries	(348,511)	(1,237,351)	(1,833,309)	(2,335,312)	(1,705,835)	(1,332,826)	(1,251,890)	(1,920,821)
Equipment purchases	(890)	(83,645)	(305,991)	(70,624)	(85,292)	(35,392)	(87,855)	(68,310)
Equipment leased/hired	(362)	(22,635)	(6,894)	0	0	(500)	0	(280)
Shared equipment/facilities	(1,119)	(21,900)	(46,750)	(58,188)	(109,407)	(54,919)	(68,661)	(66,379)
Travel and accommodation (research)	(52,363)	(354,349)	(314,206)	(282,161)	(364,065)	(221,763)	(267,358)	(141,513)
IT and lab maintenance	(1,866)	(91,292)	(208,688)	(145,441)	(82,620)	(16,334)	(33,878)	(57,278)
Student scholarships	(31,856)	(297,768)	(349,671)	(346,311)	(384,141)	(401,617)	(387,684)	(281,100)
General consumables/maintenance	(67,517)	(244,347)	(217,941)	(246,561)	(199,512)	(127,799)	(169,402)	(107,361)
Public relations and advertising	(9,289)	(105,160)	(119,364)	(53,466)	(66,299)	(36,158)	(8,945)	(74,958)
Laboratory analyses	(29,900)	(212,256)	(307,733)	(288,411)	(369,447)	(247,363)	(189,124)	(179,132)
Consultants	0	(90,290)	(108,075)	(68,962)	(62,186)	(117,203)	(98,457)	31,384
Visiting academics	(9,002)	(9,900)	(19,311)	(41,665)	(61,221)	0	0	0
New appointment expenses	0	0	(9,267)	(10,381)	(22,523)	(5,564)	(14,101)	(624)
Miscellaneous	7,561	0	0	0	(2,323)	(906)	0	(6,057)
	(545,114)	**(2,770,893)**	**(3,847,200)**	**(3,947,481)**	**(3,514,872)**	**(2,598,343)**	**(2,577,354)**	**(2,872,430)**
Balance remaining at end of year	**954,886**	**1,345,188**	**711,979**	**55,741**	**(145,268)**	**372,323**	**652,363**	**755,586**

* From 2010 onwards, visiting academic expenditure is no longer itemised separately

Figure 3
Expenditure of ARC Centre of Excellence Grant 2012



* The Consultants category is not represented in this pie chart. See "2012 Expenditure of ARC CoE Grant" text for more detail.

- $977k of AMIRA funds, related to the P843A and P1022 projects, were deposited into UTAS accounts, but were later transferred to research collaborators for the joint research projects. These funds will be listed as AMIRA income to those collaborators, and can therefore not be listed as income to CODES.

In Table 1, sub-categories labelled 'CoE agreed core funding' are used to isolate core funding from other general funds. This is in accordance with the ARC requirement that the Centre demonstrates that these agreed core funds have been received each year.

Because of the six-month delay to the establishment of CODES as a CoE, very few agreed cash payments between the CoE and its nodes/collaborators were contributed in 2005. As a result, the payments for this six-month delay period were made during 2006. This has artificially inflated 2006 income figures by approx $400,000 (i.e. node income +$50,000, UTAS +$200,000, Industry Partners +$130,000). Therefore, any comparison between 2006 and 2007 income figures needs to take this into account.

In 2008, there was a minor retrospective amendment made to the 2005 industry/private income figure, which has increased the 2005 income total by $20,000. This relates to $20,000 of CoE agreed 2005 income, which was paid in advance by Teck Cominco (now Teck Resources) in 2004. It has already been counted in the 2004 income statement of the SRC, but it is now listed again in the CoE's 2005 data (in the year that it was due) to clearly demonstrate to the ARC that Teck Cominco has met its CoE funding obligations within the five-year CoE agreement period.

Expenditure Statement Explanations

All expenditure categories are consistent with last year's reports.

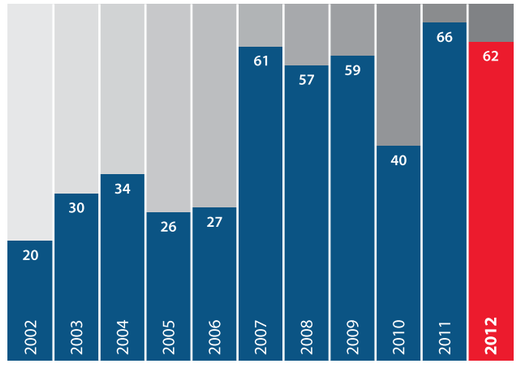
The expenditure financial statement and pie chart (Table 2 and Figure 3) include the following:

- CODES expenditure of ARC CoE Grant funds (administered by UTAS).
- The nodes' expenditure of ARC CoE Grant funds (administered by the node institutions and reported annually to UTAS).

2012 CODES' Publications

Refereed Journal Articles (62)

NAMES IN BOLD ARE AUTHORS THAT AFFILIATED THEIR ARTICLES TO CODES



Agangi, A., Kamenetsky, V.S., and **McPhie, J.,** 2012, Evolution and emplacement of high fluorine rhyolites in the Mesoproterozoic Gawler silicic large igneous province, South Australia: Precambrian Research, v. 208–211, p. 124–144.

Allen, S.R., Freundt, A., and Kurokawa, K., 2012, Characteristics of submarine pumice-rich density current deposits sourced from turbulent mixing of subaerial pyroclastic flows at the shoreline: field and experimental assessment: Bulletin of Volcanology, v. 74(3), p. 657–675.

Angerer, T., Hagemann, S.G., and **Danyushevsky, L.V.,** 2012, Geochemical evolution of the banded iron formation-hosted high-grade iron ore system in the Koolyanobbing greenstone belt, Western Australia: Economic Geology, v. 107(4), p. 599–644.

Berkenbosch, H.A., de Ronde, C.E.J., **Gemmell, J.B., McNeill, A.W.,** and Goemann, K., 2012, Mineralogy and formation of black smoker chimneys from Brothers submarine volcano, Kermadec Arc: Economic Geology, v. 107(8), p. 1613–1633.

Berry, R.F., and **Bull, S.W.,** 2012, The pre-Carboniferous geology of Tasmania: Episodes: International Geoscience Newsmagazine, v. 35(1), p. 195–204.

Bindeman, I.N., **Kamenetsky, V.S.,** Palandri, J., and Vennemann, T., 2012, Hydrogen and oxygen isotope behaviors during variable degrees of upper mantle melting: Example from the basaltic glasses from Macquarie Island: Chemical Geology, v. 310–311, p. 126–136.

Borisova, AY., Ceuleneer, G., **Kamenetsky, V.S.,** Arai, S., Bejina, F., Abily, B., Bindeman, I.N., Polve, M., de Parseval, P., Aigouy, T., and Pokrovski, G.S., 2012, A new view on the petrogenesis of the Oman ophiolite chromitites from microanalyses of chromite-hosted inclusions: Journal of Petrology, v. 53(12), p. 2411–2440.

Braxton, D., **Cooke, D.R.,** Dunlap, J., Norman, M., Reiners, P., Stein, H., and Waters, P., 2012, From crucible to graben in 2.3 Ma: A high-resolution geochronological study of porphyry life cycles, Boyongan-Bayugo copper-gold deposits, Philippines: Geology, v. 40(5), p. 471–474.

Carey, R.J., Manga, M., Degruyter, W., Swanson, D., Houghton, B., Orr, T., and Patrick, M., 2012, Externally triggered renewed bubble nucleation in basaltic magma: The 12 October 2008 eruption at Halema'uma'u Overlook vent, Kilauea, Hawai'i, USA: Journal of Geophysical Research-Solid Earth, v. 117(B11202), doi:10.1029/2012JB009496.

Chang, Z.S., and Yang, Z.M., 2012, Evaluation of inter-instrument variations among short wavelength infrared (SWIR) devices: Economic Geology, v. 107, p. 1479–1488.

Chen, H., Chen, Y-J., and **Baker, M.J.,** 2012, Isotopic geochemistry of the Sawayaerdun orogenic-type gold deposit, Tianshan, northwest China: Implications for ore genesis and mineral exploration: Chemical Geology, v. 310–311, p. 1–11.

Chmielowski, R.M., and **Berry, R.F.,** 2012, The Cambrian metamorphic history of Tasmania: The Metapelites: Australian Journal of Earth Sciences, v. 59(7), p. 1007–1019.

Ciobanu, C.L., Cook, N.J., Utsunomiya, S., Kogagwa, M., Green, L., **Gilbert, S.E.,** and Wade, B., 2012, Gold-telluride nanoparticles revealed in arsenic-free pyrite: American Mineralogist, v. 97(8–9), p. 1515–1518.

Cluzel, D., Jourdan, F., **Meffre, S.J.M.,** Maurizot, P., and Lesimple, S., 2012, The metamorphic sole of New Caledonia ophiolite: $^{40}Ar/^{39}Ar$, U-Pb, and geochemical evidence for subduction inception at a spreading ridge: Tectonics, v. 31(TC3016), doi:10.1029/2011TC003085.

Deol, S., Deb, M., **Large, R.R.,** and **Gilbert, S.E.,** 2012, LA-ICPMS and EPMA studies of pyrite, arsenopyrite and loellingite from the Bhukia-Jagpura gold prospect, southern Rajasthan, India: Implications for ore genesis and gold remobilization: Chemical Geology, v. 326–327, p. 72–87.

Durance, P.M.J., Jadamec, M.A., **Falloon, T.J.,** and Nicholls, I.A., 2012, Magmagenesis within the Hunter Ridge Rift Zone resolved from olivine-hosted melt inclusions and geochemical modelling with insights from geodynamic models: Australian Journal of Earth Sciences, v. 59(6), p. 913–931.

Evans, K.A., Elburg, M.A., and **Kamenetsky, V.S.,** 2012, Oxidation state of subarc mantle: Geology, v. 40(9), p. 783–786.

Fan, Y., Zhou, T.F., Hao, L., Yuan, F., **Zhang, L.J.,** and Wang, W.C., 2012, Ore-forming fluid characteristic of Nihe iron

Opposite page: Research vessel crew coax rock samples from the dredge basket.

deposit in Lu-Zong basin, Anhui Province and its significance to ore genesis: Acta Petrologica Sinica, v. 28, p. 3113–3124.

Fu, B., **Paul, B.,** Cliff, J., Brocker, M., and Bulle, F., 2012, O-Hf isotope constraints on the origin of zircon in high-pressure melange blocks and associated matrix rocks from Tinos and Syros, Greece: European Journal of Mineralogy, v. 24, p. 277–287.

Fu, L., Wei, J., Kusky, T.M. **Chen, H.,** Tan, J., Li, Y., Shi, W., Chen, C., and Zhao, S., 2012, The Cretaceous Duimiangou adakite-like intrusion from the Chifeng region, northern North China Craton: Crustal contamination of basaltic magma in an intracontinental extensional environment: Lithos, v. 134–135, p. 273–288.

Giuliani, A., **Kamenetsky, V.S.,** Phillips, D., Kendrick, M.A., Wyatt, B.A., and Goemann, K., 2012, Nature of alkali-carbonate fluids in the sub-continental lithospheric mantle: Geology, v. 40(11), p. 967–970.

Glen, R.A., Quinn, C.D., and **Cooke, D.R.,** 2012, The Macquarie Arc, Lachlan Orogen, New South Wales: Its evolution, tectonic setting and mineral deposits: Episodes: International Geoscience Newsmagazine, v. 35(1), p. 177–186.

Goto, Y., and **McPhie, J.,** 2012, Morphology and formation of spreading cracks on pillow lavas at Cape Grim, northwestern Tasmania, Australia: Bulletin of Volcanology, v. 74(7), p. 1611–1619.

Guillong, M., and Pettke, T., 2012, Depth dependent element ratios in fluid inclusion analysis by laser ablation ICP-MS: Journal of Analytical Atomic Spectrometry, v. 27(3), p. 505–508.

Halpin, J.A., Daczko, N.R., Milan, L.A., and Clarke, G.L., 2012, Decoding near-concordant U-Pb zircon ages spanning several hundred million years: recrystallisation, metamictisation or diffusion?: Contributions to Mineralogy and Petrology, v. 163(1), p. 67–85.

Jutzeler, M., Proussevitch, A.A., and **Allen, S.R.,** 2012, Grain-size distribution of volcaniclastic rocks 1: A new technique based on functional stereology: Journal of Volcanology and Geothermal Research, v. 239–240, p. 1–11.

Kamenetsky, V.S., Chung, S., **Kamenetsky, M.B.,** and Kuzmin, D.V., 2012, Picrites from the emeishan large Igneous Province, SW China: A compositional continuum in primitive magmas and their respective mantle sources: Journal of Petrology, v. 53(10), p. 2095–2113.

Kamenetsky, V.S., Kamenetsky, M.B., Golovin, A.V., Sharygin, V.V., and Maas, R., 2012, Ultrafresh salty kimberlite of the Udachnaya-East pipe (Yakutia, Russia): A petrological oddity or fortuitous discovery?: Lithos, v. 152, p. 173–186.

Kanouo, N.S., **Zaw, K.,** Yongue, R.F., Sutherland, F.L., **Meffre, S.J.M.,** Njonfang, E., and Ma, C., 2012, Detrital mineral morphology and geochemistry: Methods to characterize and constrain the origin of the Nsanaragati blue sapphires, south-western region of Cameroon: Journal of African Earth Sciences, v. 70, p. 18–23.

Kanouo, N.S., **Zaw, K.,** Yongue, R.F., Sutherland, F.L., **Meffre, S.J.M.,** Njonfang, E., Ma, C., and Tchouatcha, M.S., 2012, U-Pb Zircon Age Constraining the Source and Provenance of Gem-Bearing Late Cenozoic Detrital Deposits, Mamfe Basin, SW Cameroon: Resource Geology, v. 62(3), p. 316–324.

Kendrick, M.A., **Kamenetsky, V.S.,** Phillips, D., and Honda, M., 2012, Halogen systematics (Cl, Br, I) in Mid-Ocean Ridge Basalts: A Macquarie Island case study: Geochimica et Cosmochimica Acta, v. 81, p. 82–93.

Kendrick, M.A., Woodhead, J.D., and **Kamenetsky, V.S.,** 2012, Tracking halogens through the subduction cycle: Geology, v. 40(12), p. 1075–1078.

Kim, E.J., Park, M.E., and **White, N.C.,** 2012, Skarn gold mineralization at the Geodo mine, South Korea: Economic Geology, v. 107, p. 537–551.

Kiseeva, E.S., Yaxley, G.M., Hermann, J., Litasov, K.D., Rosenthal, A., and **Kamenetsky, V.S.,** 2012, An experimental study of carbonated eclogite at 3.5-5.5 GPa-implications for silicate and carbonate metasomatism in the cratonic mantle: Journal of Petrology, v. 53(4), p. 727–759.

Kouhestani, H., Ghaderi, M., **Zaw, K., Meffre, S.,** and Emami, M.H., 2012, Geological setting and timing of the Chah Zard breccia-hosted epithermal gold-silver deposit in the Tethyan belt of Iran: Mineralium Deposita, v. 47(4), p. 425–440.

Kovacs, I., **Green, D.H.,** Rosenthal, A., Hermann, J., O'Neill, H.S.C., Hibberson, W.O., and Udvardi, B., 2012, An experimental study of water in nominally anhydrous minerals in the upper mantle near the water-saturated solidus: Journal of Petrology, v. 53(10), p. 2067–2093.

Laird, J.S., Johnson, B.C., and **Ryan, C.G.,** 2012, Laser-beam-induced current microscopy of electric fields in natural minerals caused by impurity zonation and structural defects: Measurement Science & Technology, v. 23, doi:10.1088/0957-0233/23/8/085401.

Large, R.R., Thomas, H.V., Craw, D., Henne, A., and Henderson, S., 2012, Diagenetic pyrite as a source for metals in orogenic gold deposits, Otago Schist, New Zealand: New Zealand Journal of Geology and Geophysics, v. 55(2), p. 137–149.

Liu, W.H., **Borg, S.,** Etschmann, B., Mei, Y., Brugger, J., 2012, An XAS study of speciation and thermodynamic properties of aqueous zinc bromide complexes at 25–150 °C: Chemical Geology, v. 298–299, p.57–69.

Maslennikov, V.V., Ayupova, N.R., Herrington, R.J., **Danyushevsky, L.V.,** and **Large, R.R.,** 2012, Ferruginous and manganiferous haloes around massive sulphide deposits of the Urals: Ore Geology Reviews, v. 47, p. 5–41.

Meffre, S.J.M., Falloon, T.J., Crawford, A.J., Hoernle, K., Hauff, F., Duncan, R.A., Bloomer, S.H., and Wright, D.J., 2012, Basalts erupted along the Tongan fore arc during subduction initiation: Evidence from geochronology of dredged rocks from the Tonga fore arc and trench: Geochemistry Geophysics Geosystems, v. 13(Q12003), doi:10.1029/2012GC004335.

Mitchell, R.H., and **Kamenetsky, V.S.,** 2012, Trace element geochemistry of nyerereite and gregoryite phenocrysts from natrocarbonatite lava, Oldoinyo Lengai, Tanzania: Implications for magma mixing: Lithos, v. 152, p. 56–65.

Mousivand, F., Rastad, E., **Meffre, S.J.M.,** Peter, J.M., Mohajjel, M., **Zaw, K.,** and Emami, M.H., 2012, Age and tectonic setting of the Bavanat Cu-Zn-Ag Besshi-type volcanogenic massive sulfide deposit, southern Iran: Mineralium Deposita, v. 47(8), p. 1–21.

Paul, B., Paton, C., Norris, A., Woodhead, J., Hellstrom, J., Hergt, J., and Greig, A., 2012, CellSpace: A module for creating spatially registered laser ablation images within the Iolite freeware environment: Journal of Analytical Atomic Spectrometry, v. 27, p. 700–706.

Peate, D.W., Peate, I.U., Rowe, M.C., **Thompson, J.M.,** and Kerr, A.C., 2012, Petrogenesis of high-MgO lavas of the lower mull plateau group, Scotland: Insights from melt inclusions: Journal of Petrology, v. 53(9), p. 1867–1886.

Reading, A.M., Tkalcic, H., Kennett, B.L.N., Johnson, S.P., and Sheppard, S., 2012, Seismic structure of the crust and uppermost mantle of the Capricorn and Paterson Orogens and adjacent cratons, Western Australia, from passive seismic transects: Precambrian Research, v. 196–197 p. 295–308.

Schaa, R., and **Fullagar, P.K.,** 2012, Vertical and horizontal resistive limit formulas for a rectangular-loop source on a conductive half-space: Geophysics, v. 77, p. E91–E99.

Sharygin, V.V., **Kamenetsky, V.S.,** Zaitsev, A.N., and **Kamenetsky, M.B.,** 2012, Silicate-natrocarbonatite liquid immiscibility in 1917 eruption combeite-wollastonite nephelinite, Oldoinyo Lengai Volcano, Tanzania: Melt inclusion study: Lithos, v. 152, p. 23–39.

