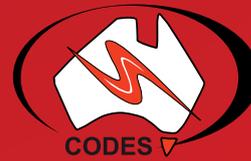


ORE SOLUTIONS

NEWSLETTER OF CODES
ARC CENTRE OF EXCELLENCE IN ORE DEPOSITS



SUMMER 2012/13
NO. 29



Bruce takes the helm

Following an extensive international search, and rigorous selection process, Professor Bruce Gemmell has been appointed as the new Director of CODES, with effect from 15 October, 2012. *Ore Solutions* spoke to Bruce, who provided the following thoughts on his appointment and the road ahead.

CODES has built an exceptional team of academic and professional staff, which is continually being augmented by a steady stream of outstanding postgraduate students. From modest beginnings back in 1989, it has grown to become one of the world's leading centres for ore deposit research and training, and I feel extremely honoured to be given the opportunity to build on this success and take the centre forward to the next stage in its evolution.

Despite this strong position, there is no doubt that we face some major challenges in the months and years ahead. The most

immediate and significant of these challenges is to address the loss of ARC Centre of Excellence funding, which ceases at the end of 2013. Representing one third of our current budget, this income has been essential not only to our development, but also our day-to-day operations. As the saying goes: 'as one door closes, another opens...' With that in mind, I have already identified a number of funding sources that have the potential to fill this gap. I will be working closely with our partners in industry, government

CONTINUED PAGE 2 >>

IN THIS ISSUE

- | | |
|--------------------------------|---------------------------------|
| Centre retains key skills 3 | Super-giant mystery solved 17 |
| Newcrest supports new lab 8 | Top ERA rating 28 |
| Cruise to the Izu-Bonin Arc 14 | Geo-Logging course announced 28 |

CODES CONTACTS

DIRECTOR

Bruce Gemmell
Tel: +61 3 6226 2893
bruce.gemmell@utas.edu.au

LEADER, PROGRAM 1, LOCATION + GRADUATE RESEARCH CO-ORDINATOR

Jocelyn McPhie
Tel: +61 3 6226 2892
j.mcphie@utas.edu.au

LEADER, PROGRAM 2, FORMATION + DEPUTY DIRECTOR

David Cooke
Tel: +61 3 6226 7605
d.cooke@utas.edu.au

LEADER, PROGRAM 3, DISCOVERY

Garry Davidson
Tel: +61 3 6226 2815
garry.davidson@utas.edu.au

ACTING LEADER, PROGRAM 4, RECOVERY

Ron Berry
Tel: +61 3 6226 2456
ron.berry@utas.edu.au

LEADER, PROGRAM 5, TECHNOLOGY

Leonid Danyushevsky
Tel: +61 3 6226 2469
l.dan@utas.edu.au

PA TO THE DIRECTOR

Deborah Macklin
Tel: +61 3 6226 2472
deborah.macklin@utas.edu.au

COMMUNICATIONS MANAGER INCLUDING EDITOR OF ORE SOLUTIONS

Steve Calladine
Tel: +61 3 6226 2743
steve.calladine@utas.edu.au

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

<< CONTINUED FROM PAGE 1

and academia over the coming months to agree on strategies that meet the needs of all parties.

A further challenge will be the loss of a few key staff members who are likely to retire between now and the end of our tenure as a Centre of Excellence. While these people will be sorely missed, I am pleased to say that we will retain an extremely strong blend of bright young talent, mixed with a critical mass of people with a vast number of years of experience. In addition, the changes provide us with an ideal opportunity to re-invigorate and revitalise CODES as we transition into the future.

The minerals industry is also facing challenges in the years ahead, including declining discovery rates, higher operating costs, an increased focus on environmental issues, and the need to explore deeper and undercover. CODES is so intrinsically linked to the industry that its challenges become our challenges. They also become our opportunities, because I believe that the centre has the expertise, experience and research programs to make significant contributions to finding solutions to all the issues that I have mentioned.

It is clear from talking with our industry partners that, while they welcome our evolution, they place great value on who we currently are and what we provide. Therefore, I plan to build on our strengths by fostering our team-based approach, and continuing to use our fundamental research as a platform for applied research outcomes, tailored to the requirements of our industry sponsors. The framework for this research will continue to be programs, which provide a comprehensive ore-systems-based research model that includes a range of disciplines from district architecture and ore characterisation, through to mineral processing, mine

optimisation and environmental geoscience. Our world-leading technological advances in laser analysis, together with ongoing refinements to our analytical techniques, will also continue to underpin these programs.

Another significant challenge facing the minerals industry is the severe shortage of skilled geoscientists – and, once again, I believe that CODES is ideally placed to assist. The centre has built an international reputation for excellence in its postgraduate training, from Honours through to MSc and PhD. For many years, it has been a source of first class geoscientists to industry, many of whom are now holding senior positions at major companies around the world. In addition, it has played a key role in up-skilling industry-based employees through courses such as those offered by the Master of Economic Geology Program. These education programs have been a cornerstone of our success and I believe that there are many opportunities for these and other programs, such as a Professional Doctorate degree, to evolve to meet the needs of our industry and the geoscience community.

Under the guidance of Ross Large, the centre has become known around the world for its excellence in training and ore deposit research. I wish to thank Ross for his vision, motivation, dedication and leadership over these past 23 years, which has led to CODES' current position. He has been a true inspiration in the field of economic geology and I believe we have all benefited from his time at CODES. It is a time of change and challenges for the centre, but most of all I see it as a time of opportunities. Ross will be a hard act to follow, but I look forward to building on his success.

See article on page 3 to find out why Ross's years of experience will not be lost to CODES.



Training is a key part of plans.

Short biography: Professor Bruce Gemmell

Born in Vancouver, Canada, Bruce attained a Bachelor of Science (1979) at the University of British Columbia, followed by a Masters degree (1983) and PhD (1987) from Dartmouth College in the USA.

After postdoctoral studies at Dartmouth investigating a lead-zinc deposit in Argentina, he arrived in Tasmania in 1988 to undertake further postdoctoral research on the Hellyer deposit on Tasmania's west coast. In 2004, he stepped up to the post of Head of the School of Earth Sciences, and was appointed as Deputy Director of CODES in 2005. Both positions ran concurrently, and were held by Professor Gemmell up to the time of his appointment as Director.