Smirnov, S.Z., Thomas, V.G., **Kamenetsky, V.S.,** Kozmenko, O.A., and **Large, R.R.,** 2012, Hydrosilicate liquids in the system Na_2O-SiO_2-H_2O with NaF, NaCl and Ta: Evaluation of their role in ore and mineral formation at high *T* and *P*: Petrology, v. 20(3), p. 271–285.

Song, G.X., Qin, K.Z., Li, G.M., Liu, T.B., Li, J.X., Li, X.H., and **Chang, Z.S.,** 2012, Geochronologic and isotope geochemical constraints on magmatism and associated W-Mo mineralization of the Jitoushan W-Mo deposit, middle-lower Yangtze Valley: International Geology Review, v. 54, p. 1532–1547.

Song, X-Y., **Danyushevsky, L.V.,** Keays, R.R., Chen, L-M., Wang, Y-S., Tian, Y-L., and Xiao, J-F., 2012, Structural, lithological, and geochemical constraints on the dynamic magma plumbing system of the Jinchuan Ni-Cu sulfide deposit, NW China: Mineralium Deposita, v. 47(3), p. 277–297.

Thomas, R., and **Davidson, P.,** 2012, Evidence of a water-rich silica gel state during the formation of a simple pegmatite: Mineralogical Magazine, v. 76(7), p. 2785–2801.

Thomas, R., and **Davidson, P.,** 2012, The application of Raman spectroscopy in the study of fluid and melt inclusions: Zeitschrift der Deutschen Gesellschaft für Geowissenschaften, v. 163(2), p. 113–126.

Thomas, R., **Davidson, P.,** and Beurlen, H., 2012, The competing models for the origin and internal evolution of granitic pegmatites in the light of melt and fluid inclusion research: Mineralogy and Petrology, v. 106, p. 55–73.

Thomas, R., and **Davidson, P.,** 2012, Water in granite and pegmatite-forming melts: Ore Geology Reviews, v. 46, p. 32–46.

Thomas, R., **Davidson, P.,** and Badanina, E., 2012, Water- and Boron-Rich Melt Inclusions in Quartz from the Malkhan Pegmatite, Transbaikalia, Russia: Minerals, v. 2(4), p. 435–458.

Veksler, I.V., Dorfman, A.M., Dulski, P., **Kamenetsky, V.S., Danyushevsky, L.V.,** Jeffries, T., and Dingwell, D.B., 2012, Partitioning of elements between silicate melt and immiscible fluoride, chloride, carbonate, phosphate and sulfate melts, with implications to the origin of natrocarbonatite: Geochimica et Cosmochimica Acta, v. 79, p. 20–40.

Winderbaum, L., Ciobanu, C.L., Cook, N.J., Paul, M., Metcalfe, A., and **Gilbert, S.E.,** 2012, Multivariate analysis of an LA-ICP-MS trace element dataset for pyrite: Mathematical Geosciences, v. 44(7), p. 823–842.

Yaxley, G.M., Berry, A.J., **Kamenetsky, V.S.,** Woodland, A.B., and Golovin, A.V., 2012, An oxygen fugacity profile through the Siberian Craton — Fe K-edge XANES determinations of $Fe^{3+}/\Sigma Fe$ in garnets in peridotite xenoliths from the Udachnaya East kimberlite: Lithos, v. 140–141, p. 142–151.

Yuan, F., **Zhou, T.F.,** Zhang, D.Y., Jowitt, S.M., Keays, R.R., Liu, S., and Fan, Y., 2012, Siderophile and chalcophile metal variations in basalts: Implications for the sulfide saturation history and Ni-Cu-PGE mineralization potential of the Tarim continental flood basalt province, Xinjiang Province, China: Ore Geology Reviews, v. 45, p. 5–15.

Zhou, T.F., Wang, B., Fan, Y., Yuan, F., **Zhang, L.J.,** and Zhong, G.X., 2012, Apatite-actinolite-magnetite deposit related to A-type granite in Luzong basin: Evidence from Makou iron deposit: Acta Petrologica Sinica, v. 28, p. 3087–3098.

Zhang, L., **Chen, H.,** Chen, Y., Qin, Y., Liu, C., Zheng, Y., and **Jansen, N.,** 2012, Geology and fluid evolution of the Wangfeng orogenic-type gold deposit, Western Tian Shan, China: Ore Geology Reviews, v. 49, p. 85–95.

Conference Abstracts, Papers, and Presentations (135)

Ageneau, M., Cooke, D.R., Gemmell, J.B., Danyushevsky, L., Rutter, J., Stewart, K., and Collett, D., 2012, Origin and geochemical evolution of the Ladolam low-sulfidation gold deposit, Lihir Island, PNG: 34th International Geological Congress, Brisbane, Australia, 5–9 August.

Ariskin, A.A., Bychkov, K.A., Danyushevsky, L.V., McNeill, A.W., Barmina, G.S., and Nikolaev, G.S., 2012, COMAGMAT-5: A new magma crystallization model designed to simulate mafic to ultramafic sulfide-saturated systems: 12th International Ni-Cu-(PGE) Symposium, Guiyang, China, 16–21 June.

Ariskin, A.A., Konnikov, E.G., Danyushevsky, L.V., McNeill, A.W., Nikolaev, G.S., Kostitsyn, Yu.A., Kislov, E.V., and Orsoev, D.A., 2012, The Dovyren Intrusive Complex: Geochemistry, petrology, and the sulfide saturation history for parental magmas: IV International Conference, Ultramafic-mafic Complexes of Folded Regions and its Minerageny, Ulan-Ude, Russia, 27–31 August.

Baker, M., Cooke, D.R., Whelan, J., and Close, D., 2012, Epidote trace element chemistry: Variations between regional metamorphic and propylitic epidote and implications for exploration: Gordon Research Conference, New Hampshire, USA, 15–20 July.

Baker, M., Cooke, D.R., Wilkinson, C., Hollings, P., and Wilkinson, J., 2012, Epidote trace element chemistry as an exploration tool: El Teniente porphyry Cu-Mo deposit case study: SEG 2012 Conference, Lima, Peru, 23–26 September.

Basori, M.B.I., Khin Zaw, Large, R.R., and Wan Fuad Wan Hassan, 2012, Sulphur isotope and fluid inclusion studies of the Tasik Chini VHMS deposit, Pahang District, Peninsular Malaysia: Asian Current Research on Fluid Inclusions – ACROFI IV, Brisbane, Australia, 10–12 August.

Basori, M.B.I.B., Khin Zaw, Large, R.R., and Hassan, W.F., 2012, Geology and characteristics of the Tasik Chini deposit, Pahang District, Peninsular Malaysia; A typical style of VHMS mineralisation: 34th International Geological Congress, Brisbane, Australia, 5–9 August.

Belousov, A., Belousov, M., Khin Zaw, and Manaka, T., 2012, Holocene gravitational collapse and explosive eruptions of Mount Popa, Myanmar: AGU Fall Meeting, San Francisco, USA, 3–7 December.

Berkenbosch, H.A, de Ronde, C.E.J., McNeill, A.W., Goemann, K., and Gemmell, J.B., 2012, Distribution of minor and trace elements in sulfide chimneys from Brothers submarine volcano, Kermadec arc: 34th International Geological Congress, Brisbane, Australia, 5–9 August.

Berkenbosch, H.A., de Ronde, C.E.J, McNeill, A.W., Goemann, K., and Gemmell, J.B., 2012, Trace element distribution, with a focus on gold, in copper-rich and zinc-rich sulfide chimneys from Brothers submarine volcano, Kermadec arc: AGU Fall Meeting, San Francisco, USA, 3–7 December.

Berry, R.F., and Hunt, J., 2012, Mineral fractionation in comminution: 34th International Geological Congress, Brisbane, Australia, 5–9 August.

Bland, P.A., Cleverley, J.S., Dyl, K.A., Hough, R.M., Fisher, L.A., and Ryan, G.C., 2012, Trace element carrier phases at micron-scale in Allende matrix and chondrules: Annual Meteoritical Society Meeting, Cairns, Australia, 12–17 August.

Borg, S., 2012, In-situ X-ray Absorption Spectroscopy at elevated temperature and pressure: Australian X-Ray Analytical Association Meeting- VIC Student Seminar Day, CSIRO, Clayton, Australia, 21st November.

Bottrill, R.S., Taheri, J., and Meffre, S., 2012, Petrology and geochronology of unusual Fe-Mg and Na-rich lithologies, Savage River, Tasmania: 34th International Geological Congress, Brisbane, Australia, 5–9 August, p. 1395.

Carey, R.J., Manga, M., Degruyter, W., Houghton, B.F., Orr, T., Patrick, M., and Swanson, D.A., 2012, Shallow triggered renewed bubble nucleation in basaltic magmas: Halema'uma'u 2008: AGU Chapman Conference: Hawaiian Volcanoes: From Source to Surface, Hawaii, USA, 24–28 August.

Chang, Z., Hedenquist, J., White, N., Cooke, D.R., Deyell, C., Garcia Jr., J., and Cuison, A.L., 2012, Exploring for buried porphyry and high-sulfidation epithermal deposits using signals in lithocaps: Implications from the Lepanto-FSE system, Philippines: 34th International Geological Congress, Brisbane, Australia, 5–9 August.

Chapman, N., Meakin, R., Kuhar, L., McFarlane, A., Turner, N., Robinson, D., Austen, P., and Berry, R., 2012, Development of small-scale test methods for coarse rock leaching: Geomet 2012, Santiago, Chile, 5–7 December.

Chapman, N., Meakin, R., Kuhar, L., McFarlane, A., Turner, N., Robinson, D., and Frangeskides, Z., 2012, Diagnostic leaching: A new approach: Geomet 2012, Santiago, Chile, 5–7 December.

Chauhan, M., Napier-Munn, T., and Keeney, L., 2012, Investigation of a mineral flotation separability test for ore characterisation in geometallurgy: Geomet 2012, Santiago, Chile, 5–7 December.

Chen, H., Cooke, D.R., and Baker, M., 2012, Formation of the Pacific Plate and Mesozoic metallogenic response in the Central Andes and Eastern China: SEG 2012 Conference, Lima, Peru, 23–26 September.

Cleverley, J.S., Ryan, C.G., Hough, R.M., Bland, P.A., Fisher, L., and Dyl, K.A., 2012, Quantified, whole section, XRF mapping of trace elements: Application of the Maia system to meteorites: Annual Meteoritical Society Meeting, Cairns, Australia, 12–17 August.

Cooke, D.R., 2012, IGC field trip – mineralisation wrap-up: 34th International Geological Congress field excursion, Brisbane, Australia, 10–14 August.

Cooke, D.R., Baker, M., Wilkinson, J.J., Chang, Z., Chen, H., Gemmell, J.B., Hollings, P., Zhou, T., Ireland, T., and Wilkinson, C.C., 2012, New advances in geochemical exploration for porphyry deposits in green rock environments: 34th International Geological Congress, Brisbane, Australia, 5–9 August.

Cooke, D.R., Hollings, P., Wolfe, R.C., Braxton, D., and Baker, M., 2012, Tectonic triggers for porphyry Cu-Au and epithermal Au-Ag ore formation and preservation: Lessons from the Philippines: 34th International Geological Congress, Brisbane, Australia, 5–9 August.

Cooke, D.R., Wilson, A.J., Masterman, G., Zukowski, W., Green, D., and Holliday, J., 2012, Porphyry, epithermal and skarn deposits of the Macquarie Arc, NSW: 34th International Geological Congress field excursion, Brisbane, Australia, 10–14 August.

Cox, S.F., 2012, Fluid-rock interaction in faults and shear zones: 2nd EGU Summer School, Lago di Neves, Italy, 22–28 August.

Cox, S.F., 2012, Permeability and fluid pathways in fault-controlled hydrothermal systems: Structural Geology and Resources, Australian Institute of Geoscientists, Kalgoorlie, Western Australia, 26–28 September.

Cracknell, M. J., and Reading, A.M., 2012, Machine learning for lithology classification and uncertainty mapping: AGU Fall Meeting, San Francisco, USA, 3–7 December.

Crawford, M.A., and Cox, S.F., 2012, The mechanical and fluid pressure evolution of the Argo fault zone, St Ives goldfield, Western Australia: An example of an Archean, shear-hosted, mesothermal gold system: 34th International Geological Congress, Brisbane, Australia, 5–9 August.

Crow, M.J., Khin Zaw, and Barber, A.J., 2012, A review of the Palaeozoic to Cenozoic in orogens and their associated mineral deposits in Thailand: GeoMyanmar, First International Conference on Regional Geology, Stratigraphy and Tectonics and Economic Geology of Myanmar and neighbouring countries, Yangon, Myanmar, 1–2 March.

Davidson, G.J., 2012, Andean lakes, stalactites, champagne, and Western Australian gold: You'll see the link by the end: Tasmanian Division of the Geological Society of Australia Annual General Meeting, Hobart, Australia, 24 May, Chairman's Address.

Donner, E., Kopittke, P.M., de Jonge, M.D., Howard, D.L., Ryan, C.G., Carey, A-M., Paterson D., Naidu, R., and Lombi, E., 2012, Recent advances in hard X-ray fluorescence mapping and tomography open new avenues for biogeochemical research: 4th International Congress Eurosoil, Bari, Italy, 2–6 July.

Dyl, K.A., Cleverley, J.S., Bland, P.A., Hough, R.M., Fisher, L., and Ryan, C.G., 2012, Micron-scale distribution of manganese in Allende and implications for constraining conditions of metamorphism: Annual Meteoritical Society Meeting, Cairns, Australia, 12–17 August.

Dyl, K.A., Cleverley, J.S., Bland, P.A., Hough, R.M., Fisher, L., and Ryan, C.G., 2012, Zinc distribution in Allende revealed via synchrotron analysis and its link to alkali-metasomatism of refractory inclusions: Annual Meteoritical Society Meeting, Cairns, Australia, 12–17 August.

Evans, K.A., Elburg, M.A., and Kamenetsky, V.S., 2012, The oxidation state of sub-arc mantle: 34th International Geological Congress, Brisbane, Australia, 5–9 August, p. 113.

Eychenne, J., Houghton, B.F., Swanson, D.A., Orr, T., and Carey, R.J., 2012, Componentry of pyroclastic fall deposits from the 2008–2012 small explosive eruptions at Kilauea summit crater: Insights into the dynamics of an open basaltic lava column: AGU Fall Meeting, San Francisco, USA, 3–7 December.

Fonseca, P., McNeill, A.W., and McPhie, J., 2012, Facies analysis and correlation in complex mineralized volcanic successions: Mount Read Volcanics, western Tasmania: AusIMM /GSA Explore the Science Symposium, Strahan, Australia, 6–7 December.

Fonseca, P., McNeill, A.W., and McPhie, J., 2012, Facies analysis and correlations in complex mineralised volcanic successions: Mount Read Volcanics, western Tasmania: XVI Peruvian Geological Congress & SEG 2012 Conference, Lima, Peru, 23–26 September. Poster.

Fox, N., Cooke, D.R., Harris, A.C., and Faure, K., 2012, Tourmaline as an indicator of hydrothermal fluid sources at the Cadia East alkalic porphyry Au-Cu deposit and comparisons with IOCG and other porphyry deposits: Gordon Research Conference, New Hampshire, USA, 15–20 July.

Fox, N., Cooke, D.R., Harris, A.C., Faure, K., and Collett, D., 2012, Controls on mineralization and alteration at the giant Cadia East porphyry Au-Cu deposit, NSW, Australia: SEG 2012 Conference, Lima, Peru, 23–26 September.

Fox, N., Cooke, D.R., Harris, A.C., Faure, K., and Collett, D., 2012, The isotope geochemistry of tourmaline at the giant Cadia East porphyry Au-Cu deposit, NSW: An indicator of hydrothermal fluid origin and evolution: 34th International Geological Congress, Brisbane, Australia, 5–9 August.

Fox, N., Harris, A.C., Cooke, D.R., and Collett, D., 2012, Structural controls on the formation of the Cadia East porphyry Au-Cu deposit, NSW, Australia: 34th International Geological Congress, Brisbane, Australia, 5–9 August.

Ghaderi, M., Kouhestani, H., Chang, Z., and Khin Zaw, 2012, Fluid inclusion and stable isotope study of the Chah Zard breccia-hosted epithermal gold-silver deposit, west central Iran: 34th International Geological Congress, Brisbane, Australia, 5–9 August.

Ghaderi, M., Kouhestani, H., Khin Zaw, and Meffre, S., 2012, Constraints on the Chah Zard Au-Ag mineralization, west-central Iran using whole-rock and Sr-Nd Isotope geochemistry of volcanic host rocks: The 9th Annual Meeting of the Asia-Oceania Geosciences Society (AOGS)-AGU (WPGM) Joint Assembly, Singapore, 13–17 August 2012, CD-ROM.

Ghaderi, M., Kouhestani, H., Khin Zaw, and Mernagh, T., 2012, Fluid inclusion microthermometry and Raman spectroscopic analysis of the Chah Zard epithermal gold-silver deposit, west central Iran: Asian Current Research on Fluid Inclusions - ACROFI IV, Brisbane, Australia, 10–12 August.

Giuliani, A., Kamenetsky, V.S., Kendrick, M.A., and Phillips, D., 2012, Mobilisation of Ni and transition metals by alkaline volatile-rich fluids and olivine serpentinisation in the sub-cratonic lithospheric mantle: 34th International Geological Congress, Brisbane, Australia, 5–9 August, p. 2705.

Giuliani, A., Kamenetsky, V.S., Phillips, D., Wyatt, B.A., and Hutchinson, G., 2012, Alkali-carbonate fluids in the lithospheric mantle: 10th International Kimberlite Conference, Bangalore, India, 6–11 February, p. 10IKC-110.

Göemann, K., Vasyukova, O.V., Kamenetsky, V.S., Macrae, C.M., and Wilson, N.C., 2012, Determination of trace element distribution in quartz by hyperspectral cathodoluminescence microscopy: 10th Asia-Pacific Microscopy Conference, Perth, Western Australia, 5–9 February, p. 365–1 – 365–2.

Graham, I.T., Voudouris, P., Melfos, V., Zaw, K., Meffre, S., Sutherland, F.L., Giuliani, G., and Fallick, A.E., 2012, Gem corundum deposits of Greece: A spectrum of compositions and origins: 34th International Geological Congress, Brisbane, Australia, 5–9 August, p. 3241.

Hunt, J., Berry, R., Bradshaw, D., and Triffett, B., 2012, Development of liberation/recovery domains: Examples from Prominent Hill, Australia: Geomet 2012, Santiago, Chile, 5–7 December.

Hunt, J., Berry, R., Bradshaw, D., and Triffett, B., 2012, Development of liberation/recovery domains: Examples from the Prominent Hill IOCG deposit, Australia: Process Mineralogy 2012, Cape Town, South Africa, 7–9 November.

Hunt, J., Berry, R., Montoya, P., Leichliter, S., Triffett, B., and Rocha, M., 2012, Using calculated mineralogy in geometallurgy: Geomet 2012, Santiago, Chile, 5–7 December.

Hunt, J., Berry, R., Triffett, B., Montoya, P., and Rocha, M., 2012, Using calculated mineralogy in geometallurgy: 34th International Geological Congress, Brisbane, Australia, 5–9 August.

Jansen, N.H., Gemmell, J.B., Chang, Z., and Hollings, P., 2012, Genesis of porphyry-epithermal mineralisation at the Cerro la Mina prospect, Mexico: 34th International Geological Congress, Brisbane, Australia, 5–9 August.

Jansen, N.H., Gemmell, J.B., Chang, Z., and Kyne, R., 2012, Origin of deep halloysite, Cerro la Mina porphyry-epithermal prospect: Gordon Research Conference, New Hampshire, USA, 15–20 July.

Jimenez, C., Cooke, D.R., White, N.C., Baker, M.J., and Turnbull, D., 2012, The Unicorn porphyry Molybdenum-(copper) deposit, NE Victoria, Australia: XVI Peruvian Geological Congress & SEG 2012 Conference, Lima, Peru, 23–26 September.

Kamenetsky, V.S, 2012, Magmatic immiscibility uncovered by melt and fluid inclusion research: 34th International Geological Congress, Brisbane, Australia, 5–9 August, p. 3218.

Kamenetsky, V.S., and Vasyukova, O.V., 2012, A mystery of hydrothermal fluids: Myths and facts about fluid inclusions: Asian Current Research on Fluid Inclusions – ACROFI IV, Brisbane, Australia, 10–12 August, p. 39–41.

Khin Zaw, 2012, Chairman opening remarks: Myanmar Mining Investment Forum, Singapore, 3–6 December.

Khin Zaw, 2012, Effectively using geospatial information for exploration in SE Asia and South China: GIS in Mining & Exploration Online Summit, 23 January – 6 February, Webinar.

Khin Zaw, 2012, Myanmar mineral deposit types and exploration potentials: Workshop on Mines and Minerals of Myanmar: Myanmar Mining Summit, Yangon, Myanmar, 22–25 July.

Khin Zaw, 2012, Tectonics and metallogeny of SE Asia: 6th International Symposium of ICREMER, Akita University, Akita, Japan, 2 July.

Khin Zaw, 2012, The outlook of Myanmar's mineral resources: Myanmar Mining Investment Forum, Singapore, 3–6 December.

Khin Zaw, 2012, VHMS deposits in SE Asia: The 9th Annual Meeting of the Asia-Oceania Geosciences Society (AOGS)-AGU (WPGM) Joint Assembly, Singapore, 13–17 August 2012, CD-ROM.

Khin Zaw, Sutherland, F.L., Meffre, S., Yui, T-F., and Thu, K., 2012, Distinctive geochemistry among placer ruby suites, Mogok gem field, Myanmar: 34th nternational Geological Congress, Brisbane, Australia, 5–9 August, p. 3243.

Khositanont, S., and Khin Zaw, 2012, Geochemical characteristics and U-Pb zircon age determination of the Lampang-Phrae volcanic belt: Implication for tectonic evolution of the Shan-Thai Terrane: GeoMyanmar, First International Conference on Regional Geology, Stratigraphy and Tectonics and Economic Geology of Myanmar and neighbouring countries, Yangon, Myanmar, 1–2 March.

Khositanont, S., Khin Zaw, and Panjasawatwong, Y., 2012, Reconstruction on plate tectonic and evolution of Sukhotai and Loei-Phetchabun Fold Belt; Evidences from geochemistry and U-Pb zircon age determination: GEOSEA 2012, 12th Regional Congress on Geology, Mineral and Energy Resources of SE Asia, Bangkok, Thailand, 7–8 March.

Khositanont, S., Meffre, S., and Khin Zaw, 2012, Application of Laser Ablation ICP-MS analytical technique to the U-Pb age determination of the gemstone quality zircon megacrysts in Thailand: The 9th Annual Meeting of the Asia-Oceania Geosciences Society (AOGS)-AGU (WPGM) Joint Assembly, Singapore, 13–17 August 2012, CD-ROM.

Kiseeva, E.S., Litasov, K.D., Yaxley, G.M., Ohtani, E., and Kamenetsky, V.S., 2012, Phase relations of eclogite + 4.4% CO2 at 9-21 GPa: Implications for diamond formation in the deep mantle: 10th International Kimberlite Conference, Bangalore, India, 6–11 February, p. 10IKC-81.

Kiseeva, E.S., Yaxley, G.M., and Kamenetsky, V.S., Carbonated eclogite at 3.5-5.5 GPa – the effect of the capsule material on solidus temperatures: 10th International Kimberlite Conference, Bangalore, India, 6–11 February, p. 10IKC-81.

Kojovic, T., and Walters, P., 2012, Development of the JK Bond Ball Lite Test: Geomet 2012, Santiago, Chile, 5–7 December.

Kojovic, T., and Walters, P., 2012, Managing your GeoMet ore characterisation needs with the JKRBT: Geomet 2012, Santiago, Chile, 5–7 December.

Lai, C.K., Khin Zaw, Meffre, S., Crawford, A.J., Halpin, J.H., Xue, C.D., Salam, A., and Manaka, T., 2012, Geology of the Paleozoic Central Ailaoshan Melange: 2012 International Association for Gondwana Research Annual Convention and 9th International Symposium on Gondwana to Asia, Adelaide, Australia, 18–20 November.

Laird, J.S., Large, R.R., and Ryan, C.G., 2012, Impurity heterogeneity in natural pyrite and its relation to internal electric fields mapped using remote Laser Beam Induced Current: 13th ICNMTA Conference, Lisbon, Portugal, 22–27 July.

Laird, J.S., Large, R.R., Thomas, H., and Ryan, C.G., 2012, Imaging micro-galvanic junctions in arsenian pyrite associated with impurity and mixed sulfide heterogeneity: 34th International Geological Congress, Brisbane, Australia, 5–9 August.

Laird, J.S., Szymanski, R., Large, R., and Ryan, C.G., 2012, Application of nuclear microprobes towards understanding complex ore geo-electrochemistry: Heavy Ion Accelerator Symposium, Canberra, Australia, 11–13 April.

Laird, J.S., Syzmanski, R., and Ryan, C.G., 2012, Beam-line control and LabVIEW FPGA based multi-channel data collection system for the nuclear microprobe: MicroDAQ: 13th ICNMTA Conference, Lisbon, Portugal, 22–27 July.

Laird, J.S., Syzmanski, R., Ryan, C.G. and Gonzalez-Alvarez, I., 2012, A Labview based FPGA data acquisition system with integrated stage and beam transport control: 13th ICNMTA Conference, Lisbon, Portugal, 22–27 July.

Large, R.R., 2012, Linking university research with industry; Two-way communication for maximum benefit: 34th International Geological Congress, Brisbane, Australia, 5–9 August.

Large, R.R., Danyushevsky, L.V., Meffre, S., Burnett, R., Bull, S., and Gilbert, S., 2012, The carbon Leader reef in the Witwatersrand Basin; New Data to Resolve the Controversy: SEG 2012 Conference, Lima, Peru, 23–26 September.

Large, R., Danyushevsky, L., Meffre, S., Burnett, R., Bull, S., and Kamenetsky, M., 2012, The Carbon Leader Reef in the Witwatersrand Basin: Why is it such a unique supergiant gold deposit?: 34th International Geological Congress, Brisbane, Australia, 5–9 August, p. 622.

Lawlis, E., Cooke, D.R., Micko, J., Jansen, N.H., Smart, G., and Rutter, J., 2012, Geology of the Kapit NE ore zone, Lihir gold mine, Papua New Guinea: Graduate Research-Sharing Excellence in Research (GR-SEiR) Conference, University of Tasmania, Hobart, Australia, 6–7 September, p. 44.

Lygin, A., Kamenetsky, V.S., Foster, J., and Goemann, K., 2012, The Avebury nickel deposit: Metal rich fluid inclusions in olivine, evidence of nickel transport by brine-rich fluids: 34th International Geological Congress, Brisbane, Australia, 5–9 August, p. 1822.

Makoundi, C., and Khin Zaw, 2012, Geological and geochemical characteristics of the Tersang orogenic gold deposit in the Central Gold Belt, Peninsular Malaysia: GeoMyanmar, First International Conference on Regional Geology, Stratigraphy and Tectonics and Economic Geology of Myanmar and neighbouring countries, Yangon, Myanmar, 1–2 March.

Manaka, T., Khin Zaw, and Meffre, S., 2012, Geology and mineralization characteristics of the Ban Houayxai Au-Ag epithermal deposit, Northern Lao PDR: GeoMyanmar, First International Conference on Regional Geology, Stratigraphy and Tectonics and Economic Geology of Myanmar and neighbouring countries, Yangon, Myanmar, 1–2 March.

McGoldrick, P.J., Satterthwait, D., Planavsky, M., and Lyons, T., 2012, The Century zinc deposit and life at the fringe: 34th International Geological Congress, Brisbane, Australia, 5–9 August, p. 3219.

McNeill, A.W., Danyushevsky, L.V., Klimm, K., Ariskin, A., and Perfit, M., 2012, Siqueiros Transform MORB; characteristics of a S-saturated suite: Goldschmidt 2012 Conference, Montreal, Canada, 24–29 June.

McNeill, A.W., Mortensen, J., and Gemmell, J.B., 2012, High precision U-Pb chronostratigraphy of the Mount Read Volcanics, Tasmania: Implications for mineral exploration and tectonic reconstructions: Selwyn Symposium, Melbourne, Australia, 27 September.

McNeill, A.W., Mortensen, J., and Gemmell, J.B., 2012, Results and implications of high precision CA-TIMS dates from the MRV: AusIMM /GSA Explore the Science Symposium, Strahan, Australia, 6–7 December.

Meffre, S., Cluzel, D., and Falloon, T.J., 2012, Paleocene to Eocene tectonic history of the SW Pacific island arc system: 34th International Geological Congress, Brisbane, Australia, 5–9 August, p. 1093.

Micko, J., Tosdal, R., Dipple, G., Chamberlain, C., and Halley S., 2012, The geochemical footprint of the Central Zone alkalic Cu-Au porphyry deposit, Galore Creek district, northwestern British Columbia, Canada: 34th International Geological Congress, Brisbane, Australia, 5–9 August.

Myint, Y.Y., and Khin Zaw, 2012, Petrological and mineralogical aspects of granitoid rocks from northwestern part of Pyetkaywe Batholith, Myittha townships, Mandalay Division, Myanmar: Implication for pegmatite-related gem deposits: The 9th Annual Meeting of the Asia-Oceania Geosciences Society (AOGS)-AGU (WPGM) Joint Assembly, Singapore, 13–17 August 2012, CD-ROM.

Myint, A.Z., Swe, Y.M., Khin Zaw, Manaka, T., and Stein, H., 2012, Petrological and geochemical constraints on the tectonic setting of Mawchi Granite, Kayah State, Myanmar: GeoMyanmar, First International Conference on Regional Geology, Stratigraphy and Tectonics and Economic Geology of Myanmar and neighbouring countries, Yangon, Myanmar, 1–2 March.

Oliver, G., Prave, A., and Khin Zaw, 2012, Upper Triassic/lower Jurassic Continental Red Beds in Singapore: Paleogeography and detrital U-Pb zircon dating of the Jurong Formation and the Indosinian Orogeny: The 9th Annual Meeting of the Asia-Oceania Geosciences Society (AOGS)-AGU (WPGM) Joint Assembly, Singapore, 13–17 August 2012, CD-ROM.

Oo, K.L., Khin Zaw, Meffre, S., and Myitta, D.W.A., 2012, Tectonic setting of the Pondaung Sandstones, Southern Chindwin Basin, Myanmar: Evidences from petrography, XRF-trace element geochemistry and LA ICP-MS U-Pb zircon geochronology: GeoMyanmar, First International Conference on Regional Geology, Stratigraphy and Tectonics and Economic Geology of Myanmar and neighbouring countries, Yangon, Myanmar, 1–2 March.

Oo, N.N., Khin Zaw, and Sutherland, F., 2012, Petrological and geochemical studies of the Bawpadan-Chinthe Taung area, Mogok, Mandalay Divison, Myanmar: Implications for ruby genesis: The 9th Annual Meeting of the Asia-Oceania Geosciences Society (AOGS)-AGU (WPGM) Joint Assembly, Singapore, 13–17 August 2012, CD-ROM.

Oo, Z.N., Khin Zaw, and Tun, S.T., 2012, Formation of orogenic gold deposits in regional strike-slip tectonic domain: Example from Meyon Gold deposit, Mon State, Southern Myanmar: GeoMyanmar, First International Conference on Regional Geology, Stratigraphy and Tectonics and Economic Geology of Myanmar and neighbouring countries, Yangon, Myanmar, 1–2 March.

Orovan, E.A., Cooke, D.R., Harris, A.C., and Ackerman, B., 2012, Geology of the Namosi porphyry Cu-Au district, southeastern Viti Levu, Fiji: 34th International Geological Congress, Brisbane, Australia, 5–9 August, p. 29.

Orovan, E.A., Cooke, D.R., Harris, A.C., and Micko, J., 2012, Geology, geochemistry and genesis of the Namosi Porphyry Copper Deposits, Fiji: Gordon Research Conference, New Hampshire, USA, 15–20 July.

Pass, H.E., Cooke, D.R., Davidson, G., Maas, R., Dipple, G., Rees, C., Ferreira, L., Taylor, C., and Deyell, C.L., 2012, Isotope geochemistry of the Northeast Zone, Mount Polley Cu-Ag-Au porphyry deposit: A case for carbonate assimilation: 34th International Geological Congress, Brisbane, Australia, 5–9 August.

Patel, A., Manga, M., Carey, R.J., Degruyter, W., and Dufek, J., 2012, Effects of thermal quenching on the breakup of pyroclasts: AGU Fall Meeting, San Francisco, USA, 3–7 December.

Pilia, S., Rawlinson, N., Direen, N.G., and Reading, A.M., 2012, Beneath Bass Strait: Linking Tasmania and mainland Australia using ambient seismic noise: AGU Fall Meeting, San Francisco, USA, 3–7 December.

Piquer, J., and Skarmeta, J., 2012, Tectonic evolution of the Andes in the Rio Blanco-Los Bronces district, Central Chile: Controls on stratigraphy, magmatism and mineralization: Geological Society of Australia, SGTSG Conference, Waratah Bay, Australia, 29 January – 3 February, Proceedings, p. 105–107.

Piquer, J., and Skarmeta, J., 2012, Structural controls on stratigraphy, magmatism and mineralization in the Rio Blanco-Los Bronces district, Central Chile: Chilean Geological Congress, 13th, Antofagasta, Chile, 5–9 August, Proceedings, Thematic Session 1, p. 19–21.

Prokofiev, V.Y., Selector, S.L., Kamenetsky, V.S., and Rodemann, T., 2012, Triassic age colloid solutions in fluid inclusions in

chalcedony: Asian Current Research on Fluid Inclusions – ACROFI IV, Brisbane, Australia, 10–12 August, p. 59–60.

Reading, A.M., 2012, Australian adventures with the ambient seismic wavefield: Heiland Lecture, Colorado School of Mines, USA, 5 April.

Reading, A.M., 2012, Seismic noise sources and storm severity in the Southern Ocean: Insights from the Warramunga Array, WRA, Northern Territory, Australia: AGU Fall Meeting, San Francisco, USA, 3–7 December.

Reading, A.M., Young, M.K., Rawlinson, N., Tkalcic, H., and Sandiford, M., 2012, Infrequent earthquakes and far-field plate tectonic forces: The importance of structure in relating short and long term tectonic processes: AGU Fall Meeting, San Francisco, USA, 3–7 December.

Rinne, M.L., Cooke, D.R., Harris, A.C., Erceg, M., Finn, D., Menzies, D., Croaker, M., and Micko, J., 2012, The geology and genesis of the telescoped Wafi-Golpu porphyry-epithermal system, Papua New Guinea: 34th International Geological Congress, Brisbane, Australia, 5–9 August.

Ryan, C., Kirkham, R., Parry, D., Siddons, P., Dunn, P., Laird, J., Kuczewski, A., Szymanski, R., Jensen, M., Li, Z.Y., de Jonge, M., Paterson, D., Howard, D., De Geronimo, G., Davey, P., Moorhead, G., Farrant, D., Cleverley, J., and Hough, R., 2012, Maia in a box: High definition PIXE mapping system for the CSIRO Nuclear Microprobe: International Conference on Nuclear Microprobe Technology and Applications (ICNMTA 2012), Lisbon, Portugal, 22–27 July.

Ryan, C.G., Kirkham, R., Siddons, D.P., de Jonge, M.D., Paterson, D., Dunn, P.A., Kuczewski, A., Jensen, M., Li, Z.Y., De Geronimo, G., Howard, D.L., Moorhead, G., Cleverley, J., Borg, S., Lombi, E., Barnes, S.J., Hough, R., Davey, P., and Donner, E., 2012, High definition 2D and 3D X-ray fluorescence imaging in real-time: Maia detector system quantitative imaging methods: 11th International Conference on X-ray Microscopy, Shanghai, China, 5–10 August.

Salam, A., and Khin Zaw, 2012, Chatree Volcanic Complex and low-sulphidation epithermal gold mineralisation, Phetchabun Province, central Thailand: GeoMyanmar, First International Conference on Regional Geology, Stratigraphy and Tectonics and Economic Geology of Myanmar and neighbouring countries, Yangon, Myanmar, 1–2 March.

Salam, A., Khin Zaw, Meffre, S., and McPhie, J.,2012, Geochemistry of Chatree Volcanic Complex Phetchabun Province, central Thailand: GEOSEA 2012, 12th Regional Congress on Geology, Mineral and Energy Resources of SE Asia, Bangkok, Thailand, 7–8 March.

Sanematsu, K., Kon, Y., Imai, A., Manaka, T., Khin Zaw, and Watanabe, Y., 2012, Potential of weathering REE deposits in Southeast Asia: Resource Geology Society Conference on Mineral Exploration in Asia, University of Tokyo, Japan, June.

Scott, R.J., Halpin, J., Selley, D., Duffett, M., and Richards, M., 2012, The ups and downs of Africa's largest copper deposit: The structural and metamorphic history at Lumwana, Mwombezhi Dome, NW Zambia: Geological Society of Australia, SGTSG Conference, Waratah Bay, Australia, 29 January – 3 February, p. 125–127.

Smith, S., and Khin Zaw, 2012, Mineral prospectivity of Myanmar- Lessons from adjacent regions: Myanmar Mining Summit, Yangon, Myanmar, 22–25 July.

Spetsius, Z.V., and Kamenetsky, V.S., 2012, Mapping of mineral phases around diamonds in eclogite xenoliths from the Udachnaya kimberlite pipe (Yakutia): Remarks to their metasomatic genesis: 10th International Kimberlite Conference, Bangalore, India, 6–11 February, p. 10IKC-178.

Sutherland, F.L., Abduriyim, A., Khin Zaw, and Graham, I.T., 2012, Geographic typing of gem corundum: Possibilities and pitfalls: 34th International Geological Congress, Brisbane, Australia, 5–9 August.