Other career highlights while at UTAS include three Teaching Merit Certificates, and the Dean's Research Award. During this period he has supervised numerous postgraduate students, including 25 Honours, 34 Masters, and more than 30 PhDs. He has also successfully led many AMIRA projects, and his efforts were rewarded in 2012 when he received the AMIRA International Award for Geoscience Research Excellence.

His specialist area of research is the geology and genesis of modern and ancient volcanic-hosted massive sulfide and epithermal Ag-Au deposits, and he has had more than 80 papers published on related topics. In addition, he has sat on the editorial boards of both *Mineralium Deposita* and *Economic*



Geology, and guest-edited several special issues of the latter journal.

Bruce also has six years of mineral exploration experience in the Yukon and British Columbia, Canada, primarily with Anaconda Canada.

Centre retains key skills after changes

In addition to the change of Director, there have been a number of other staff movements recently. Prof. David Cooke has been appointed as Deputy Director, a position previously held by the new Director, Prof. Bruce Gemmell. David is also leader of the Formation Program, and has been with the Centre for over two decades, bringing a wealth of experience to the post.

The leaders of the Discovery Program, Andrew McNeill, and the Recovery Program (GeM^{III}), Jeff Foster, have moved on. However, they are expected to maintain close collaborative ties with the Centre, and both the positions have been filled by highly experienced researchers. Garry Davidson (Discovery Program) and Ron Berry (Recovery Program) have been with CODES since its inception, and the latter is also a founding member of the GeM^{III} project team.

Prof. Tony Crawford has decided to step down from many of his duties at the end of 2012, including his role as leader of the Location Program. However, another long-standing staff member, Prof. Jocelyn McPhie, has agreed to take over the leadership of this important program. Similar to Ron in the case of GeM^{III}, Jocelyn has been a key member of the Program



Ross Large will have a more hands-on role in the future.

since it started. Tony will continue to be actively involved with research at CODES, where he will retain an office.

Last, and certainly not least, of the changes is Prof. Ross Large stepping down from his position as Director. Ross was the 'founding father' of CODES and it has been his drive, enthusiasm and leadership that has seen it grow to become a world leader in its field. However, like Tony, he will certainly not be lost to CODES, where he also retains an office that he will use as a base for further research.

"I am proud of what we have achieved at CODES, and how it has grown to where it is today. Nevertheless, it has long been part of our strategic planning for us to



Tony Crawford to continue with CODES' research.

transition to new leadership at this time. It is an opportunity for someone new to take control, build on the success, and take the Centre to the next stage in its development.

"It has been a very enjoyable journey, but it is a journey that is taking a fork in the road, rather than coming to an end. Stepping back from the managerial duties will allow me to get my hands dirty again and focus on areas of CODES' research in which I have always held a keen interest. This includes looking at pyrite as a proxy in the sediment record to understand ocean chemistry and the atmosphere through time. I am very much looking forward to this next stage of my career at the Centre," says Ross.

Meetings discuss strategic directions

The annual Science Planning Meeting was held at the Hotel Grand Chancellor in the Hobart CBD on 29 August. The morning session was built around reviews of CODES' five key research programs, and also included highlights of the main education programs.

The afternoon session focussed on planning for the future, with project proposals, the new laboratory (see

article on page 8), and financial support beyond the end of the Centre of Excellence funding term being the principal areas of discussion.

As in previous years, the Science Planning Meeting was followed the next day by the annual meeting of the Advisory Board. However, with the appointment of the new Director imminent, and a number of key strategic

issues requiring further discussion, it was agreed to have a second meeting before the end of the year.



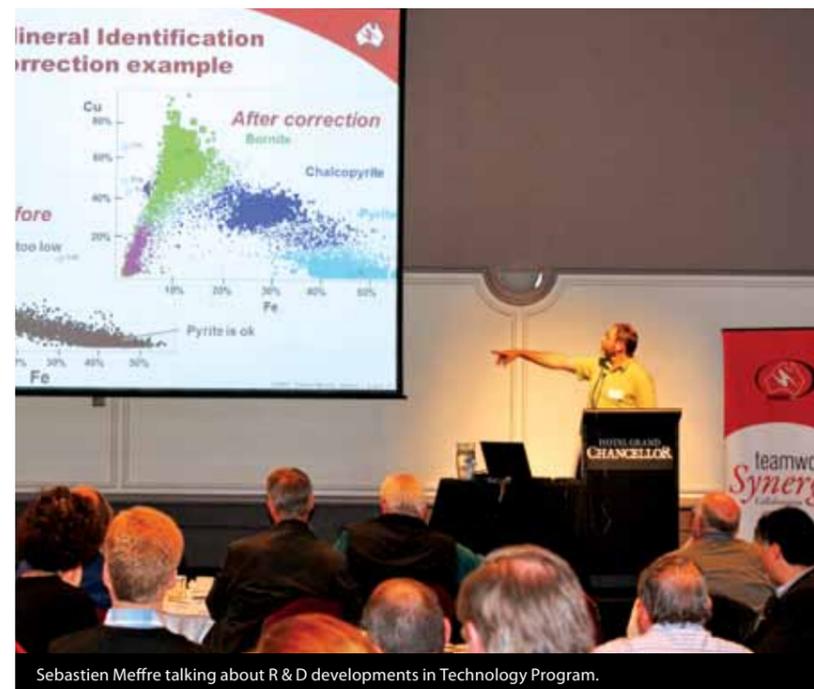
Full house at the Grand Chancellor.



Dima Kamenetsky (right) 'catches up' with Jamie Laird (CSIRO) during a break.



The poster presentations were again a popular feature of the event.



Sebastien Meffre talking about R & D developments in Technology Program.

New Chairman for the Advisory Board

An additional meeting of the Advisory Board was held on 19 November, where John Dow, Chairman for the past seven years, officially announced his intention to step down from the Board. The members thanked John for his exceptional handling of the role of Chairman over the years and the significant part that he has played in CODES' success.

The Board was pleased to announce Dr Paul Heithersay as the new Chairman, and with his extensive experience working in both the minerals industry and the Public Service was seen as an ideal

replacement. Paul is currently Deputy Chief Executive Resources and Energy at the South Australian Government's Department of Manufacturing, Innovation, Trade, Resources and Energy (DMITRE).

Before joining the Public Service in 2002, Dr Heithersay spent more than 20 years in the mining industry in Australia, South East Asia and China, working for North Ltd and its predecessor Geopeko.

In June 2012, Dr Heithersay was awarded a Public Service Medal for his outstanding contribution to the growth and development of the mineral



John Dow is stepping down after seven years as Chairman.



New Chairman, Dr Paul Heithersay has a wealth of experience in industry and the Public Service.

resources sector in South Australia, and in November of the same year he was elected to the Fellowship of the Fellows of the Australian Academy of Technological Sciences and Engineering (ATSE).

Goldschmidt session provides insights into O₂ events

A session co-convened by CODES researcher, Peter McGoldrick, at the recent Goldschmidt conference in Montreal has revealed a wealth of new data from Earth's 'middle age'. This data will be invaluable in helping geobiologists better understand major oxidation events of the Proterozoic Eon, which have previously been poorly constrained.

The session was titled 'Between the O₂ steps: life and the environment between the GOE and the Late Neoproterozoic rise of ice and animals', and included 22 oral presentations and 10 posters. Peter's fellow co-conveners were Tim Lyons and Noah Planavsky from the University of California Riverside, whom Peter has had close collaborative associations with for a number of years.

The background to the research

The Earth is a planet with abundant oxygen in the atmosphere, and a predominantly well-ventilated ocean – but it wasn't always that way. For the first half of its history, the planet lacked free oxygen.

Geobiologists believe that organisms capable of oxygenic photosynthesis evolved sometime during the Archean Eon. This led to an abrupt rise in atmospheric oxygen about 2.4 billion years ago, which is commonly known as the Great Oxidation Event, or GOE. However, even though this was a significant rise, the ratio of oxygen to other atmospheric gases was still relatively small compared with today. It is believed that the jump to near modern levels only occurred toward the end of the Neoproterozoic Era and presaged the rise of large, complex organisms.

Until recently, details of atmospheric oxygen variation between these two oxidation events were very limited, which was proving to be a major obstacle for geobiologists seeking to constrain questions relating to the tempo and mode of organic evolution. In addition, because redox reactions are fundamental to forming many types of ore deposits, a more nuanced understanding of Proterozoic atmospheric oxidation and ocean ventilation may give economic geologists insight into Proterozoic mineralisation processes.

The session

The keynote address by Lee Kump, from Penn State, described the theory that the GOE began as a slow build-up of O₂ over several hundred million years, but may have culminated about 2.2 – 2.0



Peter McGoldrick

billion years ago with an 'overshoot' to levels exceeding modern values. Interestingly, and seemingly supporting the theory, this is the time frame when the Hamersley Banded Iron Formation (BIF) experienced a major enrichment event, and uranium mobility in oxygenated groundwaters caused natural nuclear reactors in Gabon. Much of this new understanding of the GOE comes from sedimentary basins from the Karelian region of western Russia.



Fact finding in Finland

Paleoproterozoic metasedimentary sequences of a similar age to the Karelian sedimentary basins in Russia can be found in Finland. Therefore, Peter flew to the Scandinavian country immediately after the conference, where he met with a long-established collaborator with CODES, Peter Sorjonen-Ward, plus his colleagues from the Geological Survey of Finland. They were joined by Ross Large and Sean Johnson – a newly enrolled PhD student, who at that stage was still based in the UK.

As a group, they travelled nearly 500 kilometres north of Helsinki to visit Europe's largest Ni mine – the Kuusilampi-Kolmisoppi deposit (shown in image above), operated by Talvivaara Mining. This very large, low-grade, polymetallic (Ni, Co, Cu, Zn & U) resource is hosted by ~2 billion year old, organic carbon-rich, fine grained metasedimentary rocks. Sean will be returning to the mine soon, as it is the topic of his PhD research. One question he will address is whether O₂ 'overshoot' played a significant role in metal enrichment.

A notable feature of the visit was the large-scale bio-leach process the company employs on site to liberate metals from the crushed rock. This specialised process utilises living microbes that can tolerate the sub-Arctic winters. The group thought that this was quite an appropriate process, given that the abundant organic matter in the host rocks has its origin in the remains of ancient dead microbes.



Dr Anya Reading holds a paperweight presented by CSM in acknowledgement of her talk, entitled Australian Adventures with the Ambient Seismic Wavefield.

Anya delivers Heiland Lecture in Colorado

Dr Anya Reading was invited to present the Heiland Lecture at the Colorado School of Mines (CSM) during a recent study visit to the American states of Utah and Colorado. The Heiland Lecture is a seminar series, sponsored by CSM's Department of Geophysics, in which they invite distinguished speakers from academia, industry, or government to give talks on topics pertinent to the geosciences.

While at the university, Anya took the opportunity to visit Professor Roel Snieder and his students, who are working on 'ambient seismic techniques', similar to the Program Three (Discovery) project of the same name that Anya leads at CODES. The work uses background 'ambient' seismic energy, previously thought of as noise, to form images of the subsurface. This helps to determine tectonic structure and the depth to basement for mineral exploration under cover.

A hat trick of successes

Congratulations to Dima on three significant achievements in recent months. In late September, he received the UTAS Vice-Chancellor's Award for Internationally Recognised Research in the fields of igneous petrology, geochemistry and ore genesis. A few weeks later, he received the good news that he had been awarded an ARC Discovery Grant as sole Chief Investigator (CI) for a three-year research project on carbonatites, using data from melt inclusions. At around the same time, he also learned that a Large Infrastructure, Equipment and Facilities (LIEF) proposal, on which he was co-CI, had been accepted by the ARC. The proposal was for an x-ray scattering facility for

advanced characterisation of natural and novel materials, and was submitted with colleagues from Monash, Deakin, La Trobe and Melbourne universities, with Monash as the administering organisation.



Dima receives his award from UTAS Vice-Chancellor Professor Peter Rathjen.

Dima fosters ties with Europe

Professor Dima Kamenetsky has returned from a fruitful three-month trip to Europe that has resulted in new or strengthened relationships with a number of highly regarded institutions and universities. Key stops included the University of Bonn, University of Münster, University of Barcelona, Max Planck Institute, Vilnius University, VU University Amsterdam, Université de Toulouse, GFZ Potsdam and the GEOMAR institute.

The catalyst for the trip was a research collaboration request from former UTAS Geology Department (pre-CODES) postdoc, Chris Ballhaus. Chris is now a professor, and Head of the Geology Department, at the University of Bonn, which was Dima's host institution during his stay.