Thomas, H.V., Large, R.R., and Danyushevsky, L.V., 2012, Using Laser Ablation-ICPMS technology to investigate gold deportment in sulfides: SEG 2012 Conference, Lima, Peru, 23–26 September.

Thorne, A.M., Tyler, I.M., Korsch, R.J., Johnson, S.P., Brett, J.W., Cutten, H.N., Blay, O., Kennett, B.L.N., Blewitt, R.S., Joly, A., Dentith, M., Holzschuh, J., Goodwin, J., Salmon, M., Reading, A.M., and Boren, G., 2012, Preliminary interpretation of deep seismic reflection line 10GA-CP1: Crustal architecture of the northern Capricorn Orogen: 34th International Geological Congress, Brisbane, Australia, 5–9 August.

Tran, H.T., Khin Zaw, and Le, T.X., 2012, Sedimentary rock-hosted gold mineralization in Ngan Son district, Northeastern Vietnam: GeoMyanmar, First International Conference on Regional Geology, Stratigraphy and Tectonics and Economic Geology of Myanmar and neighbouring countries, Yangon, Myanmar, 1–2 March.

Tran, T.H., Ngo, T., Khin Zaw, and Halpin, J., 2012, The nature of ophiolite-style mélanges along the Northeastern margin of Indochina and their possible linkage to the paleotethys: The 9th Annual Meeting of the Asia-Oceania Geosciences Society (AOGS)-AGU (WPGM) Joint Assembly, Singapore, 13–17 August 2012, CD-ROM.

Umor, M.R., Ghani, A.A., Mohamad, H., Leman, M.S., Khin Zaw and Hussin, A., 2012, The comparison study of granite affinities between Bukit Sawak Granite and Gunung Raya Granite from Laangkawi Island, Malaysia Peninsular: GeoMyanmar, First International Conference on Regional Geology, Stratigraphy and Tectonics and Economic Geology of Myanmar and neighbouring countries, Yangon, Myanmar, 1–2 March.

Umor, M.R., Ghani, A.A., Shafeea, H.M., Leman, M.S., Khin Zaw and Hussin, A., 2012, The petrography and geochemistry of the Palong Pluton from the Central Belt of Malaysia Peninsula: Implications to tectonic emplacement: GeoMyanmar, First International Conference on Regional Geology, Stratigraphy and Tectonics and Economic Geology of Myanmar and neighbouring countries, Yangon, Myanmar, 1–2 March.

Voudouris, C.P., Graham, I., Melfos, V., Sutherland, F.L., and Khin Zaw, 2012, Gemstones of Greece: Mineralogy and origins: 34th International Geological Congress, Brisbane, Australia, 5–9 August.

Weaver, S.J., Rust, A., Carey, R.J., and Houghton, B.F., 2012, Characterisation of fine ash fractions from the AD1314 Kaharoa eruption: AGU Fall Meeting, San Francisco, USA, 3–7 December.

Wilkinson, J., Chang, Z., Cooke, D.R., Baker, M., Inglis, S., and Wilkinson, C., 2012, Chlorite chemistry as an exploration tool in the propylitic halo of porphyry-epithermal systems: A case study of the Batu Hijau porphyry Cu-Au system, Indonesia: Gordon Research Conference, New Hampshire, USA, 15–20 July.

Wu, S., McNeill, A.W., and Gemmell, J.B., 2012, Alteration mineral chemistry of the VHMS deposits in the Que-Hellyer Volcanics, Tasmania: AusIMM /GSA Explore the Science Symposium, Strahan, Australia, 6–7 December.

Xie, Y., Cooke, D.R., Dominy, S.C., Danyushevsky, L., and Li, Y., 2012, Can small volume carbonatite melts cause giant REE mineralization?: 34th International Geological Congress, Brisbane, Australia, 5–9 August.

Yaxley, G.M., Berry, A.J., Kamenetsky, V.S., Woodland, A.B., Paterson, D., de Jonge, M.D., and Howard, D.L., 2012, Application of Fe K-edge XANES determinations of Fe3+/ΣFe in garnet to peridotite xenoliths from the Udachnaya Kimberlite: 10th International Kimberlite Conference, Bangalore, India, 6–11 February, p. 10IKC-74.

Yaxley, G.M., Berry, A.J., Woodland, A.B., Kamenetsky, V.S., Paterson, D., de Jonge, M.D., and Howard, D.L., 2012, Application of Fe K-edge XANES determinations of Fe3+/ΣFe in garnet to peridotite xenoliths from the Udachnaya Kimberlite: EGU General Assembly, Vienna, Austria, 22–27 April, p. EGU2012-1727.

Zhang, L., Cooke, D.R., Zhou, T., Fan, Y., Chang, Z., Chen, H., and Yuan, F., 2012, The Nihe Iron Deposit, Anhui Province, Eastern China: Skarn, IOCG or porphyritic iron deposit? Gordon Research Conference, New Hampshire, USA, 15–20 July.

Zhang, L., Zhou, T., Cooke, D.R., Fan, Y., Chang, Z., Chen, H., Fox, N., and Yuan, F., 2012, The alteration, mineralization and mineral chemistry of the Nihe iron deposit, Anhui Province, China: 34th International Geological Congress, Brisbane, Australia, 5–9 August.

Zhang, L., Zhou, T., Cooke, D.R., Fan, Y., Chang, Z., Chen, H., Fox, N., and Yuan, F., 2012, The alteration, mineralization and mineral chemistry of the Nihe iron deposit, Anhui Province, Eastern China: SEG 2012 Conference, Lima, Peru, 23–26 September.

Zhitova, L., Kamenetsky, V., Sharygin, V., Gora, M., and Shevko, A., 2012, Origin of the Bushveld and Norilsk basic melts recorded in Cr-spinels and spinel-hosted multiphase inclusions: 34th International Geological Congress, Brisbane, Australia, 5–9 August, p. 3219.

Invited Keynote Addresses (14)

Burrett, C.F., Meffre, S., Khin Zaw, Khositanont, S., Chaodumrong, P., and Udchachon, M., 2012, Sibumasu (Shan-Thai) in the Palaeozoic-Part of greater Gondwana or a vagrant terrane? Evidence from palaeontology, geology and sedimentary provenance: GEOSEA 2012, 12th Regional Congress on Geology, Mineral and Energy Resources of SE Asia, Bangkok, Thailand, 7–8 March.

Cooke, D.R., Baker, M., Wilkinson, J.J., Chang, Z., Chen, H., Gemmell, J.B., Hollings, P., Zhou, T., Ireland, T., and Wilkinson, C.C., 2012, New advances in geochemical exploration for porphyry deposits in green rock environments: 34th International Geological Congress, Brisbane, Australia, 5–9 August.

Cox, S.F., 2012, Permeability and fluid pathways in fault-controlled hydrothermal systems; a seismogenic framework: Structural Geology and Resources, Australian Institute of Geoscientists, Kalgoorlie, Western Australia, 26–28 September.

Danyushevsky, L., and Ariskin, A. A., 2012, Olivine record of crystal residence times and the internal dynamics of magmatic plumbing systems: Goldschmidt 2012 Conference, Montreal, Canada, 24–29 June.

Gemmell, J.B., Cooke, D.R., Chang, Z., White, N., Hollings, P., and Wilkinson, J., 2012, Metal dispersion around porphyry Cu-Mo-Au deposits: Implications for fluid flow and exploration: Gordon Research Conference, New Hampshire, USA, 15–20 July.

Kamenetsky, V.S., and Vasyukova, O.V., 2012, A mystery of hydrothermal fluids: Myths and facts about fluid inclusions: Asian Current Research on Fluid Inclusions – ACROFI IV, Brisbane, Australia, 10–12 August.

Kamenetsky, V.S., 2012, Magmatic immiscibility uncovered by melt and fluid inclusion research: 34th International Geological Congress, Brisbane, Australia, 5–10 August.

Khin Zaw, Tectonics and Metallogeny of SE Asia: Resource Geology Society Conference on Mineral Exploration in Asia, University of Tokyo, Japan , June, 2012.

Khin Zaw, 2012, Potential and prospectivity of Myanmar mineral resources in the context of SE Asian tectonics and metallogeny: GEOSEA 2012, 12th Regional Congress on Geology, Mineral and Energy Resources of SE Asia, Bangkok, Thailand, 7–8 March.

Khin Zaw, Tectonic setting and mineral deposits of Myanmar: 34th International Geological Congress, Brisbane, Australia, 5–10 August.

Khin Zaw, 2012, Tectonics, magmatism and mineral deposit types in SE Asia: GeoMyanmar, First International Conference on Regional Geology, Stratigraphy and Tectonics and Economic Geology of Myanmar and neighbouring countries, Yangon, Myanmar, 1–2 March.

Large, R.R., Danyushevsky, L.V., Meffre, S., Burnett, R., Bull, S., and Gilbert, S., 2012, The Carbon Leader Reef in the Witwatersrand Basin; Why is it such a Unique Supergiant Gold Deposit: 34th International Geological Congress, Brisbane, Australia, 5–10 August.

Large, R.R., 2012, Sources of gold and processes of concentration in sediment hosted gold deposits: AMEQ Convention, Quebec City, Canada, 18–22 November.

Ryan, C.G., Kirkham, R., Siddons, D.P., Dunn, P.A., Paterons, D., de Jonge, M.D., Kuczewski, A., Li, Z.Y., Howard, D.L., Moorhead, G., De Geronimo, G., Cleverley, J., Borg, S., Lombi, E., Barnes, S.J., Donner, E., Davey, P., and Jensen, M., 2012 Maia driven X-ray fluorescence imaging: Megapixels per hour for high definition 2D and 3D element imaging: 11th International Conference on Synchrotron Radiation Instrumentation, Lyon, France, 9–13 July.

Research Reports to Industry/ Government Agencies (119)

INCLUDES REPORTS IN A PRESENTATION FORMAT

Ageneau, M., Cooke, D.R., Gemmell, J.B., Danyushevsky, L., Rutter, J., Stewart, K., and Collett, D., 2012, Origin and geochemical evolution of the Ladolam low-sulfidation gold deposit, Lihir Island, PNG: Newcrest Sponsors Meeting, Brisbane, 10 August 2012, 45 p.

AMIRA P1060 team, 2012, Forward Program: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 3, Salt Lake City, USA, 12 July 2012, p. 200–201.

AMIRA P1060 team, 2012, Forward Program: Workshop for CODELCO, Rancagua, Chile, February 2012, 11 p.

Baig, A., Hollings, P., and Cooke, D.R., 2012, MAX mine porphyry Mo, Trout Lake, B.C.: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 4, Hobart, 5 December 2012, p. 25–34.

Baker, M., Cooke, D.R., Wilkinson, J.J., Cannell, J., and Vry, V., 2012, El Teniente, Chile: Workshop for CODELCO, Rancagua, Chile, February 2012, 33 p.

Baker, M., and Jimenez, C., 2012, Quebrada Blanca, Fieldwork report – December 2012: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 4, Hobart, 5 December 2012, p. 87–91.

Baker, M., Thompson, J., and Cooke, D.R., 2012, El Teniente – Quartz: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 4, Hobart, 5 December 2012, p. 135–140.

Baker, M., Thompson, J., Cooke, D., and Chen, H., 2012, Grasberg porphyry Cu-Au deposit study site update – July, 2012: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 3, Salt Lake City, USA, 12 July 2012, p. 10–23.

Baker, M., Thompson, J., and Gemmell, B., 2012, Newcrest green rock blind test: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 3, Salt Lake City, USA, 12 July 2012, p. 154–172.

Baker, M., Thompson, J., and Gemmell, B., 2012, Newcrest green rock blind test: Workshop for Freeport McMoRan, Manila, Philippines, 13 November 2012, 56 p.

Baker, M., Thompson, J., Lounejeva, E., Cooke, D.R., and Chen, H., 2012, Grasberg porphyry Cu-Au deposit, study site update – December 2012: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 4, Hobart, 5 December 2012, p. 117–134.

Baker, M., Wilkinson, J.J., Wilkinson, C.C., Thompson, J., and Feig, S., 2012, El Teniente – Magnetite: Workshop for CODELCO, Rancagua, Chile, February 2012, 22 p.

Baker, M., Zhang, L., Cooke, D.R., Wilkinson, J., Wilkinson, C., and Hollings, P., 2012, Bingham Canyon and Wasatch Mountains update: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 4, Hobart, 5 December 2012, p. 67–76.

Basori, M.B.I., 2012, Fluid inclusion study of the Tasik Chini VHMS deposit, Pahang District, Central Belt of Peninsular Malaysia: Ore Deposits of SE Asia (2010–2014) Report No. 4 and CD-ROM, Hobart, October 2012, 6 p.

Beattie, A., 2012, Geology and geochemistry of the Gooleys alkalic Cu-Au porphyry prospect, Cadia District, New South Wales: Newcrest Sponsors Meeting, Brisbane, Australia, 10 August 2012, 18 p.

Berry, R.F., 2012, Cadia East Copper/gold predictive recovery modelling: Final report: AMIRA P843A Cadia East Case Study Report, 94 p.

Berry, R.F., 2012, Core-scale imaging: A manual: AMIRA P843A Technical Report 10, 4.1–4.12.

Berry, R.F., 2012, P843A at a glance: Deliverables and status: AMIRA P843A Technical Report 10, 2 p.

Berry, R.F., Hunt, J.A., and Nguyen, K., 2012, Los Bronces Project: Core Imaging: AMIRA P843A Los Bronces Case Study Report, 17 p.

Burrett, C., Khin Zaw, and Meffre, S., 2012, Tectonic and palaeogeographic models of SE Asia: Ore Deposits of SE Asia (2010–2014) Report No. 4 and CD-ROM, Hobart, October 2012, 7 p.

Chang, Z., White, N., Cooke, D.R., Chen, H., and Gemmell, B., 2012, Lithocap exploration: Progress and challenges: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 3, Salt Lake City, USA, 12 July 2012, p. 223–240.

Chen, H., Gemmell, B., Zhang, L., Jansen, N., Cobenas, G., White, N., Thompson, J., and Lounejeva, E., 2012, La Zanja, Peru: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 3, Salt Lake City, USA, 12 July 2012, p. 143–153.

Chen, H., Gemmell, B., Zhang, L., Jansen, N., Cobenas, G., White, N., Thompson, J., and Lounejeva, E., 2012, La Zanja, Peru – Lithocap: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 4, Hobart, 5 December 2012, p. 77–86.

Chen, H., Gemmell, B., Zhang, L., Jansen, N., Cobenas, G., White, N., Thompson, J., and Lounejeva, E., 2012, La Zanja, Peru – Lithocap: Workshop for Freeport McMoRan, Manila, Philippines, 13 November 2012, 34 p.

Chen, H., Zhang, L., Cooke, D.R., White, N., Thompson, J., and Lounejeva, E., 2012, Mankayan District, Philippines: Testing the vectoring potential of quartz and pyrite: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 3, Salt Lake City, USA, 12 July 2012, p. 106–129.

Cooke, D.R., 2012, AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems – Introduction: Workshop for CODELCO, Rancagua, Chile, February 2012, 30 p.

Cooke, D.R., 2012, Forward program: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 4, Hobart, 5 December 2012, p. 211–212.

Cooke, D.R., Baker, M., Chen, H., Wilkinson, J., Gemmell, J.B., Chang, Z., and White, N., 2012, The sides of porphyry copper-gold deposits – Exploring in green rocks: Workshop for Freeport McMoRan, Manila, Philippines, 13 November 2012, 63 p.

Cooke, D.R., Chang, Z., White, N., Chen, H., Zhang, L., and Hedenquist, J., 2012, The tops of porphyry deposits – HS deposits, lithocaps and other features: Workshop for Freeport McMoRan, Manila, Philippines, 13 November 2012, 106 p.

Cooke, D.R., Fox, N., Thompson, J., Baker, M., and Zhang, L., 2012, Epidote synthesis – December 2012: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 4, Hobart, 5 December 2012, p. 155–194.

Cooke, D.R., Gemmell, J.B., Chang, Z., Hedenquist, J., White, N., Chen, H., and Jansen, N.H., 2012, The tops of porphyry deposits – Lithocaps and other features: Newcrest Sponsors Meeting, Brisbane, 10 August 2012, 23 p.

Cooke, D.R., Gemmell, J.B., Large, R.R., Micko, J., Jansen, N., Fox, N., Meffre, S., Orovan, E., Rinne, M., Ageneau, M., Clark, L., Lawlis, E., Beattie, A., and Dunne, M., 2012, Newcrest – CODES research workshop introduction: Newcrest Sponsors Meeting, Brisbane, 10 August 2012, 3 p.

Cooke, D.R., Thompson, J., Fox, N., Wilkinson, C., and Wilkinson, J., 2012, Bingham Canyon: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 3, Salt Lake City, 12 July 2012, p. 33–67.

Cooke, D.R., Wilkinson, J.J., Baker, M., Chang, Z., Chen, H., Wilkinson, C.C., Inglis, S., and Hollings, P., 2012, Technique validation using blind test sites: Workshop for CODELCO, Rancagua, Chile, February 2012, 23 p.

Cooke, D.R., Wilkinson, J., Gemmell, B., Chen, H., Baker, M., Hollings, P., Fox, N., Zhang, L., and Thompson, J., 2012, AMIRA P1060 – Introductory Workshop: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 3, Salt Lake City, USA, 12 July 2012, p. 202–222.

Cooke, D.R., Wilkinson, J., Hollings, P., Baker, M., Zhang, L., and Thompson, J., 2012, P1060 field guide – Intrusive and magmatic-hydrothermal features of the Central Wasatch Mountains, Utah: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 3, Salt Lake City, USA, 11 July 2012, 22 p.

Cooke, D.R., Wilkinson, J.J., and Wilkinson, C.C., 2012, P1060 – Methodology: Workshop for CODELCO, Rancagua, Chile, February 2012, 15 p.

Cooke, D.R., and Zhang, L., 2012, AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems – Introduction: Workshop for Freeport McMoRan, Manila, Philippines, 13 November 2012, 14 p.

Cox, S.F., 2012, Textural analysis and mineral assemblages of a suite of veins from the Far Southeast ore system, northern Luzon, Philippines: Report to Far Southeast Gold Resources, 38 p.

Crow, M., 2012, Sumatra and its mineral systems potential: Ore Deposits of SE Asia (2010–2014) Report No. 4 and CD-ROM, Hobart, October 2012, 6 p.

Crow, M., and Van Waveren, I., 2012, The western Permian volcanic arc, west of Bangko, Sumatra: Ore Deposits of SE Asia (2010–2014) Report No. 4 and CD-ROM, Hobart, October 2012, 8 p.

Davidson, G.J., 2012, Sunrise Dam stable isotopes, Report II: Report to Anglogold Ashanti, Brisbane, February 2012, 23 p.

Davidson, G.J., and Salam, A., 2012, Chatree case study, Central Thailand: Evaluation of the exploration applications of pyrite chemistry from a Mesozoic epithermal setting; Pit D: AMIRA P1041 – Application of New Technologies to Gold Deposits, Progress Report 2, Hobart, September 2012, 29 p.