A highlight of his itinerary was the field work in the Troodos Mountains of Cyprus, which were formed from about 90 million years ago during the collision of the African and European tectonic plates and closure of the ocean Tethys. The area

is known throughout the world for its remarkable geology and mineral deposits, particularly its exceptional examples of ophiolite stratigraphy. This was of special interest to Dima as the ophiolite contains deposits of chromite, as well as picritic rocks with abundant chromite phenocrysts. The improved understanding of the origin of the Troodos chromites, tested through the study of sulfide and silicate melt inclusions, can help to shed new light on the processes involved in the formation of the supergiant Bushveld and Noril'sk deposits. The work at Troodos was performed in collaboration with researchers from GEOMAR, based in Kiel, Germany.

"I look forward to returning to Europe next year to continue my work and attend the Goldschmidt conference. It will further enhance our strong relationships with these world-class institutions, and create synergy through the sharing of ideas," says Dima.

Language no barrier in Lima

CODES made good use of the multicultural nature of its PhD cohort by ensuring that its exhibition booth was staffed by Spanish-speaking students at the Lima 2012 Congress, held at the Peruvian capital's Westin Hotel from 23 to 26 September.

Argentinean Francisco Testa took by far the largest allocation of duties on the booth, but he was ably assisted at various times by Gisela Cobenas from Peru and Carlos Jimenez from Colombia – plus a number of non Spanish-speaking students (and staff). The team was aided in its communications with the many Latin American visitors by a range of bilingual marketing materials.

Lima 2012 was organised by the Society of Economic Geologists (SEG) in conjunction with the

Geological Society of Peru, and comprised two events that ran in parallel. One event was the SEG's annual conference, which naturally focussed on topics related to economic geology,

with invited talks from Professor Ross Large and Dr Mike Baker. The second event was the Peruvian Geological Congress, which covered a broader range of the geosciences.



Francisco Testa conversing in Spanish to a visitor, with translated information on CODES as his backdrop.

Major presence at IGC

CODES staff have played a significant role in the 34th International Geological Congress (IGC), held at the Brisbane Convention and Exhibition Centre (BCEC) from 5 to 10 August, 2012. Contributions included 37 presentations by 29 CODES speakers, including keynotes by David Cooke, Dima Kamenetsky, Ross Large and Khin Zaw, and invited talks by Basril Basori, Nathan Fox and Julie Hunt. An invited talk was also given by Taryn Noble, who is part of CRC ORE, but also a key member of the CODES GeM^{III} team.

The 34th IGC was the largest geological event ever to be held in Australia, with 6,012 delegates from 112 countries, plus 3,232 speakers. There were also over 30 field trips, which encompassed every Australian state, plus New Zealand, New Caledonia, Papua New Guinea and Malaysia.

Running alongside the conference was a major international exhibition that included 268 exhibition sites.

One of these sites was occupied by a CODES booth that was designed specifically for the event. The design included distinctive backlit graphics, which served as a beacon for both the extended 'CODES family' and those finding out about the Centre for the first time.

The IGC was hosted by the Australian Geoscience Council, with the theme of *Unearthing Our Past and Future – Resourcing Tomorrow*. The congress

was first held way back in 1878, and has become the oldest and most prestigious gathering of geoscientists in the world. The next IGC, the 35th, will be held in Cape Town, South Africa, in 2016. However, planning is already underway for the 36th congress in New Delhi in 2020, which is testament to the huge logistical challenges in hosting such a mammoth event.



CODES Corner: the booth proved to be a popular stopping-place at the congress.

Newcrest supports new laboratory

CODES has secured the support of one of the world's top gold-producers, Newcrest Mining, as a foundation client of its new mineral research facility focussed on ore deposit characterisation. The mining company has agreed to contribute \$1 million to the development of the facility, plus a further \$1.5 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. These techniques reveal quantitative information about the siting of gold within the mineral assemblage of an ore deposit and the deleterious trace elements associated with mineral complexes, which could affect the economic extraction and recovery of minerals, and their environmental impact.

"It's all about knowing your deposit better. Australia has been blessed with an abundance of mineral resources. However, while new ore bodies continue to be discovered, they are increasingly found at greater depths. Not surprisingly, an ore body buried kilometres underground is much more difficult to identify. It is also harder to ascertain its extent, consistency and potential for producing good ore grades, with good recoveries and minimum environmental impact. This new CODES facility will greatly enhance a mining company's knowledge of newly

discovered deposits, giving it the tools and data to make informed decisions that will significantly improve the potential for high returns on its investments.

"Nowadays, the major mining companies want to reduce the risk of problems at the start-up of a new mine. This means better ore deposit characterisation, or in everyday terms 'knowing your deposit better', so that mining and processing plans are designed with a maximum amount of ore body knowledge. The costs of mine start-up are so high these days that companies cannot afford to make mistakes," says Professor Ross Large, who was Director of CODES at the time of the announcement, and has played a key role in the initiative.

"The Technology Program is critical to all our research. It is the thread that runs through our other four programs, contributing greatly to successful outcomes. Therefore, it is vital that CODES continues to make the necessary investments to ensure that our staff and external users have access to facilities that are not only state-of-the-art, but also have the capacity to handle our increasing analytical requirements.

"Many of the gold mines of the future will be processing very fine grained sulfides containing 'invisible gold', now termed nano-gold or refractory gold. The costs and energy required to extract the gold from these ores are very high and new technologies will be required to reduce costs and energy consumption. This is where CODES' mineral research facility comes

into play", says Professor Large.

CODES has advanced to the forefront of technology, applied to ore characterisation, through a strategy centred around ongoing investment in cutting-edge equipment, building and maintaining a



Professor Leonid Danyushevsky is the Scientist in Charge of the new lab.

team of world-class researchers, and fostering synergistic collaborations with other leaders in the field.

In addition to the planned new mineral research facility, the Centre has invested extensively over the past decade in developing innovative mineral and rock analytical techniques using the rapidly advancing laser ablation (LA) ICP-MS technology. Its laboratories already house a broad suite of cutting-edge instrumentation capable of high quality, precision analysis for ore characterisation. The Centre's leading edge is based on a number of unique analytical techniques and calibration standards for analysis of sulfides, combined with having staff that have extensive expertise in analytical protocols and the interpretation of results.

The existing state-of-the-art facilities cover a wide range of applications encompassing the routine multi-element analysis of sulfide and oxide minerals, including the full range of platinum group elements; U/Pb dating of zircon and monazite; and multi-element analysis of silicate minerals and glasses.