Davidson, G.J., Williams, P., Gale, K., Bull, S., and Meffre, S., 2012, Sulfide sulfur isotope variation of Gap Zone hole D576: Insights into ore zonation and formation in metacarbonate units at Prominent Hill: Report to OZ Minerals, Adelaide, July 2012, 35 p.

Fox, N., 2012, Controls on alteration and mineralisation at the Cadia East alkalic porphyry Au-Cu deposit, NSW: Newcrest Sponsors Meeting, Brisbane, 10 August 2012, 47 p.

Fox, N., Baker, M., and Wilkinson, C., 2012, La Colosa porphyry-Au deposit, Colombia: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 3, Salt Lake City, USA, 12 July 2012, p. 24–32.

Fox, N., Cooke, D.R., and Thompson, J., 2012, Green rock blind test – Gold Fields #2: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 3, Salt Lake City, USA, 12 July 2012, p. 90–105.

Fox, N., Thompson, J., and Cooke, D.R., 2012, Results of LA-ICPMS analyses of epidote and chlorite for indications of porphyry Cu mineralisation and fertility: Confidential Report for BHP Billiton, 20 p.

Fox, N., Thompson, J., and Cooke, D.R., 2012, Results of LA-ICPMS analyses of epidote from 10 drill core samples: Confidential Report for St. Barbara Limited, 26 p.

Gemmell, J.B., 2012, Introduction to P1060: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 3, Salt Lake City, USA, 12 July 2012, p. 4–9.

Gemmell, J.B., 2012, Introduction to P1060: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 4, Hobart, 5 December 2012, p. 3–6.

Gemmell, J.B., 2012, May Progress Report – Deposit to District-scale Study of the Gosowong Goldfield: Report submitted to Newcrest, 18 p.

Gemmell, J.B., and Fulton, R., 2012, Geology and geochemistry of the hanging-wall argillite, Greens Creek VHMS deposit, Alaska: Implications for exploration: CAMIRO Project 08E04 Progress Report, March, 15 p.

Goh, K.C., 2012, Sediment-hosted Jugan Au deposit, Bau Mining District, Sarawak, east Malaysia: Ore Deposits of SE Asia (2010–2014) Report No. 4 and CD-ROM, Hobart, October 2012, 6 p.

Hai Thanh Tran, Khin Zaw, and Lai, C.K., 2012, Nature of ophiolite melanges along northeastern margin of indochina and their possible linkage to the paleotethys: Ore Deposits of SE Asia (2010–2014) Report No. 4 and CD-ROM, Hobart, October 2012, 11 p.

Hollings, P., Baker, M., Piquer, J., and Cooke, D.R., 2012, Regional geology of Central Chile: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 3, Salt Lake City, USA, 12 July 2012, p. 83–89.

Hollings, P., Baker, M., and Thompson, J., 2012, Cobre Panama porphyry Cu-Mo-Au district: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 4, Hobart, 5 December 2012, p. 101–116.

Hutchinson, D.I., Berry, R., Rodemann, T., and Goemann, K., 2012, Review of applications for laser Raman spectroscopy in geometallurgy: AMIRA P843A Technical Report 10, 6.1–6.14.

Jansen, N.H., 2012, Field report on the steam heated clay alteration, Lihir gold deposit: Report to Newcrest Mining Ltd, 29 May 2012, 6 p.

Jansen, N.H., 2012, Field report on the Wafi Lithocap: Report to Newcrest Mining Ltd, 21 November 2012, 5 p.

Jansen, N.H., 2012, Lithocap exploration and the Wafi lithocap: Report to Morobe Mining Joint Venture, Lau, PNG, 30 p.

Jansen, N.H., 2012, Progress report on Lihir steam-heated blanket fieldwork: Report to Newcrest Mining Ltd, 5 December 2012, 5 p.

Jansen, N.H., and Cooke, D.R., 2012, Exploring the lithocap and steam heated environment: Newcrest Sponsors Meeting, Brisbane, 10 August 2012, 19 p.

Jansen, N.H., and Cooke, D.R., 2012, Progress update on the Lihir steam-heated environment: Report to Newcrest Mining Ltd, 15 October 2012, 14 p.

Kamenetsky, V., McPhie, J., Kamenetsky, M., Orth, K., Cotterill, J., and Hennessy, S., 2012, Olympic Dam supergiant Cu-U-Au-Ag deposit: Towards a new genetic model: Final Report, 17 pp.

Khin Zaw, 2012, Aims, background and progress: Ore Deposits of SE Asia (2010–2014) Report No. 4 and CD-ROM, Hobart, October 2012, 7 p.

Khin Zaw, 2012, Executive summary: Ore Deposits of SE Asia (2010–2014) Report No. 4 and CD-ROM, Hobart, October 2012, 3 p.

Khin Zaw, 2012, Future program: Ore Deposits of SE Asia (2010–2014) Report No. 4 and CD-ROM, Hobart, October 2012, 9 p.

Khin Zaw and CODES research team, Quarterly Progress Report: Ore Deposits of SE Asia (2010–2014) Report No. 2, Hobart, Australia, April 2012, 379 p.

Khin Zaw and CODES research team, Quarterly Progress Report: Ore Deposits of SE Asia (2010–2014) Report No. 3, Hobart, September 2012, 930 p.

Khin Zaw, and Meffre, S., 2012, An overview of tectonics and ore deposit types in SE Asia: Ore Deposits of SE Asia (2010–2014) Report No. 4 and CD-ROM, Hobart, October 2012, 10 p.

Knight, J., 2012, Geological and geochronological framework of high-sulphidation Monywa Cu deposit area: Ore Deposits of SE Asia (2010–2014) Report No. 4 and CD-ROM, Hobart, October 2012, 8 p.

Kuhar, L., Benvie, B., Chapman, N.M., and Robinson, D.J., 2012, Predictive leaching indices: Mineralogical analysis in geometallurgical hydrometallurgy: AMIRA P843A Technical Report 10, 2.1–2.9.

Kuhar, L., Chapman, N., Meakin, R., Martin, R., McFarlane, A., Turner, N., and Robinson, D., 2012, Predictive leaching indices: Blast to leach: AMIRA P843A Technical Report 10, 3.1–3.14

Lai, C.K., Khin Zaw, and Meffre, S., 2012, G-Plate reconstruction of SE Asia: Ore Deposits of SE Asia (2010–2014) Report No. 4 and CD-ROM, Hobart, October 2012, 6 p.

Lai, C.K., Khin Zaw, and Meffre, S., 2012, New U-Pb zircon geochronological constraints on the Mogok–Ruili Metamorphic Belt: Ore Deposits of SE Asia (2010–2014) Report No. 4 and CD-ROM, Hobart, October 2012, 7 p.

Large, R., 2012, Temporal changes in molybdenum, copper and gold in the oceans: Significance for sediment-hosted copper and gold exploration: Ore Deposits of SE Asia (2010–2014) Report No. 4 and CD-ROM, Hobart, October 2012, 19 p.

Large, R.R., and Thomas, H.V., 2012, Gold-pyrite-magnetite mineral relationships Geita Hill, Tanzania: AMIRA P1041 – Application of New Technologies to Gold Deposits, six monthly report, February, 52 p.

Lawlis, E., Cooke, D.R., Micko, J., Jansen, N.H, Smart, G., and Rutter, J., 2012, Au-bearing Fe-sulfide ore of Lihir, PNG: Its physicochemical character and nature of the causative fluids: Newcrest Sponsors Meeting, Brisbane, 10 August 2012, 28 p.

Le, T.X., 2012, Xa Loi-Dong Chat Au deposit, Quang Tri Province, central Vietnam: Ore Deposits of SE Asia (2010–2014) Report No. 4 and CD-ROM, Hobart, October 2012, 8 p.

Lim, Y.G., 2012, North Kratie Au-base metal system, eastern Cambodia: Ore Deposits of SE Asia (2010–2014) Report No. 4 and CD-ROM, Hobart, October 2012, 10 p.

Lueck, W., and Hollings, P., 2012, Highland Valley porphyry Cu-Mo district, British Columbia, Canada: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 4, Hobart, 5 December 2012, p. 35–42.

Makoundi, C., 2012, Sediment-hosted Au deposits in central Malaysia: Ore Deposits of SE Asia (2010–2014) Report No. 4 and CD-ROM, Hobart, October 2012, 11 p.

Makoundi, C., 2012, Trace element variation in Phanerozoic shale sequences in Malaysia: implications for Au metallogeny of Sibumasu terrane: Ore Deposits of SE Asia (2010–2014) Report No. 4 and CD-ROM, Hobart, October 2012, 11 p.

Manaka, T., Khin Zaw, Lim, Y., Salam, A., and Meffre, S., 2012, Tectonics and mineral deposits of southern Indochina in Laos, Vietnam and Cambodia: Ore Deposits of SE Asia (2010–2014) Report No. 4 and CD-ROM, Hobart, October 2012, 10 p.

Manaka, T., Sanemasu, K., and Khin Zaw, 2012, Granitoid and mineralization in southern Myanmar: Ore Deposits of SE Asia (2010–2014) Report No. 4 and CD-ROM, Hobart, October 2012, 8 p.

Meffre, S., 2012, Gold deportment deliverables and workflow: AMIRA P1041 – Application of New Technologies to Gold Deposits Report, 21 February 2012, 19 p.

Meffre, S., 2012, Representivity: Comparing pyrite trace element spots, lines and images: Report to Newcrest, Hobart, 13 June 2012, 10 p.

Meffre, S., Khin Zaw, and Lai, C.K., 2012, Pb isotopes in SE Asia: Ore Deposits of SE Asia (2010–2014) Report No. 4 and CD-ROM, Hobart, October 2012, 3 p.

Micko, J., 2012, The green rock environment of the Cadia alkalic Au-Cu porphyry district, New South Wales, Australia: Newcrest Sponsors Meeting, Brisbane, 10 August 2012, 36 p.

Micko, J., Cooke, D.R., and Jansen, N., 2012, The hydrothermal alteration and mineralization of GW047 – Ladolam Au deposit, Lihir Island: Newcrest Sponsors Meeting, Brisbane, 10 August 2012, 17 p.

Nguyen, K., and Berry, R.F., 2012, STORC – Structure from oriented core: AMIRA P843A Technical Report 10, 5.1–5.7.

Orovan, E.A., Cooke, D.R., Harris, A.C., and Ackerman, B., 2012, Geology of the Namosi porphyry Cu-Au deposits, Viti Levu, Fiji: Newcrest Board Meeting, Brisbane, October 2012, 1 p.

Orovan, E.A., Cooke, D.R., Harris, A.C., and Ackerman, B., 2012, Geology of the Namosi porphyry Cu-Au deposits, Viti Levu, Fiji: Newcrest Sponsors Meeting, Brisbane, 10 August 2012, 31 p.

Pacey, A., Wilkinson, J., Jimenez, C., Cooke, D.R., and Zhang, L., 2012, Other student projects: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 4, Hobart, 5 December 2012, p. 43–56.

Piquer, J., Cooke, D.R., Berry, R., Scott, R., Hollings, P., and Baker, M., 2012, Central Chile: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 4, Hobart, 5 December 2012, p. 7–12.

Rinne, M.L., 2012, Summary of research progress on the Wafi-Golpu porphyry-epithermal system: Report to Newcrest Mining Ltd, 16 March 2012, p. 3.

Rinne, M.L., Cooke, D., Harris, A., Erceg, M., Finn, D., Menzies, D., and Croaker, M., 2012, PhD research progress on the Wafi-Golpu porphyry-epithermal system: Newcrest Sponsors Meeting, Brisbane, 10 August 2012, 35 p.

Rinne, M.L., Cooke, D., Harris, A., Erceg, M., Finn, D., Menzies, D., and Croaker, M., 2012, Summary of project outcomes and preliminary exploration implications of the Wafi-Golpu study: Newcrest Board Meeting, Brisbane, 10 October 2012, 1 p.

Salam, A., 2012, Up-date of Sumatra: Ore Deposits of SE Asia (2010–2014) Report No. 4 and CD-ROM, Hobart, October 2012, 7 p.

Salam, A., Khin Zaw, Meffre, S., Manaka, T., and Khositanont, S., 2012, Sukhothai and Loei belts in Eastern Thailand and Cambodia: Ore Deposits of SE Asia (2010–2014) Report No. 4 and CD-ROM, Hobart, October 2012, 3 p.

Schaa, R., and Fullagar, P., 2012, AMIRA P1022 – Rapid 3D Inversion of TEM Data: Progress Report, February, 54 p.

Scott, R.J., Goemann, K., and Rodemann, T., 2012, Gold paragenesis and deportment at Martabe HS epithermal deposit, Sumatra: AMIRA P1041 – Application of New Technologies to Gold Deposits, Sponsors Meeting 6, Hobart, September 2012, 49 p.

Subandrio, A., 2012, Evolution of magmatic rock and metallogenesis of Silboga granitoids complex, northern Sumatra: Ore Deposits of SE Asia (2010–2014) Report No. 4 and CD-ROM, Hobart, October 2012, 10 p.

Testa, F., Cooke, D.R., Baker, M., Zhang, L., Fox, N., Jimenez, C., and Wilkinson, C., 2012, San Francisco de los Andes, Argentina (Rio Blanco-Los Bronces, Chile): AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 4, Hobart, 5 December 2012, p. 13–24.

Thomas, H.V., and Large, R.R., 2012, Gold in sulfide minerals at the Golpu deposit, PNG: AMIRA P1041 – Application of New Technologies to Gold Deposits, six monthly report, February, 52 p.

White, N., Zhang, L., Chen, H., Chang, Z., and Cooke, D.R., 2012, Lithocap synthesis: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 4, Hobart, 5 December 2012, p. 141–154.

White, N., Zhang, L., Chen, H., and Testa, F., 2012, Pascua-Lama-Penelope-Veladero, Argentina and Chile: Insights and Exploration: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 4, Hobart, 5 December 2012, p. 57–66.

Wilkinson, C., Wilkinson, J., Bertini, M., and Chang, Z., 2012, Developing the toolbox: Magnetite at Batu Hijau: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 4, Hobart, 5 December 2012, p. 195–210.

Wilkinson, C., Wilkinson, J., and Chang, Z., 2012, Developing the toolbox: Magnetite at Batu Hijau: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 3, Salt Lake City, USA, 12 July 2012, p. 68–82.

Wilkinson, J., Cooke, D.R., Wilkinson, C., Baker, M., Thompson, J., Zhang, L., and Fox, N., 2012, P1060 drill core guide – Intrusions, wallrocks, mineralisation and alteration features of the Bingham Canyon district: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 3, Salt Lake City, USA, 13 July 2012, 28 p.

Zhang, L., Baker, M., and Cobenas, G., 2012, Haquira porphyry Cu-Mo deposit, Peru: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 4, Hobart, 5 December 2012, p. 93–100.

Zhang, L., Baker, M., Cooke, D.R., and Cobenas, G., 2012, Haquira porphyry Cu-Mo deposit, Peru: Workshop for Freeport McMoRan, Manila, Philippines, 13 November 2012, 28 p.

Zhang, L., Chen, H., White, N., Cooke, D.R., and Thompson, J., 2012, Greenrock blind test – INMET: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 3, Salt Lake City, USA, 12 July 2012, p. 173–199.

Zhang, L., Chen, H., White, N., Cooke, D.R., and Thompson, J., 2012, Greenrock blind test – INMET: Workshop for Freeport McMoRan, Manila, Philippines, 13 November 2012, 90 p.

Zhang, L., Chen, H., White, N., and Testa, F., 2012, Pascua-Lama-Penelope-Veladero, Argentina and Chile: AMIRA P1060 – Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems, Sponsors Meeting 3, Salt Lake City, USA, 12 July 2012, p. 130–142.

Zhang, L., Chen, H., White, N., and Testa, F., 2012, Pascua-Lama-Penelope-Veladero, Argentina and Chile: Workshop for Freeport McMoRan, Manila, Philippines, 13 November 2012, 58 p.

Zhou, T., et al., 2012, 3D model construction of the Nihe iron deposit in Luzong: Report to China Minmetals, December 2012.

Zhou, T., et al., 2012, Controlling factors and exploration targeting for the Shaxi porphyry copper deposit in Anhui: Report to Tongling Nonferrous Metals Group Holding, November 2012.

Appendices

CODES Postgraduate Students 2012

Graduate Diploma of Science (1)

Student	Supervisors	Project	Support
Wayne Baker	McNeill	The Correlations and exploration significance of the Natone Volcanics, Rosebery Group, western Tasmania	MMG

Bachelor of Science (Honours) (20)

Student	Supervisors	Project	Support
Andrew Beattie*	Cooke, Jansen, Micko	Geology and geochemistry of the Gooleys alkalic Cu-Au porphyry prospect, Cadia District, New South Wales	Newcrest Technology, TGMS
Renee Birchall*	Roach, Reading	Seismic characteristics of Plutonic Gold Mine	Barrick (Plutonic)
Jesse Cotterill^	V.Kamenetsky, McPhie	Mafic magmatism at the Wirrda Well prospect, Olympic Domain, Gawler Craton, South Australia: Implications for IOCG mineralisation	BHP Billiton Olympic Dam
Andrew Dolan*	Roach	Petrology and electrical properties of key lithologies at Prominent Hill, SA	OZ Minerals
Michael Dunne*	Roach, Gemmell	The magnetic and radiometric character of the Gosowong Goldfield, Halmahera Island, Indonesia	Newcrest Mining
Margaret (Meg) Ellis*	McGoldrick, Bull	Geology and enrichment of the Sharpnose Prospect, WA	Anglo American Exploration
Matthew Ferguson	Crawford, Large	Mineral paragenesis and geometallurgical characteristics of the Karlawinda Deposit, Western Australia	Independence Group
Kian Chee Goh^	Zaw	Geological and mineralisation characteristics of the Jugan Au deposit, Bau, Malaysia	Ore Deposits of SE Asia Project, Olympus Pacific Minerals
Sean Hennessy*	V.Kamenetsky, McPhie	Petrography, geochemistry and lead isotopes of the Upper Gawler Range Volcanics, South Australia	BHP Billiton Olympic Dam
Dilani Singappuli Jayathilaka^	Lottermoser	Experimental study on the prevention of acid mine drainage from Mt Lyell mine, Tasmania	Copper Mines of Tasmania (CMT)
Andrew Kleeman*	Bull, G.Davidson	The petrology and trace element geochemistry of the Carrapateena deposit, Olympic IOCG Province, South Australia	OZ Minerals Carrapateena, TGMS
Joe Knight*	Zaw	The geochemical and geochronological framework of the Monywa high sulphidation Cu and low sulphidation Au – epithermal deposits, Myanmar	Ore Deposits of SE Asia Project
Michael McGuire-Febey	McNeill, McPhie	Stratigraphy, structure and correlations of the Rosebery Group west of the Rosebery fault, Rosebery district, western Tasmania	MMG Exploration
Chris Memish*	McNeill, G.Davidson, Lottermoser	Hydrogeochemistry as an exploration method in the Mount Read Volcanics (MRV), western Tasmania	MMG Exploration
Eddie Morris*	Scott	Structural relationship of the Oonah Formation near the Arthur Lineament, Savage River, NW Tasmania	Grange Resources
Max Ostberg*	G.Davidson, Roach	Architecture of the Parrawe Basalt Province, and its hydrogeological implications, Tasmania	School of Earth Sciences
Tom Ostersen*	Roach	Electrical response of the Latitude Hill West Prospect (West Musgraves), Western Australia	Anglo American Exploration
Ariel Pascoe*	Crawford	The geochemistry and petrogenesis of the Giles Intrusions at Latitude Hill, West Musgrave province, Western Australia	Anglo American Exploration
Nicholas Smith^	Reading, Roach, Asten (Monash)	A trial of the MMSPAC passive seismic for mineral exploration in remote inland Australia	OZ Minerals
Craig Winter*	McNeill, McPhie	Stratigraphy, structure and correlations of the Hangingwall Sequence, Rosebery, western Tasmania	MMG Exploration

Master of Economic Geology (41)

Student	Supervisors	Project	Support
Abdul Arbi^		coursework only	Ivanhoe
Fabian Baker	Cooke	TBA	Lydian International
Lynelle Beinke		coursework only	Heathgate Resources
Mark Burdett^		coursework only	Monash University
Cesar Calderon-Tipiani	Gemmell	Geochemical halo to intermediate sulfidation epithermal veins, Azuca Project, Peru	Buenaventura
Wayne Carter		coursework only	Silver Lake Resources
Chloe Cavill	TBA	TBA	Xstrata Copper, Mount Isa
Djohanne Celiz		coursework only	Freeport-McMoran Exploration Corporation
Corrie Chamberlain		coursework only	Minera IRL Patagonia S.A.
Glen Diemar	Kamenetsky, Ehrig (BHP Billiton), McPhie	Geochronology of hydrothermal REE minerals and their relationships with economic mineralisation at the Olympic Dam breccia complex, South Australia	BHP Billiton Olympic Dam
Fumba Donzo		coursework only	Leighton Contractor
Peter Duerden	Cooke, Crawford	TBA	Alkane
Phil Gilmore	Davidson	An aspect of the geology of the Koonenberry Belt, NSW	Geological Survey of NSW
Rachel Harrison	Cooke	Tujuh Bakit Cu-Au porphyry-epithermal deposit, Java Indonesia	Intrepid Mines
Margaret Hawke	Gemmell	Geology of the DeGrussa prospect, WA: Implications for ore genesis and exploration	Sandfire Resources

Opposite page: Top: Participants core logging during a short course in Indonesia. **Bottom:** PhD students, Evan Orovan and Erin Lawlis, looking after the CODES booth at the 34th IGC in Brisbane.