CODES currently has three main laboratories, which focus primarily on the following areas, respectively:

- Mapping and trace element zonation in sulfide minerals; including a focus on refractory gold ores – using Agilent 7500a mass spectrometer and New Wave UP213 laserprobe.
- Quantitative multi-element spot analysis of sulfide and oxide minerals – using the Agilent 7700s mass spectrometer and New Wave UP193 laserprobe.



The new lab will augment CODES' existing LA-ICP-MS facilities.

- Uranium and lead dating, plus silicate trace element analysis and imaging – using the Agilent 7500cs mass spectrometer and Resonetics Resolution M50 excimer laserprobe.

Its facilities and expertise are used extensively by other leading organisations, and its own capabilities are greatly enhanced by collaborations with its node partners, plus a host of renowned international institutions, such as Hefei University of Technology, Imperial College London, Moscow State University, and the University of Johannesburg. In total, there are currently 12 national and 15 international collaborations solely related to the Technology Program.

In addition, the Centre has reciprocal arrangements with the UTAS Central Science Laboratory, which has an extensive suite of complementary equipment, particularly in the areas of electron microscopy, X-ray microanalysis, spectroscopy, ICP-MS, and Mineral Liberation Analysis (MLA).

The new minerals research facility is expected to be completed by mid-2013. CODES is seeking additional foundation clients to participate in the expansion of this new facility.

For further information, please contact the Technology Program Leader, **Professor Leonid Danyushevsky**, at +61 3 6226 2469 or email: l.dan@utas.edu.au

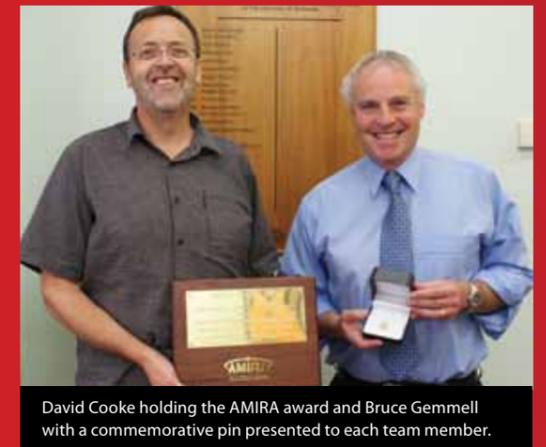
Team wins award for geoscience research excellence

A team of CODES researchers has received the inaugural AMIRA International Award for Geoscience Research Excellence, which was presented at the organisation's biennial global conference for exploration managers, held at the Vines Resort, Swan Valley, Western Australia.

The team, led by Professors David Cooke and Bruce Gemmell, won the award for its research into enhancing the ability of exploration geologists to identify productive ore zones in porphyry-related mineral districts (projects P765, P765A and P1060). Key criteria for the award included the quality of the research, the quality of the research management (which needed to be demonstrated by exemplary execution of the research program), strong collaborations, timely delivery of results, and the impact of the research on the sponsors' operations and the industry as a whole. These last two criteria relating to impacts were of particular

significance, bearing in mind that the award was presented based on votes from representatives of the minerals industry.

The research was conducted in collaboration with Imperial College London (UK), the Colorado School of Mines (USA), Lakehead University (Canada), and the Hefei University of Technology (China). Other past and present CODES-based members of the team were Mike Baker, Zhaoshan Chang, Huayong Chen, Nathan Fox, Shaun Inglis, Tim Ireland, Nic Jansen, Roisin Kyne, Elena Lounejeva, Jose Piquer, Michael Roach, Francisco Testa, Jennifer Thompson, Noel White, Cari Wurst and Lejun Zhang.



David Cooke holding the AMIRA award and Bruce Gemmell with a commemorative pin presented to each team member.

Five-year collaboration leads to Skinner Award

Professor Ross Large and Dr Stuart Bull from CODES, and Professor Valeriy Maslennikov from the Russian Academy of Sciences, are the principal authors of a paper that has been awarded the international Brian J Skinner Award by

the Society of Economic Geologists (SEG) for the best scientific paper published in *Economic Geology* during the year.

The paper outlines a new theory on the processes by which gold is concentrated in sedimentary basins and subsequently

upgraded to form major ore deposits. A second outcome described in the paper, and already adopted by several exploration companies, is a new method for predicting the presence and location of gold deposits in these types of geological formations.

The paper is the result of a five-year collaborative research initiative with scientists from the Russian Academy of Sciences, which included field work in western Tasmania, Bendigo in Victoria, Nevada in the USA, and Siberia in Russia.



Ross Large



Stuart Bull



Valeriy Maslennikov



The group at the Mupane gold mine in Botswana.

Chapter goes deep in Africa

The CODES SEG Student Chapter can always be relied on to choose somewhere interesting, and of great geological significance, for its annual field trip. This year was certainly no exception, with the group heading off for South Africa on a journey that included the renowned gold fields of the Witwatersrand Basin, the platinum-rich Bushveld Igneous Complex, plus various mines over the border in Botswana

3 Ks down on the Highveld

The group, led by Ross Large, Chris Large and Dave Hutchinson, started its field trip on South Africa's Highveld, where

a highlight was a visit to AngloGold Ashanti's Mponeng mine, currently the deepest mine in the world. The mine is one of three adjacent mines that form the West Wits gold field near Carletonville to the west of Johannesburg. The other two mines, Savuka and Tau Tona, have each held the 'world's deepest' accolade at various times, but at the time of this particular visit Mponeng held the record at 3.4 kilometres. The group descended almost the full depth, venturing 3.2 kilometres to witness active mining of the Ventersdorp Contact Reef (VCR). This was followed by a stop at the core yard where several different examples of the VCR and the Carbon Leader Reef were closely examined. At this point in the itinerary, CODES Director, Ross Large, and Rob Burnett of AngloGold Ashanti were able to provide a detailed talk on the sedimentology and mineralogy of these deposits. Ross and Rob are actively

involved in a research collaboration involving the Witwatersrand Basin and were therefore the perfect match for a talk on this subject.

On to Marikana

The next destination was Lonmin's Marikana mine, near Rustenburg in the country's North West Province. This site was later destined to hit the headlines around the world under tragic circumstances. However, there was no hint of the unrest to come on the day the group visited the mine. In fact, it was a public holiday and everything was exceptionally quiet. Nevertheless, staff at the mine were on hand to show the party around its core yard, where they saw samples of the world class PGE mineralisation of the Merensky and UG2 reefs from the renowned Bushveld Igneous Complex – the world's richest resource of platinum group metals.

Crossing the Limpopo

The second segment of their journey saw the group travelling across the border to Botswana – often referred to as 'crossing the Limpopo' by locals, in reference to the river that separates the two countries.

Co-leader of the group, Chris Large, worked in the minerals industry in Botswana for a number of years, and was therefore ideally placed to share his local knowledge with the participants, both in terms of mining / geological aspects as well as less scientific matters.

The group based themselves in Francistown, which is near the border with Zimbabwe, but also close to many of Botswana's key mining operations.



Chrysocolla vein mineralisation at Discovery Metal's Zeta operations.

Busy in Botswana

The group visited a host of mining operations during a very busy schedule in Botswana. These included the Mupane gold mine, Mokobaesi uranium prospect, Pheonix nickel mine, Selebi-Phikwe nickel-copper mine, Mowana copper mine, and the Zeta Pit.

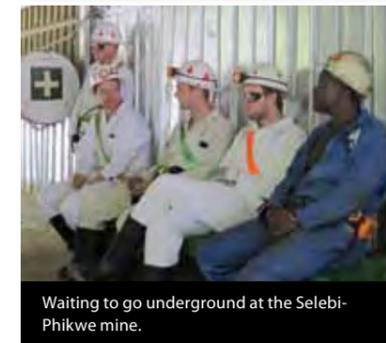
At Mupane the group saw ironstone-related orogenic gold mineralisation, typical of eastern Botswana, in two open pits on the mine site (Tau and Tholo). At the Mokobaesi uranium prospect, they examined the supergene uranium mineral, carnotite, in trenches on the property. Low grade gabbro-hosted Ni and PGE mineralisation were viewed at the Phoenix mine, which utilises dense, medium separation techniques to mine down to a cut-off grade of 0.1% Ni, making it one of the lowest grade nickel mines in the world.



Processing plant at the Phoenix mine.



Ventersdorp Contact Reef from the Mponeng mine.



Waiting to go underground at the Selebi-Phikwe mine.

Top, right: Chris Large (left) at Discovery Metal's Zeta Pit.

At Selebi-Phikwe, one of the country's oldest mines, the group again ventured underground where they observed both massive and disseminated nickel/copper mineralisation. The penultimate stop on the series of mine visits took the group to the Mowana copper mine, where they saw chalcopyrite and bornite associated with quartz veins and breccias within north north-east trending shear zones. The final stop was at Discovery Metal's Zeta Pit, where they were able to see the early stages of mine construction at the copper-silver mineralisation prospect, before travelling to the core yard to examine mineralised core from several different zones on the company's tenements.

Okavango, relaxation – and a big thank you

After a hectic schedule, all that was left was to relax for a short while and take in the wonders of the world famous Okavango Delta. This huge inland delta formed where the Okavango River met a tectonic trough in the central part of the endorheic basin of the Kalahari. However, the group were not too concerned with the geology of the delta by this stage. All they wanted to do was enjoy their game drive, during which they saw literally hundreds of elephants, lions with their cubs, and a wide range of other African fauna.



Examining samples of UG2 and Merensky Reef at Marikana.

In addition to the group leaders, the SEG Student Chapter wishes to thank:

- The sponsors: Barrick Australia, AngloGold Ashanti, Teck Resources, Data Metallogenica, SEG and CODES.
- Companies that assisted during the various mine visits: AngloGold Ashanti, Lonmin, Tati Nickel, Galane Gold, A-Cap Resources, BCL, African Copper and Discovery Metals.
- Industry participants from AngloGold Ashanti, Rio Tinto, First Quantum Minerals and Keiran Munro (independent).

Plans are already underway for the 2013 trip. A destination had not been finalised at the time of going to press, but it is sure to once again be somewhere brimming with geological interest and diversity.

Please note that a limited number of places are available to people from outside the CODES SEG Student Chapter.

For further details, please contact **Francisco Testa** +61 3 6226 2478 F.J.Testa@utas.edu.au



Gondwana link found off WA

CODES Research Fellow, Jacqui Halpin, was a primary investigator in a team of geoscientists that made international headlines when they discovered two plateaux far off the coast of Western Australia that are believed to be remnants of the ancient Gondwana supercontinent.

The discovery was made during a three-week expedition led by members of the Earthbyte Group at Sydney University aboard the research vessel *RV Southern Surveyor* to map the poorly understood Perth Abyssal Plain. The team's objective was to better characterise the ocean basin by collecting new bathymetric and magnetic anomaly data and directly sampling prominent features on the seafloor.

The abyssal plain was formed from about 130 million years ago when East Gondwana split and drifted apart to form what are now India, Antarctica and Australia. The team believe that the plateaux, named Batavia Knoll and Gulden Draak Ridge after seventeenth century ships that came to grief off the coast of WA, were also once part of Gondwana, but they became detached as the supercontinent broke up and formed the more familiar landmasses we recognise today. This left the plateaux, which together are roughly the size of Tasmania, submerged and stranded in the Indian Ocean approximately 1,600 kilometres west of Perth.

On navigation charts, these bathymetric features are mapped as undersea volcanoes (seamounts). Therefore, the team were intrigued when dredging harvested continental rocks such as granite, gneiss and sandstone containing fossils, rather than the expected common ocean floor rocks, such as basalt.

"Even though we had the hypothesis of the Gondwana link in mind when we set-out on the expedition, it was still very exciting to find such a huge variety

Above: Jacqui Halpin (third from left) with the geology team on board the *RV Southern Surveyor*. From left Robyn Gardner (Macquarie University), Madeline Kobler (Macquarie University), Jacqui, and Nathan Daczko (Macquarie University).
Left: CSIRO/Marine National Facility crew coaxing the precious rock samples out of the dredge basket.



of continental rocks so far out to sea," said Jacqui.

In addition to Jacqui, the team consisted of scientists from Sydney University, Macquarie University and international collaborators. Jacqui was chosen to join the team through her strong links and research collaborations with these institutions. She carried out postgraduate studies at Sydney University, where she attained a PhD researching the metamorphic and geochronological evolution of granulite facies rocks from the Rayner Complex in east Antarctica, and has participated in collaborative research with Macquarie University.