Student	Supervisors	Project	Support
Jonathon Hoye	TBA	TBA	Rangott Mineral Exploration
Brian Kay^	Scott	Combined economic and geologic evaluation of eastern Australian gold projects – selection of acquisition targets	Northgate Australian Ventures
Martin Kent		coursework only	Straits (Tritton Mines)
Chris Large		coursework only	Cam Bow
Xuan Truong Le	Zaw	Mineralisation of Me Xi gold deposit, Vietnam	Axiom Mining, Hanoi University of Mining and Geology
Yungu Lim*	Zaw	Geological setting and mineralisation characteristics of the Steung Nambrai-Elephant Au-base metal system, eastern Cambodia	Korea Resources Corporation
Esther Little		coursework only	DGR Global, Archer Resources
Chantelle Lower	TBA	An aspect of the geology of the Olympic Dam deposit	BHP Billiton
Thomas Lucas		coursework only	Ivanhoe Australia
Imam Malik		coursework only	
Kane Maxwell		coursework only	Peabody Energy Australia
Joanne Morrison	Cooke	TBA	Newcrest Mining
Michael Musialike	Scott	TBA	Copperbelt University
Joshua Phillips		coursework only	Newcrest Mining
Anna Price^		coursework only	Silver Lake Resources
Tatjana Pucko		coursework only	Ivanhoe Australia (Mt Dore)
Michelle Puskas		coursework only	Rex Minerals
Scott Randall		coursework only	AngloGold Ashanti
Steven Richardson	Gemmell, McNeill	The Fossey Zone, Hellyer Mine	Bass Metals
Alan Riles		coursework only	Riles Integrated Resource Management, AMC
Jonathan Robbeson		coursework only	Signature Gold
Linda Sprigg*		coursework only	
Edward Summerhayes		coursework only	Silver Lake Resources
John Taylor		coursework only	Solid Energy New Zealand
Yong Zhang*		coursework only	Anglogold Ashanti (Tropicana JV)
Stanley Zutah*		coursework only	Gold Fields

Master of Science (4)

Student	Supervisors	Project	Support
Paul Ferguson§	G.Davidson, Roach	Evaluation of low magnetic responses of mid-ocean ridge crust: Interpretation and insights into Macquarie Island's geology	"SEG Australian Antartic Division"
Myall Hingee	Foster, Fullager (Fullagar Geophysics)	Approximate Inverse Mapping (AIM) inversion of Transient Electromagnetic (TEM) data	AMIRA P1022, UTAS
Stacey Leichliter*	Hunt, Berry	Gold deportment and geometallurgical recovery model for the La Colosa, porphyry gold deposit, Colombia	AngloGold Ashanti, GeM Project
Charles Makoundi^	Zaw, Large	Geology, geochemistry, and metallogenesis of selected sediment-hosted Au deposits in the Central Gold Belt, Peninsular Malaysia	Selinsing Gold Mine, CoE

Doctor of Philosophy (44)

Student	Supervisors	Project	Support
Mathieu Ageneau*	Cooke, Gemmell, Danyushevsky	Geology of the Kapit ore zone and comparative geochemistry with Minifie and Lienetz ore zones, Ladolam Gold Deposit, Lihir Island, Papua New Guinea	Lihir Gold, Newcrest Mining, SEG, UTAS
Olga Apukhtina	V.Kamenetsky, McPhie, Markl (Universität Tübingen)	Stable isotopes (C, S and O) and halogens (Cl, F) in gangue and ore minerals at Olympic Dam: Evaluation of mantle and crustal contributions to mineralisation	BHP Billiton Olympic Dam, UTAS
Mohd Basril Iswadi Bin Basori	Zaw, Large	Geology of volcanic hosted massive sulfide (VHMS) deposits in Central Belt, Peninsular Malaysia	Malaysian Govt, Ore Deposits of SE Asia Project
Heidi Berkenbosch	Gemmell, McNeill, Christie (GNS Science)	Geochemistry of hydrothermal mineral chimneys from Brothers volcano, Kermadec Arc	CoE, GNS Science, UTAS, SEG, AusIMM, Australian Synchrotron
Fiona Best^	Crawford, Foster	The petrogenesis and Ni-Cu-PGE potential of the Dido Batholith, north Queensland, Australia	CoE, Anglo American Exploration, UTAS, SEG
Natalee Bonnici^	Walters, Berry	The mineralogical and textural characteristics of Cu-Au deposits related to mineral processing attributes	GeM Project, TGRS
Victoria Braniff	Scott, Berry, Webster	The structure and deformational history of the Savage River magnetite orebodies and host rocks, NW Tasmania	Grange Resources
Mitesh Chauhan (JKMRC)	Napier-Munn (UQ)	Application of small scale flotation testing	GeM Project
Lindsey Clark*	Gemmell, Cooke, Micklethwaite	The geology and genesis of the Kencana epithermal Au-Ag deposit, Gosowong goldfield, Halmahera Island, Indonesia	Newcrest Mining, SEG
Gisela Cobenas Benites	Danyushevsky, Falloon	The behaviour of metals during differentiation of subduction-related lavas: A case study of active submarine volcanoes on the Hunter Ridge, SW Pacific	UTAS, CoE

Student	Supervisors	Project	Support
Matthew Cracknell	Reading, Foster	Innovative data inference from spatial datasets in earth science	UTAS, CoE
Nathan Fox^	Cooke, Harris	Controls on alteration and mineralisation at the Cadia East alkalic porphyry Au-Cu deposit, NSW	Newcrest Mining
Victor Hugo Galván-Gutiérrez*	Cooke, Gemmell, McPhie	Palmarejo carbonate-base metal epithermal Ag-Au district, Chihuahua, México	IPRS, Coeur d'Alene
Sarah Gilbert	Danyushevsky, Large	Development of analytical methods and standard reference materials for the determination of trace element concentrations and isotopic ratios in sulphur-rich minerals and silicate glasses	CoE, CODES, Agilent Technologies
Daniel Gregory	Large, Bull	Gold trace metal accumulation in diagenetic pyrite, from a present and Archean perspective	CSIRO, CoE, UTAS
JianXiang Guan	Danyushevsky, Crawford	Origin of associated magnetite and sulfide mineralisation in large gabbroic intrusions: A LA-ICP-MS study of minerals and melt inclusions from the Panzhihua and Taihe intrusions in Emeishan LIP and Duluth Complex	CoE, UTAS
Margy Hawke	Gemmell, Large, Davidson	Geology of the DeGrussa VMS deposit, WA	UTAS, Sandfire Resources
Qiuyue Huang	V.Kamenetsky, McPhie, Allen	Mafic dykes at Olympic Dam	UTAS, CoE
Nicholas Jansen^	Gemmell, Chang	Geology and genesis of the Cerro la Mina porphyry – high sulfidation prospect, Mexico	AMIRA P765a, Kinross
Carlos Andres Jimenez Torres	Cooke, White, Baker	Genesis of epithermal and porphyry deposits	UTAS Foundation, AMIRA P1060
Sean Johnson	Large, Meffre	The effect of metamorphic grade on trace element mobility in black shales	UTAS, CoE
Martin Jutzeler^	McPhie, Allen	Characteristics and origin of subaqueous pumice-rich pyroclastic facies: Ohanapecosh Formation (USA) and Dogashima Formation (Japan)	CoE, USGS, UTAS
Teera Kamvong*	Zaw, Meffre	Geology and genesis of porphyry-skarn Cu-Au deposits at the Northern Loei and Truong Son Fold Belts, Thailand and Laos	IPRS, ARC Linkage, CoE, SEG, Pan Australian
Roisin Kyne	Berry, Gemmell, Scott	Structural controls on mineralisation, including sulfide mineralogy, at the CSA mine, Cobar NSW	UTAS, Cobar Management
Chun-kit Lai^	Crawford, Meffre, Zaw	Tectonic evolution of the Ailaoshan Fold Belt and its SE Asia connection	CoE, Ore Deposits of SE Asia Project, UTAS
Erin Lawlis	Cooke, Jansen	Au-bearing Fe-sulfide ore of Lihir, PNG: Its physiochemical character and nature of the causative fluids	Newcrest Mining, UTAS
Alexey Lygin	V.Kamenetsky, McNeill	The geology, geochemistry and genesis of the Avebury Ni deposit, Tasmania	CoE, UTAS, MMG Exploration
Charles Makoundi	Zaw, Ross Large	Trace element variation in Phanerozoic shale sequences in Malaysia: implications for gold metallogeny of Sibumasu terrane	IPRS, UTAS, Ore Deposits of SE Asia Project
Takayuki Manaka	Zaw, Meffre	Geology and mineralisation characteristics of the Phuoc Son goldfields, central Vietnam	CoE, UTAS, Ore Deposits of SE Asia Project, SEG, Olympus Pacific Minerals
Brendan McGee§	McNeill, Gemmell	The geology and mineralisation of Tala Hamza Pb-Zn, Algeria	Terramin Australia, UTAS
Claire McMahon	G.Davidson	Distribution of, and controls upon, pyrite trace element content of hydrothermal alteration zones at Hercules VHMS ore deposit, Tasmania and NICO IOCG ore deposit, Northwest Territories, Canada	ARC
Evan Orovan	Cooke, Harris	Geology, geochemistry and genesis of the Namosi porphyry Cu-Au deposits, Fiji	CODES, Newcrest Mining, SEG
Anita Parbhakar-Fox^	Lottermoser	Establishing the value of an integrated geochemistry-mineralogy-texture approach for acid rock drainage prediction	SEG, GeM Project
Hector Ivan Parra Galvez (BRC)	Onederra (BRC)	Quantifying the impact of blast induced fragment conditioning on leaching performance	GeM Project
Richelle Pascual	V.Kamenetsky, Noble, Lottermoser	The characteristics and role of colloidal silica fluids in the formation of the Grieves Siding Pb-Zn prospect, western Tasmania	CoE, UTAS, CRC ORE
Pedro Pereira da Fonseca	McPhie, McNeill, Relvas (GeoFCUL)	Facies analysis and correlations in complex submarine volcanic successions: Mount Read Volcanics, western Tasmania	Portuguese Govt (FCT), CoE
Jose Meulen Piquer Romo	Cooke, Berry, Scott	Structural geology of the Andes of Central Chile: Evolution, controls on magmatism and the emplacement of giant ore deposits and implications for exploration	Chilean Govt, Codelco, AMIRA P1060
Daniele Redi	Danyushevsky, De Vivo (UNINA), Lima (UNINA)	A contribution to the understanding of the eruptive behaviour of Somma-Vesuvius; A mineral chemistry perspective	University of Naples, CoE
Marc Rinne	Cooke, Jansen	Geology and genesis of the contrasting Wafi-Golpu porphyry-epithermal deposit, Papua New Guinea	Newcrest Mining, Harmony Gold, Morobe Mining Joint Venture, UTAS
Abhisit Salam*	Zaw, Meffre, McPhie	A geological, geochemical and metallogenic study of the Chatree epithermal deposit, Phetchabun Province, central Thailand	Kingsgate Consolidated, IPRS, SEG, ARC Linkage, CoE
Jeffrey Steadman	Large, Bull, G.Davidson	The source of gold in banded iron formation (BIF)-hosted gold deposits	CoE, CSIRO, Integra Mining
Bronto Sutopo*	Gemmell, Cooke	The Martabe Au-Ag high-sulfidation epithermal mineralisation in the Tapanuli Selatan district, North Sumatra Province, Indonesia: Implications for ore genesis and exploration	Newmont Mining
Francisco Testa	David Cooke, Baker	Tourmaline breccia pipes: San Francisco de los Andes, Argentina and Rio Blanco-Los Bronces, Chile	UTAS, AMIRA P1060
Selina Wu	McNeill, Gemmell, Large	Volcanic hosted massive sulphide deposits of the Que-Hellyer Volcanics, western Tasmania	Bass Metals

* Degree completed, not yet graduated ^ Graduated § Withdrawn/terminated

Academic and Government Research Collaborations with CODES in 2012

National Collaborations (in addition to nodes)

Institution	Researcher(s)	CODES Collaborator(s)	Project / Research Focus
ANU	Charlotte Allen, Ian Campbell	Evan Orovan, Marc Rinne, David Cooke	Exploring the porphyry environment
ANU	Nicholas Rawlinson	Anya Reading, Nicholas Smith	Ambient seismic energy techniques
ANU	Malcolm Sambridge	Anya Reading, Matthew Cracknell	Data inference techniques applied to diverse geoscientific datasets
Australian Museum	Lin Sutherland	Sebastien Meffre	Links between tectonic setting, magmatism, basin evolution and ore deposit formation in modern and ancient settings.
CSIRO	Charles Butt	Bruce Gemmell	Genesis of volcanic-hosted copper-lead-zinc-silver-gold massive sulfide deposits
CSIRO	James Cleverley, June Hill	Garry Davidson	Sediment-hosted gold-arsenic-tellurium deposits: genesis & exploration models
CSIRO	James Cleverley, Rob Hough	Chris Ryan	New synchrotron-based applications
CSIRO	Robin Kirkham, David Parry	Jamie Laird	Ion beam analysis development
Geological Survey of WA	Arthur Hickman, Peter Haines	Ross Large, Stuart Bull, Jacqueline Halpin	Sediment-hosted gold-arsenic-tellurium deposits: genesis & exploration models
Geoscience Australia	David Huston, Terry Mernagh	Khin Zaw	Genesis of volcanic-hosted copper-lead-zinc-silver-gold massive sulfide deposits
Geoscience Australia	Roger Skirrow, Geoff Fraser, Terry Mernagh	Garry Davidson, David Cooke	Iron oxide copper-gold and related deposit types
James Cook University	Zhaoshan Chang	Huayong Chen, David Cooke	Polymetallic mineralisation and associated magmatic and volcanic activity in Cretaceous volcano-sedimentary basins of eastern China
James Cook University	Nick Oliver	Garry Davidson	Sediment-hosted gold-arsenic-tellurium deposits: genesis & exploration models
Mineral Resources Tasmania	Ralph Bottrill, Jafar Taheri	Ron Berry, Rob Scott	Structure and formation of the Savage River magnetite deposit
Monash University	Chris Wilson	Ron Berry, Rob Scott	Structure and formation of the Savage River magnetite deposit
Northern Territory Geological Survey	Masood Ahmad	Garry Davidson	Iron oxide copper-gold and related deposit types
University of Adelaide	Joel Brugger, Barbara Etschmann	Chris Ryan	Synchrotron X-ray probe development; New synchrotron-based applications
University of Ballarat	Stafford McKnight	Marc Rinne, David Cooke	Exploring the porphyry environment
University of Melbourne	Mark Kendrick	Leonid Danyushevsky, Vadim Kamenetsky	Mafic magmatism in modern submarine SW Pacific settings
University of Melbourne	Roland Maas	Vadim Kamenetsky, Jocelyn McPhie	Olympic Dam project
University of Melbourne	Jeff McCallum, Roland Szymanski	Jamie Laird	Ion beam analysis development
University of NSW	Ian Graham	Khin Zaw	Ore deposits of SE Asia
University of Queensland	Paulo Vasconcelos, Sue Golding	Khin Zaw	Ore deposits of SE Asia
University of Sydney	Maria Seaton	Sebastien Meffre	Links between tectonic setting, magmatism, basin evolution and ore deposit formation in modern and ancient settings.
University of Western Australia	Mark Barley	Khin Zaw	Ore deposits of SE Asia
University of Western Australia	Steven Micklethwaite	Sebastien Meffre	Links between tectonic setting, magmatism, basin evolution and ore deposit formation in modern and ancient settings.
University of Western Sydney	Lin Sutherland	Khin Zaw	Ore deposits of SE Asia

International Collaborations (in addition to nodes)