The trip was not without its dramas. On the third day of the cruise, the team's magnetometer, which was being towed 200 metres behind the ship, sprung a leak, possibly due to a shark attack – evidenced by several large bite marks on the equipment. Fortunately, Geoscience Australia had provided a backup unit, which was then used during the rest of the cruise to collect the vital detailed magnetic profiles. Dredging at depths of 2,000–3,500 metres also presented its challenges. Nonetheless, the team managed to gather hundreds of kilograms of rocks – all that's left now is finding the time and the resources to analyse them all.

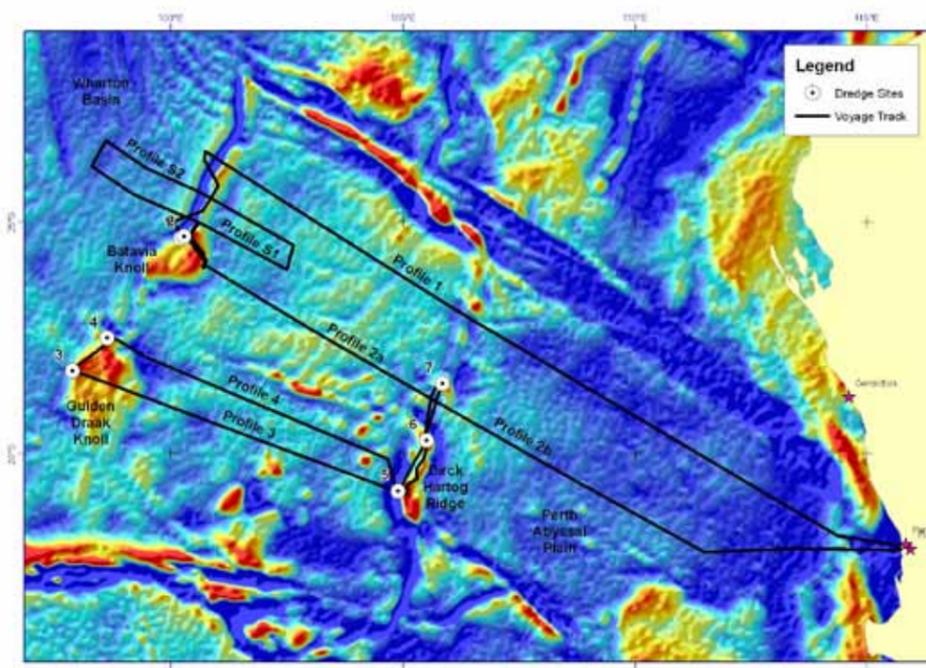
"We have a lot of work to do. The detailed studies have the potential to reap rewards in a variety of scientific areas. They will enhance our understanding

of the way the Earth evolved over geological time and the mechanics of how continents actually break apart. From an economic geology perspective, it's important for Australia to know what geological formations lie offshore and if they might be viable future resources.

"Two students from Macquarie University have recently finished research projects looking at the basement rocks from Batavia Knoll and Gulden Draak Ridge. Their results confirm these microcontinents were part of Gondwana and the oldest rocks actually date back to the Archaean. Correlations can be made with onshore geology in Western Australia and Antarctica. It's vital to build on this research with a further expedition to the area. We have been successful in securing more ship time in 2014 to return to Batavia Knoll and the surrounding region, including the poorly explored Zenith Plateau to the north east. We would like to do a detailed swath sonar survey to look at the surface topography in detail and even some seismic lines to understand the deeper crustal structure. Of course, we will aim to recover more rocks too! We have also applied to head back to the Gulden Draak region in 2015," said Jacqui.

The *RV Southern Surveyor* will soon be replaced by a brand new research vessel, the *RV Investigator*, funded by the Australian Government's 'Super Science Initiative', opening the door to many more exciting discoveries in the vast unexplored marine territories surrounding Australia.

And in further good news, Dr Jo Whittaker, who has been instrumental in setting up the Perth Abyssal Plain research, will be joining the Institute for Marine and Antarctic Studies (IMAS) at UTAS in 2013. Jo will be working primarily with the IMAS Director, Professor Mike Coffin, who already has ties with CODES and the School of Earth Sciences. Therefore, this appointment will further strengthen collaborations, add to the university's marine geoscience capability, and ensure that there will be plenty more to report in future issues of *Ore Solutions*.



Above: A swath bathymetry image of the NW corner of Batavia Knoll (looking SE). The incised gullies were targeted for dredging to maximise recovery of fresh basement rock samples. The trench in the foreground is approximately 6km below sea level, and the top of the plateau about 2.5km deep.
Left: Gravity image of the Perth Abyssal Plain offshore southern Western Australia showing the ship's track and dredge locations.



Rebecca strengthens JAMSTEC links

- VIA RESEARCH CRUISE TO THE NORTHERN IZU-BONIN ARC, JAPAN

ARC Research Fellow, Rebecca Carey, further cemented CODES' long-standing collaboration with the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), by being invited to join its international research team on a 16-day cruise to the northern Izu-Bonin Arc in Japan, concluding in early August.

The principal aims of the expedition were to use an array of multidisciplinary approaches to improve the understanding of the geology and geological history of three submarine silicic volcanoes – Oomurodashi, Kurose-Nishi Hole, and Kurose Hole – and gain a greater understanding of the volcanic processes that occur during their explosive submarine eruptions. Additional aims were to conduct heat flow measurements and search for underwater active hydrothermal areas and vents. Successes in meeting this very diverse set of objectives included the initial construction of a geological map for each of the areas, the discovery of ancient and new sulfide chimneys, and the collection of a wide variety of high quality rock samples for further analysis.

The research ship, the *Natsushima*, is frequently used for volcano and ocean

research, and was therefore extremely well-equipped to meet the researchers' scientific requirements. Included in its impressive array of equipment were multibeam bathymetry, single channel seismics, and acoustic sensors for detecting anomalies, such as fluids of different densities, bubbles, and particles in the water column beneath the ship.

The *Natsushima* is also the mother ship of the *Hyper-Dolphin*, which is a state-of-the-art remotely operated vehicle (ROV) capable of conducting surveys at depths of up to 3,000 metres, using a fibre optic cable encased in a protective steel tube for communication. Equipped with an ultra-high-sensitivity high-definition TV camera, the vehicle can facilitate detailed visual and filmed surveys in the deep sea. Two mechanical arms are

used to collect samples from the ocean floor, which it then stores in multiple baskets, ensuring that rocks collected from different sites are kept separate. For sediment stratigraphy and thermal conductivity measurements, it has two heat flow probes, a high temperature (500°C) thermometer, and push cores. It also has pH, H₂S, turbidity and oxidation-reduction potential (ORP) chemical sensors for use in hydrothermal areas.