Institution	Researcher(s)	CODES Collaborator(s)	Project / Research Focus
British Geological Survey, UK	Mike Crow	Khin Zaw	Ore deposits of SE Asia
Brookhaven National Laboratory, USA	Gianluigi De Geronimo, Tony Kuczewski, Zhi Yong Li, Peter Siddons	Chris Ryan	Synchrotron X-ray probe development
Chiang Mai University, Thailand	Sampan Singhajwarapan, Phisit Limtrakun, Weerapan Srichan	Khin Zaw	Ore deposits of SE Asia
Chinese Academy of Sciences, China	Chengbiao Leng	David Cooke	Studies of apatites in porphyry Cu deposits and sulfides in Pb-Zn deposits in China
Colorado School of Mines, USA	Thomas Monecke	Bruce Gemmell, Ross Large	Hydrothermal event recognition and target vectoring in volcano-sedimentary strata
Colorado State University, USA	Holly Stein	Khin Zaw	Ore deposits of SE Asia
Department of Mineral Resources, Thailand	Pol Chaodumrong, Somboon Khositanont	Khin Zaw	Ore deposits of SE Asia
ETH Zurich, Switzerland	Detlef Gunther	Leonid Danyushevsky	New LA-Q-ICP-MS applications
Geological Survey of Canada	Jan Peter	Bruce Gemmell, Ross Large	Hydrothermal event recognition and target vectoring in volcano-sedimentary strata
Geological Survey of Finland	Peter Sorjonen-Ward	Garry Davidson, Ross Large	Sediment-hosted gold-arsenic-tellurium deposits: genesis & exploration models
Geological Survey of Japan	Kenzo Sanematsu	Khin Zaw	Ore deposits of SE Asia
GNS, New Zealand	Cornel de Ronde	Bruce Gemmell, Andrew McNeill	Genesis of volcanic-hosted copper-lead-zinc-silver-gold massive sulfide deposits
GNS New Zealand	Kevin Faure	Nathan Fox, Lejun Zhang, David Cooke	Efficiency of ore-forming processes
GNS New Zealand	Nick Mortimer, Chris Adam	Sebastien Meffre	Links between tectonic setting, magmatism, basin evolution and ore deposit formation in modern and ancient settings.
Guangzhou Institute of Geochemistry, China	Huayong Chen	David Cooke, Bruce Gemmell, Mike Baker	Enhanced geochemical targeting in magmatic-hydrothermal systems
Hanoi University of Mining and Geology, Vietnam	Hai Thanh Tran	Khin Zaw	Ore deposits of SE Asia; Genesis of volcanic-hosted copper-lead-zinc-silver-gold massive sulfide deposits
Hefei University of Technology, China	Taofa Zhou, Fan Yu, Feng Yuan, Shiwei Wang	David Cooke, Lejun Zhang	Polymetallic mineralisation and associated magmatic and volcanic activity in Cretaceous volcano-sedimentary basins of eastern China
Imperial College London, UK	Jamie Wilkinson, Clara Wilkinson	David Cooke, Bruce Gemmell, Mike Baker	Enhanced geochemical targeting in magmatic-hydrothermal systems
Institute of Technology, Indonesia	Andri Subandrio	Khin Zaw	Ore deposits of SE Asia
KAU University, Saudi Arabia	Hesham Harbi	Garry Davidson	Sulfur isotope insights into Arabian Shield ores
Lakehead University, Canada	Peter Hollings, Wesley Leuck, Ayat Baig	David Cooke, Bruce Gemmell, Mike Baker	Enhanced geochemical targeting in magmatic-hydrothermal systems
Memorial University, Canada	Steve Piercy	Bruce Gemmell, Ross Large	Hydrothermal event recognition and target vectoring in volcano-sedimentary strata
Moscow State University, Russia	Pavel Plechov	Leonid Danyushevsky	Modelling of crystallisation and melting processes
Muroran Institute of Technology, Japan	Yoshi Goto	Jocelyn McPhie	Submarine lavas
Nanyang Technology University, Singapore	Chris Newall, Marina Belousova, Alexander Belousov	Khin Zaw	Ore deposits of SE Asia
National University of Chile	Hans Niemeyer	Sebastien Meffre	Links between tectonic setting, magmatism, basin evolution and ore deposit formation in modern and ancient settings.
National University of Singapore	Grahame Oliver	Khin Zaw	Ore deposits of SE Asia
New Mexico Institute of Mining and Technology, USA	Matt Heizler	Marc Rinne, David Cooke	Exploring the porphyry environment
Queen's University, Canada	Dan Layton-Matthews	Bruce Gemmell, Ross Large	Hydrothermal event recognition and target vectoring in volcano-sedimentary strata
Royal Holloway University of London, UK	Ian Watkinson	Khin Zaw	Ore deposits of SE Asia

Institution	Researcher(s)	CODES Collaborator(s)	Project / Research Focus
Tarbiat Moallem University, Iran	Zahra Bonyadi, Behzad Mehrabi	Garry Davidson, Sebastien Meffre	Iron oxide copper-gold and related deposit types
Universidad Nacional de la Patagonia, Argentina	Marcelo Marquez	Vadim Kamenetsky, Jocelyn McPhie	Jurassic rhyolites, Patagonia
Universidad Nacional del Sur – INGEOSUR-CONICET, Argentina	Graciela Mas	Francisco Testa, David Cooke	The Bi-Cu-Au San Francisco de los Andes breccia pipe, Argentina
Universiti Kebangsaan Malaysia	Wan Fuad Wan Hassan	Khin Zaw	Ore deposits of SE Asia; Genesis of volcanic-hosted copper-lead-zinc-silver-gold massive sulfide deposits
Universiti Kebangsaan Malaysia	Mohd Rozi Umor	Khin Zaw	Ore deposits of SE Asia
University of Alberta, Canada	Robert Creaser	Marc Rinne, David Cooke	Polymetallic mineralisation and associated magmatic and volcanic activity in Cretaceous volcano-sedimentary basins of eastern China
University of British Columbia, Canada	Jim Mortensen	Bruce Gemmell, David Cooke	Genesis of volcanic-hosted copper-lead-zinc-silver-gold massive sulfide deposits
University of Lisbon, Portugal	Carlos Rosa, Jorge Relvas	Jocelyn McPhie	Iberian Pyrite Belt
University of Malaya, Malaysia	Azman Ghandi	Khin Zaw	Ore deposits of SE Asia
University of Malaya, Malaysia	Teh Guan Hoe	Khin Zaw	Ore deposits of SE Asia; Genesis of volcanic-hosted copper-lead-zinc-silver-gold massive sulfide deposits
University of Naples, Italy	Benedetto De Vivo	Leonid Danyushevsky	Mafic magmatism in modern submarine SW Pacific settings
University of New Caledonia	Dominique Cluzel	Sebastien Meffre	Links between tectonic setting, magmatism, basin evolution and ore deposit formation in modern and ancient settings
University of Otago, New Zealand	David Craw	Ross Large, Helen Thomas	Sediment-hosted gold-arsenic-tellurium deposits: genesis & exploration models
University of Ottawa, Canada	Mark Hannington	Bruce Gemmell, Ross Large	Hydrothermal event recognition and target vectoring in volcano-sedimentary strata
University of Padjajaran, Indonesia	Mega Rosana	Khin Zaw	Ore deposits of SE Asia
University of the Witwatersrand, South Africa	Allan Wilson	Leonid Danyushevsky	Ni-PGE potential of mafic and ultramafic magmas – a combined melt inclusions and numerical modelling approach
Vernadsky Institute, Russia	Alexey Ariskin	Leonid Danyushevsky	Ni-PGE potential of mafic and ultramafic magmas – a combined melt inclusions and numerical modelling approach
Victoria University of Wellington, New Zealand	John Creech	Paul Bence, Janet Hergt	New stable isotope MS applications

Opposite page: Participants in the Volcanology and Mineralisation in Volcanic Terrains short course near Mt. Tarawera, NZ.

Visitors to CODES 2012

Industry Visitors

Name	Company
Michael Agnew	AngloGold Ashanti
Paul Agnew	Rio Tinto
Steve Beresford	MMG
Dave Braxton	Anglo American
Paul Burrell	MMG
Cameron Cairns	Pan Australian
Corrie Chamberlain	Minera IRL
Dean Collett	Newcrest Mining
Stephen Cook	Teck Resources
Paul Cromie	Anglo American
Matt Daly	GHD
David Death	Agilent Technologies
Cathy Dickins	St Barbara
Mark Doyle	AngloGold Ashanti
Kathy Ehrig	BHP Billiton
Sam Ekins	Predrill Stresses International
James Ferguson	Newcrest Mining
David First	Freeport McMoRan Australasia
Fred Fryer	Agilent Technologies
Charles Funk	OZ Minerals
Clifford Gabay	Resonetics, USA
Anthony Harris	Newcrest Mining
Zaidi Harun	Monument Mining
Nick Hayward	Teck Resources
John Holliday	Consultant
Tony Hope	GHD
Marcello Imaña	INMET Mining, Finland
Carl Jackman	Bluestone Mines Tasmania

Name	Company
Ron James	Issara Mining/Kingsgate
Simon Jones	First Quantum Minerals
Teera Kamvong	Indochine Mining
Dave Lawie	IoGlobal
Angela Lorrigan	Unity Mining
Craig McEwan	Barrick Gold
Mike Nemitz	Newmont
Ashley Norris	Norris Software, Australia
Holger Paulick	Boliden Mineral AB, Sweden
Aubrey Paverd	Compania de Minas Buenaventura
Paul Polito	Anglo American
Leon Rawson	GHD
Ahmad Saleem	MMG
Lee Sampson	Barrick Gold
Ian Sandl	Teck Resources
Donna Sewell	AngloGold Ashanti
Michael Shelley	Laurin Technic
Stuart Smith	Tigers Realm Minerals
Murray Stevens	Olympus Pacific Minerals
Bronto Sutopo	PT Antam Mining
Pauline Tauka	Barrick (PNG Exploration)
Steve Turner	Newmont Exploration
David Wallace	MMG
Mike Whitbread	BHP Billiton
Noel White	Consultant
Ian Willis	Anglo American

National Academic and Government Visitors

Name	Institution
Michael Asten	Monash University
Alexander Babanin	Swinburne University of Technology
Elena Belousova	GEMOC, Macquarie University
Stacey Borg	CSIRO
Graham Carr	CSIRO
Dave Champion	Geoscience Australia
Stephen Cox	Australian National University
Kim Creak	Mineral Resources Tasmania
Joe Cucuzza	AMIRA International
Nathan Daczko	Macquarie University
Martin Fairclough	DMITRE-Geological Survey of SA
Andrea Giuliani	University of Melbourne
Dick Glen	Geological Survey of NSW
Geoff Green	Mineral Resources Tasmania
Lutz Gross	University of Queensland
David Groves	CET, University of Western Australia
Peter Hatherly	University of Sydney

Name	Institution
Paul Heithersay	DMITRE-Geological Survey of SA
Janet Hergt	University of Melbourne
Dave Huston	Geoscience Australia
Mark Kendrick	University of Melbourne
Jamie Laird	CSIRO
Richard Lynch	Institute of Mine Seismology
Roland Maas	University of Melbourne
Aleksander Mendecki	Institute of Mine Seismology
Nicholas Rawlinson	Australian National University
Chris Ryan	CSIRO
Malcolm Sambridge	Australian National University
Adele Seymon	AMIRA International
Lin Sutherland	Australian Museum
Dan Wood	BRC, University of Queensland
Greg Yaxley	Australian National University
Mallory Young	Australian National University

The 2012 SEG Distinguished Lecturer, Dan Wood, delivering a talk entitled 'Crucial Challenges to Discovery and Mining – Tomorrow's Deeper Ore Bodies'.

International Academic and Government Visitors

Name	Institution
Chris Adam	GNS, New Zealand
Andrea Agangi	University of Johannesburg, South Africa
Wei Chen	University of Notre Dame, USA
Michael Crow	Geological Survey of Great Britain
Bob Duncan	Oregon State University, USA
Jim Gill	University of California Santa Cruz, USA
Yoshi Goto	Muroran Institute of Technology, Japan
Marc Hirshmann	University of Minnesota, USA
Peter Hollings	Lakehead University, Canada
Akira Imai	Akita University, Japan
Alexey Ivanov	Institute of the Earth's Crust, Russia
Qin Kezhang	Chinese Academy of Sciences
Chengbiao Leng	Chinese Academy of Sciences
Wesley Leuck	Lakehead University, Canada
Zhanke Li	China University of Geosciences
George Ma	Academia Sinica, Taiwan
Svetlana Maslennikova	Russian Academy of Sciences

Name	Institution
Valeriy Maslennikov	Russian Academy of Sciences
Toshio Mizuta	Akita University, Japan
Jim Mortensen	University of British Columbia, Canada
Adam Pacey	Imperial College London, UK
Kwan-Nang Pang	National Taiwan University
Pavel Plechov	Moscow State University, Russia
Peter Sorjonen-Ward	Geological Survey of Finland
Irma Vejelyte	Vilnius University, Lithuania
Kuo-Lung Wang	Academia Sinica, Taiwan
Jamie Wilkinson	Imperial College London, UK
Allan Wilson	University of Witwatersrand, South Africa
Junxing Zhao	Chinese Academy of Sciences
Lyudmila Zhitova	Novosibirsk University, Russia

Major Externally Funded Research Projects*

AMIRA-ARC Centre of Excellence Projects 2012†

Investigators	Project	Industry Partners	Period	CoE-ARC Funding for 2012	AMIRA Funding for 2012	Misc Funding for 2012	Additional Funding for 2012	Case Study Funding for 2012
Foster, Walters (consultant), Lottermoser, Hunt, Berry, Kojovic[1], Michaux[1], Cocker[1], Bradshaw[1], Robinson (CSIRO), Kuhar (CSIRO) ([1] UQ-SMI)	AMIRA P843A. GeM Geometallurgical Mapping and Mine Modelling (extension)	Anglo American, AngloGold Ashanti, ALS, Barrick Gold, BHP Billiton, Boliden, Codelco, Datamine, Gold Fields, ioGlobal, Metso, Minera San Cristobal, MMG, Newcrest Mining, OZ Minerals, Quantitative Geoscience, Rio Tinto, Teck, Vale Inco, Xstrata Copper/Mt Isa Mines	2009–2013	$500,000	$1,268,846	$0	$513,198 (Parker Centre) $59,452 (CRC Ore- UQ)	$64,288
Cooke, Gemmell, Baker, Chen, White, Fox, Zhang, Thompson, Lounejeva, Hollings (Lakehead), J.Wilkinson (Imperial), C.Wilkinson (Imperial)	AMIRA P1060. Enhanced geochemical targeting in magmatic-hydrothermal systems	Anglo American Exploration Australia, AngloGold Ashanti Australia, Barrick (Australia Pacific), BHP Billiton Marketing Asia, Codelco, Compania de Minas Buenaventura, Eldorado Gold, First Quantum Minerals, Freeport McMoRan Australasia, Gold Fields, G-Resources, Inmet Mining, Intrepid Mines, Lundin Mining, MMG Australia, Newcrest Mining, Newmont USA, Rio Tinto Exploration, Teck Resources,Vale Exploration, Xstrata Copper	2011–2014	$150,000	$968,000	$12,258	$40,000 (Lakehead University)	
Large, Thomas, Bull, Meffre, Danyushevsky, Scott	AMIRA P1041. Application of new technologies to gold deposits	AngloGold Ashanti, Newcrest Mining, Newmont Mining, G-Resources, Issara Mining, Sipa Resources	2010–2013	$45,000	$157,600	$1,480	$0	
Foster, Schaa, Fullagar (Fullagar Geophysics)	AMIRA P1022. The applied rapid constrained inversion of TEM data	AngloGold Ashanti, Gold Fields Australia, Rio Tinto, Mira Geoscience	2010–2013	$45,000	$144,000	$0	$0	

ARC Discovery Grants 2012^

Investigator	Project	Period	ARC Funding for 2012	Misc Funding for 2012
Allen	Discovery Grant: Submarine explosive eruptions of silicic magma: constraints on products and processes from modern sea-floor examples, ancient successions and experiments	2004–2012	**	$0
Carey	Submarine volcanoes: degassing of silicic magma with implications for ascent and eruption processes	2011–2014	$104,214	$3,623

Industry and Other Externally Funded Research Grants 2012

Investigators	Project	Funding Body	Period	Funding for 2012	Misc Funding for 2012
Large, Danyushevsky	Research and development in mineral deportment and exploration	Newcrest Mining Limited	2012–2016	$1,180,000	$0
Khin Zaw, Meffre, Salam, Large, Crawford, Burrett, Lai, Khositanont (DMR Thailand), Tran (Hanoi), Rosana (Padjadjaran), Subandrio (ITB, Bandung), Crow (ex BGS, London), Azman (Uni Malaya, Kuala Lumpur), Sanematsu (ASIT, Japan)	Ore Deposits of SE Asia (extension)	Indochine Resources Ltd, Issara Mining, MMG, Monument Mining, Olympus Pacific, Phu Bia Mining, PT Antam (Persero), Tigers Realm Minerals, Anglo American Exploration, Newcrest Mining	2011–2014	$450,000	$0
Cooke, Micko, Jansen, Harris (Newcrest)	Exploring the porphyry environment	Newcrest Mining Limited	July 2009–2013	$416,852	$2,165
McPhie, V.Kamenetsky	Setting, age and architecture of the Olympic Dam Au-Cu-U deposit, SA	BHP Billiton Olympic Dam Corp	July 2010–2013	$198,122	$744
Orth	Carson Volcanics-Hart Dolerite Large Igneous Province project	Geological Survery of Western Australia	2012–2014	$162,950	$0
V.Kamenetsky, McPhie, Markl (Tuebingen), Apukhtina (student)	Stable isotopes (C, S and O) and halogens (Cl, F) in gangue and ore minerals at Olympic Dam: Evaluation of mantle and crustal contributions to mineralisation	BHP Billiton Olympic Dam Corp	2012–2015	$143,000 ‡‡	$0

Investigators	Project	Funding Body	Period	Funding for 2012	Misc Funding for 2012
Reading, Bombardieri	A geophysical investigation of western Tasmania	Mineral Resources Tasmania	2012–2014	$98,951	$10,909
Scott, Berry, Braniff (student)	The structure and deformational history of the Savage River magnetite orebodies and host rocks, NW Tasmania	Grange Resources (formerly Australian Bulk Minerals)	2008–2012	$55,000	$0
G.Davidson	Geochemical controls on gold, Sunrise Dam (extension)	AngloGold Ashanti Australia Ltd	2012–2013	$53,298	$0
Meffre	Toward at site whole rock LA-ICPMS analyses	Deep Exploration Technologies CRC	2012–2013	$25,000	$0
McNeill, Feig, Falloon, D.H.Green	Sulfur and metal evolution in parental mid ocean ridge basalt magmas	IODP (via Australian National University)	2012–2015	$24,890	$0
McNeill, Gemmell, Large, Wu (student)	Volcanic hosted massive sulphide deposits of the Que-Hellyer Volcanics, western Tasmania	Bass Metals	2010–2013	$23,250	$0
Berry, Gemmell, Scott, Kyne (student)	Structural controls on mineralisation, including sulfide mineralogy, at the CSA mine, Cobar NSW	Cobar Management Pty Ltd	2009–2013	$15,000	$0
Bull, G.Davidson, Kleeman (student)	The petrology and trace element geochemistry of the Carrapateena deposit, Olympic IOCG Province, SA	OZ Minerals Carrapateena Pty Ltd	2012	$10,000	$0
Cooke, Baker, Beattie (student)	Geology and geochemistry of the Gooleys alkalic Cu-Au porphyry prospect, Cadia District, NSW	Newcrest Technology	2012	$10,000	$0
Roach, Gemmell, Dunne (student)	The magnetic and radiometric character of the Gosowong Goldfield, Halmahera Island, Indonesia	Newcrest Mining Limited	2012	$10,000	$0
Crawford, Ferguson (student)	Mineral paragenesis and geometallurgical characteristics of the Karlawinda deposit, WA	Independence Group NL	2012–2013	$9,720	$0
Reading, Roach, Birchall (student)	Seismic characteristics of Plutonic Gold Mine	Barrick (Plutonic) Limited	2012	$8,944	$0
Crawford, G.Davidson, Pascoe (student)	The geochemistry and petrogenesis of the Giles Intrusions at Latitude Hill, West Musgrave province, WA	Anglo American Exploration (Australia) Pty Ltd	2012	$7,000	$0
G.Davidson, Lottermoser, Memish (student)	Hydrogeochemistry as an exploration method in the Mount Read Volcanics (MRV), western Tasmania	MMG Exploration Pty Ltd	2012	$7,000	$0
McGoldrick, Ellis (student)	Geology and enrichment of the Sharpnose Prospect, WA	Anglo American Exploration (Australia) Pty Ltd	2012	$7,000	$0
Roach, Ostersen (student)	Electrical response of the Latitude Hill West Prospect (West Musgraves), WA	Anglo American Exploration (Australia) Pty Ltd	2012	$7,000	$0
Zaw, Manaka (student)	Geology and mineralisation characteristics of the Phuoc Son goldfields, central Vietnam	Olympus Pacific Minerals	2011–2012	$7,000	$0
McNeill, Febey (student)	Stratigraphy, structure and correlations of the Rosebery Group west of the Rosebery Fault, Rosebery district, western Tasmania	MMG Exploration Pty Ltd	2012–2013	$6,800	$0
Reading, Dolan (student)	Petrology and electrical properties of key lithologies at Prominent Hill, SA	OZ Minerals Limited	2012	$6,470	$0
McNeill, Winter (student)	Stratigraphy, structure and correlations of the Hangingwall Sequence, Rosebery, western Tasmania	MMG Exploration Pty Ltd	2012	$5,000	$0
Zaw, Le (student)	Mineralisation of Me Xi Gold Deposit, Vietnam	Axiom Mining	2012	$5,000	$0
Gemmell, McNeill, Christie (GNS) Berkenbosch (student)	Geochemistry of hydrothermal mineral chimneys from Brothers volcano, Kermadec Arc	AusIMM Education Endowment Fund	2012	$3,600	$0
McNeill, Baker (student)	The correlations and exploration significance of the Natone Volcanics, Rosebery Group, western Tasmania	MMG Exploration Pty Ltd	2012	$2,500	$0
Bull, Meffre, G.Davidson	Volcano-sedimentary and chrono-stratigraphic architecture for the host rock succession at Prominent Hill, South Australia	OZ Minerals	2011–2012	**	$0

* Projects with greater than $2,000 external (non-CoE-ARC) funding per year † ARC funding for these projects comes from the CoE-ARC Grant
^ ARC funding for these projects comes directly from the ARC Discovery or Linkage programs ** All project funding received, project still active
‡‡ Full project funding received in one year

Activity Plan 2013

Program One

Project	Leader(s)	Activity Plan
P1A3	Peter McGoldrick	Continue describing microfossil assemblages from Century mine. Complete a paper on the origin of northern Australian sedimentary zinc deposits.
P1A4A	Khin Zaw	Conduct further negotiations with two prospective new sponsors. Appoint two postdoctoral fellows – one full-time, and one part-time. Attract one MSc/PhD student to study Cu-Au deposits in central Myanmar. Secure up to two Honours students for deposit-scale studies in Thailand, Malaysia, Sumatra and Myanmar. Continue to build and develop the geochemical/geochronological database and deposit summary of SE Asia. Conduct regional field work and sampling in southern and central Myanmar, eastern Thailand, and Sumatra. Conduct three web-based quarterly reports, plus a face-to-face annual report meeting.
P1A7	Peter McGoldrick	Prepare a paper on the geochronology of the Rocky Cape Group. Prepare a paper on marine redox conditions during the Mesoproterozoic in western Tasmania.
P1B1	Jocelyn McPhie, Vadim Kamenetsky	Submit two manuscripts from Martin Jutzeler's PhD thesis. Submit a manuscript on the bedded sedimentary facies at Olympic Dam. Complete data collection on submarine rhyolitic samples. Submit a manuscript on picrites at Olympic Dam. Submit two manuscripts on textural criteria for eruption intensity involving submarine rhyolite.
P1B3B	Paul Davidson	Fully commence the new project on a magnetite-apatite deposit at Zanjan, Iran. Revise a paper on the Pilot Knob magnetite-apatite occurrence, following a review. Prepare and publish a review paper on granitic pegmatites.

Program Two

Project	Leader(s)	Activity Plan
P2A2A	Stephen Cox	Submit papers on fluidised breccias and seismogenic permeability enhancement in overpressured hydrothermal systems. Investigate mechanics of vein formation in porphyry Cu-Au systems.
P2A3	David Cooke	Conduct second field season collecting samples and mapping magmatic-hydrothermal features in western Tasmanian Sn granites. Initiate analytical program on tourmaline, quartz, magnetite and K-feldspar. Conduct EMPA and LA-ICP-MS analyses of major and trace-element compositions of apatite from the Zhongdian porphyry copper system. Conduct LA-ICP-MS analyses of the trace-element compositions of sulfides from the Kukeazi Pb-Zn-(Cu-W) deposit. Conduct EMPA and LA-ICP-MS analyses of garnet, and sulfides in the Hongshan skarn deposit, China. Compile results of the abovementioned EMPA and LA-ICP-MS analyses for publication in *Economic Geology*.
P2B1A	David Cooke, Nic Jansen	Nic Jansen to complete SWIR and LA-ICP-MS analyses of alunite from Lihir steam-heated and Wafi lithocap samples. Complete final report on exploration in the Lihir steam-heated blanket. Evan Orovan to complete all remaining analytical work on the Namosi porphyry Cu-Au deposits, including fluid inclusion analyses, radiogenic and stable isotopes and petrographic studies. Erin Lawlis to complete two field seasons at the Lihir alkalic epithermal gold deposit in PNG, and commence writing phase of PhD manuscripts. Marc Rinne to write and submit PhD thesis. Jacqui Rush (Honours) to conduct research of the Marsden porphyry Cu-Au deposit. Vikraman Selvaraja (Honours) to conduct research of clay alteration at Gosowong, Indonesia.
P2B1B	Taofa Zhou, David Cooke	Continue fieldwork in Luzong Basin. Submit Co-operation Research Agreement grant application for a collaboration with Hefei University of Technology. The application will be for funding from 2014 to 2018 for research related to the ore-forming system of intra-continental porphyry-skarn copper-gold and magnetite-apatite iron deposits in the Middle-Lower Yangtze River Valley metallogenic belt in eastern China. Shiwei Wang to spend one year at CODES to conduct LA-ICP-MS analyses and to work collaboratively with David Cooke and Lejun Zhang. Present research results during field trip to the Luzong basin in December.
P2B1D	David Cooke, Thomas Bissig (MDRU)	Publication of the alkalic special issue of *Economic Geology*.
P2B3B	Bruce Gemmell	Continue PhD research on deposits at Fossey-Hellyer-Que River-Mt Charter (Tasmania), DeGrussa (WA), Duc Bo (Vietnam), and Tasik Chini (Malaysia). Initiate a PhD project researching the geology and genesis of the ore bodies at Greens Creek, Alaska. Project to be funded by Hecla Mining. It is anticipated that a PhD project will be initiated to research the geology and genesis of the ore bodies at Myra Falls, British Columbia. Project to be funded by Nyrstar. Jo Condon to complete her Master of Exploration Geoscience project at DeGrussa, WA. Submit results from the second stage of the age dating throughout the Mount Read Volcanics.
P2B3C	Bruce Gemmell	Complete project with a sponsors meeting at the 2013 SEG Conference in Whistler, Canada. Contribute three papers for a special issue of *Economic Geology*.
P2B3D	Bruce Gemmell	Submit paper on the synchrotron analyses of seamount chimney samples from the Brothers volcano.
P2B4	Garry Davidson	A PhD study on the Merlin Mo deposit to commence in April. Analyse a comprehensive suite of Merlin molybdenites – scheduled for early in the year. Publish geochronological results from Coronation Hill. Publish a paper in *Economic Geology* on Mesozoic breakup and IOCG mineralisation in the Andes – scheduled for publication in January, 2013.

Program Three

Project	Leader(s)	Activity Plan
P3A1C	Peter Fullagar	Complete interpretation of sponsor data using VPem3D software. Hold VPem3D workshop with sponsor companies on 19–20 March.
P3A2A	Anya Reading	Nicholas Smith to present project results at ASEG in Melbourne, August 2013. Develop AMIRA project proposal to gauge industry interest in method development. Carry out further processing of existing data and prepare results for publication.
P3A3A	Anya Reading	Matthew Cracknell to prepare Random Forest computing tools for wider use. Submit an eclectic, yet ground-breaking, paper entitled 'A topological approach to the morphology of high-dimensional dataspaces' to *Nature*.
P3B1B	David Cooke, Bruce Gemmell, Mike Baker	Conduct the following field campaigns by postdoctoral researchers: • Mike Baker – Grasberg (Indonesia) • Lejun Zhang – Haquira (Peru) • Nathan Fox – La Colosa (Colombia) Conduct the following PhD fieldwork: • Carlos Jimenez – Bantug, Philippines • Adam Pacey – Northparkes, NSW • Jose Piquer – Central Chile
P3B1C	Bruce Gemmell, Jocelyn McPhie, David Cooke	Initiate a new PhD study on the Don Nicholas low to intermediate sulfidation deposit, Patagonia, Argentina. Conduct further discussions with Almaden Minerals on a potential RHD study on the Ixtaca low-intermediate epithermal sulfidation deposits in Mexico. Initiate discussions with MAG Silver on a potential RHD study on the low-intermediate sulfidation epithermal deposits in Mexico.
P3B2A	Ross Large, Sebastien Meffre	Complete the gold footprint and halo research on the Geita deposit, Tanzania. Complete the gold footprint and halo research on the Henty deposit, Tasmania. Circulate AMIRA proposal for new gold project aimed at advances in gold ore processing and genetic modelling.
P3B3A	Bruce Gemmell	Publish results, which conclude the project.
P3B5C	Vadim Kamenetsky	Alexey Lygin to complete his PhD study on the Avebury deposit, Tasmania.
P3B6A	Ron Berry, Rob Scott	Victoria Braniff to submit her PhD.
P3B7A	Garry Davidson	Seek further funding support from OZ Minerals for several aspects of the project.

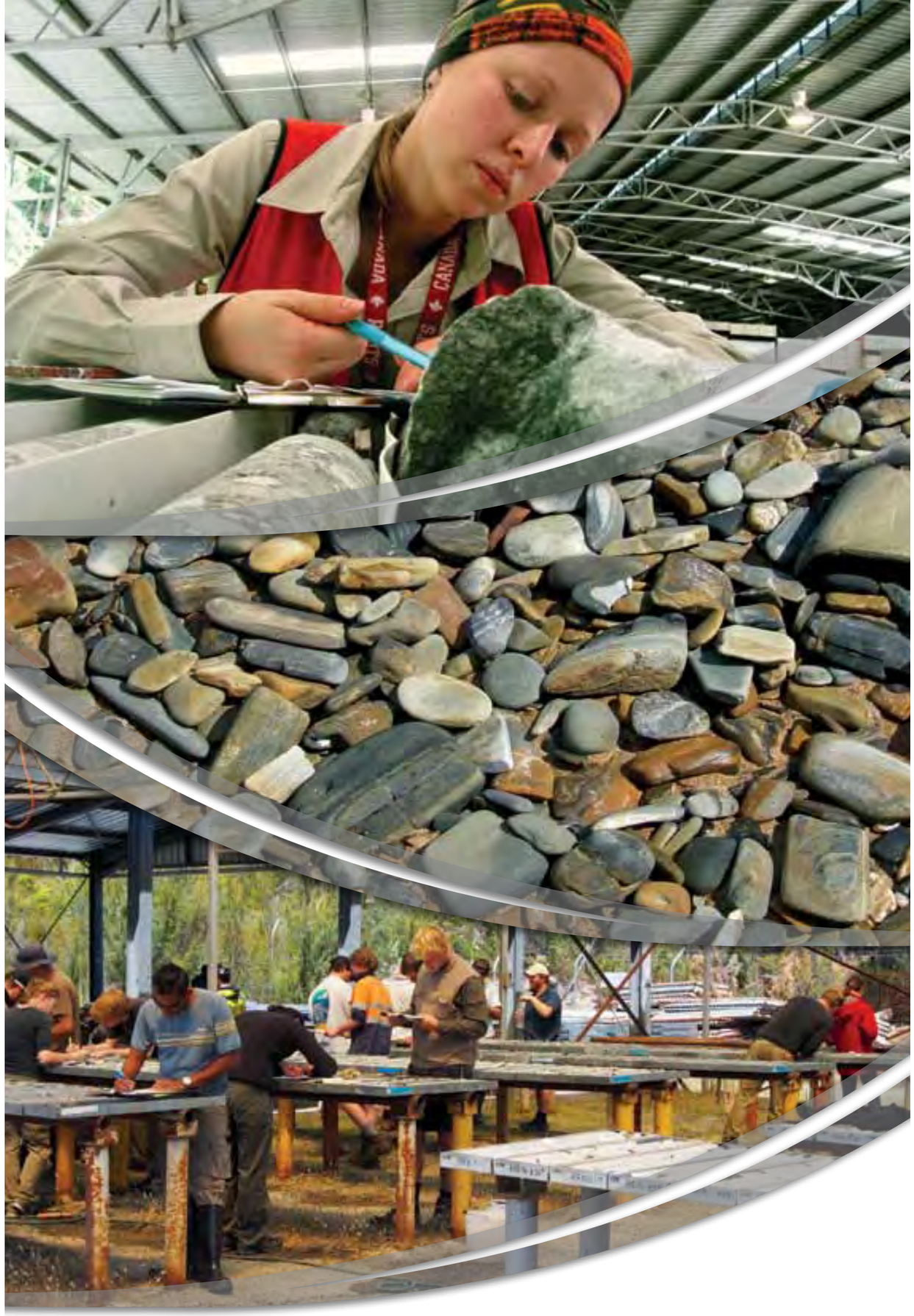
Program Four

Project	Leader(s)	Activity Plan
P4A1	Ron Berry	Theme 1 was transferred to CRC ORE during 2012 and will have no activities within Program 4 in 2013.
P4A2	Alan Cocker	Complete documentation of IFragX and 3DFrag. Finalise results of synthetic blast to leach experiment.
P4A3	Toni Kojovic	Complete interactive CD on comminution measurements in geometallurgy.
P4A4	Dee Bradshaw	Continue to develop sampling protocols for batch flotation. Reassess role of JKMSI equipment, and investigate alternate experimental methods. Finalise development of software tools for textural measurement and data extraction as a liberation indicator.
P4A5	Dave Robinson, Laura Kuhar	Finalise small-scale diagnostic leaching tools, protocols and proxies. Develop software that combines fluid-flow and chemical equilibrium models for dump/heap leach performance prediction and planning. Develop scoping study for agglomerate porosity and hydrology test.
P4A6	Ron Berry	Finalise study of the application of laser Raman systems to geometallurgy. Review the transfer of geometallurgical data into the block model in case studies.
P4A7	Steve Walters	Finalise the five remaining case studies and report on general findings.

Program Five

Project	Leader(s)	Activity Plan
P5A1	Leonid Danyushevsky	Commission the new LA-ICP-MS laboratory, funded by Newcrest Mining.
P5A2	Sebastien Meffre	Continue development of analysis of trace element in rock powders by LA-ICP-MS. Characterise ablated condensate on different sulfide minerals. Continue investigation of the effects of radiation dose on ablation characteristics of zircon.
P5A3	Bence Paul, Janet Hergt	Publish paper on MinMapper software. Conduct another international Iolite workshop, which will be held in conjunction with the Goldschmidt conference in Florence, Italy.
P5A4	Bence Paul, Janet Hergt	Publish results of hydrothermal sediment Cu isotope study. Publish paper describing new double spike deconvolution software. Finish Mo isotopes in ore deposit samples study.
P5A4A	Garry Davidson	Produce and submit methods and applications manuscript. Undertake trials of large volume, ultra-low sulfate samples using Sn chloride reagent to improve extraction efficiency; thereby extending the Sn chloride trials completed in 2012 on higher S abundance samples. Undertake CAMECA mapping of S in an IOCG carbonate vein set, and then apply the CAS technique to these samples. This step cannot be undertaken until the methods paper is submitted.
P5A5	Sebastien Meffre, Ross Large, Leonid Danyushevsky	Integrate automated reflected light microscopy, laser ICP-MS, automated SEM and pyrite etching to characterise Lihir pyrite.
P5A6	Leonid Danyushevsky	Standardise the LA-ICP-MS interface for S isotopic analyses. Conduct case studies of S isotope variation in a range of ore deposit styles.
P5B1	Jamie Laird	Install new target chamber and integrate with data collection system (MicroDAQ) and HYMOD for the Maia detector. Conduct PIXE tests on standard samples. Install optics and backscatter detectors on new chamber. Integrate into MicroDAQ. Conduct PIXE and IL analysis of quartz minerals.
P5B2	Jamie Laird	Complete EBSD and EDS analyses. Publish two papers on current results. Complete micro-resistivity mapping and apply to Otago samples. Complete cryogenic LBIC system for vastly improved LBIC mapping over much larger areas.
P5B3	Chris Ryan	Publish new method developments for quantitative SXRF imaging using Maia. Reintegrate the HT/HP mAESTRO system in the second hutch at the XAS beamline of the Australian Synchrotron with fluorescence detection capability. Further develop GeoPIXE methods to support quantitative XANES imaging, including XANES spectral analysis and fitting. Evaluate new Maia upgrade performance for improved energy resolution and low-energy range.
P5B4	Stacey Borg	Further develop XANES imaging methods and software platform to allow routine species identification and mapping. Collect XAS data on Ni, Zn and Pd using the mAESTRO system. Develop a high pressure UV-Vis cell for the study of pressure effects on solution species. Publish results from apatite mineral transformation study.
P5C3	Leonid Danyushevsky	Publish a new model for plagioclase-melt equilibrium and its incorporation into the Petrolog3 software.
P5C5	Leonid Danyushevsky	Develop new software for multi-standard data reduction for LA-ICP-MS.

Opposite page: Top: Erin Lawlis inspecting core samples at Newcrest's operations in PNG. **Middle:** Rocks that caught the eye of Katie McGoldrick. **Bottom:** A mix of students attending the mapping camp on Tasmania's west coast.



CODES
ARC Centre of Excellence in Ore Deposits
University of Tasmania
Private Bag 126, Hobart,
Tasmania, 7001, Australia
Tel: +61 3 6226 2472
Fax: +61 3 6226 7662
www.utas.edu.au/codes

ISSN 1440-6411


EN EDUCACIÓN DE
yectos de investigación
opciones de estudio
es con 42 empresas
institutos y universidades
programas de investigación
ncipales: Ubicación, Formación,
scubrimientos, Recuperación
ecnología

CODES

UTAS