This wide array of equipment on the *Hyper-Dolphin* and its mother ship proved to be critical to the success of the research cruise. For example, the bathymetry, coupled with the seismic profiles collected at night, enabled the volcanic edifice and shallow 3D structure to be mapped. In the morning, the team was then able to choose well-



'Mission control' – the *Hyper-Dolphin* Command Room.

targeted locations for the recovery of rock samples by the ROV. The ROV was lovingly operated by 4 ROV crew and the commander, who were advised by the Scientist in Charge, with input from the scientific team. Collecting particular samples in outcrop was critical to the Cruise Science Objectives.

Additionally, acoustic anomalies in the water column enabled the team to find an area of high temperature active hydrothermal vents at only ~250 metres below sea level. New and ancient sulfide chimneys were identified, with subsequent measurements of temperatures and heat flows, and collection of samples. Further inspection of these samples on board showed sulfide minerals, such as galena, sphalerite and pyrite, in abundance.

A highlight of the expedition was the study of the Kurose-Nishi Hole. This relatively young caldera is situated at great depth, with its base at between 1,300 and 1,400 metres below sea level. Eruption depths are thought to be in the region of 1,000 metres – which is considered by many to be the depth limit for silicic explosive eruptions. Two ROV dives up the caldera wall revealed an amazing 500+ vertical metres of fresh-looking rhyolitic pumice, which was sampled by the ROV at different depths. JAMSTEC has provided CODES researchers with a subset of these samples, which will provide an invaluable deep end-member for



Rebecca with Scientist in Charge, Dr Kenichiro Tani from JAMSTEC.



Rebecca (left, foreground) and other team members identifying rock types and compositions from the samples.

their existing suite of samples from submarine silicic explosive eruptions.

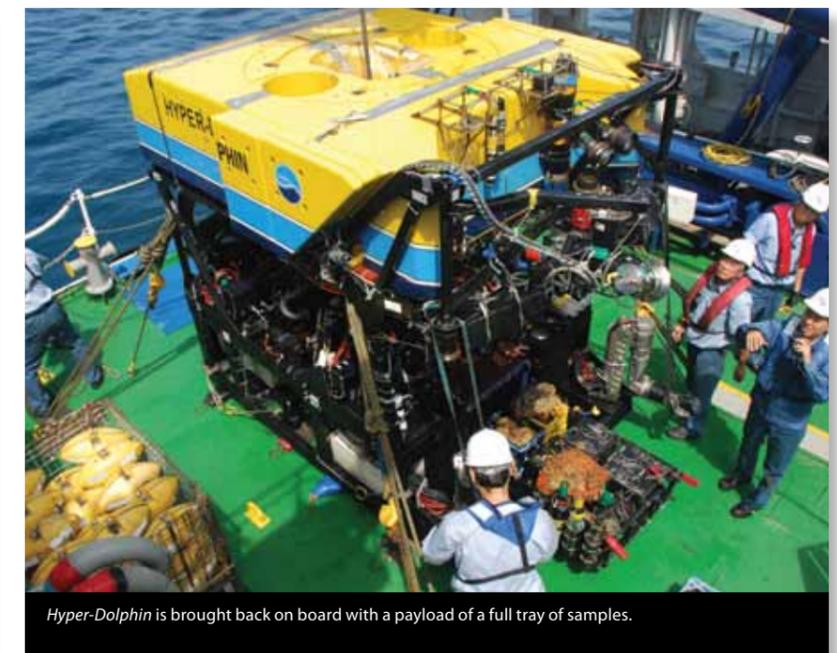
Overall, it was a highly fruitful expedition for Rebecca and her fellow team members, who hailed from Japan, the UK and the USA. Despite the fact that the team lost two full days while anchored in Takeyama Bay waiting for a typhoon to pass, the cruise reaped many rewards, particularly in terms of identifying recent and ongoing activity from these submarine volcanoes, which have implications for submarine volcanic hazards in Japan. The surveys performed by the team also generated a host of areas for further research. For example:

- It is known that confining the pressure of the overlying water influences the degassing behaviour and, theoretically, the explosivity is suppressed with increasing water depth. Therefore, further

research is planned to increase the understanding of how confining the pressure of the overlying water column modulates processes of silicic magma degassing during ascent and fragmentation in the conduit.

- External water at the vent during eruptions (at, or close to, atmospheric pressure) is known to cause magma-water interaction, arresting vesiculation and driving highly explosive eruptions. Therefore, further research will be conducted to determine the role of ambient seawater fluid during fragmentation in seafloor silicic eruptions.

The quest to find answers to these and other intriguing scientific questions has set a strong platform for continuing CODES-JAMSTEC collaborative submarine research well into the future.



Hyper-Dolphin is brought back on board with a payload of a full tray of samples.

Collaborations play vital role in ARC-funded research

CODES' collaborations with JAMSTEC (Japan), Lawrence Berkeley National Laboratories (USA), and the Australian Synchrotron are proving pivotal to two separate, but closely related, ARC research projects being conducted by Dr Rebecca Carey and Dr Sharon Allen. Both projects are researching the degassing of silicic magma with implications for ascent and eruption processes.

JAMSTEC plays vital role

The research performed on the JAMSTEC Izu-Bonin Arc cruise (see page 14), and ongoing collaborative work between CODES and JAMSTEC, is making a significant contribution to the understanding of underwater volcanic activity. Three-quarters of the world's modern volcanoes are submarine. Therefore, due to the obvious challenges in terms of access, the understanding of the eruption processes for these types of volcanoes is in its infancy compared to their subaerial counterparts. The work of both CODES researchers is focussed on making a contribution to addressing this imbalance. Therefore, the samples and data provided via the extensive dive program undertaken by JAMSTEC, which encompasses the full spectrum of eruption depths and intensity of modern seafloor volcanoes, are proving invaluable to their quest to achieve research outcomes. A good example of the benefits of this relationship is the high quality set of submarine volcanic pumice samples that was collected on the recent Izu-Bonin Arc cruise.

Building on CODES / CSL capabilities

Nevertheless, gathering a world-class set of samples is only beneficial if the researchers have access to world-class facilities for the subsequent analysis. Rebecca and Sharon have the best of both worlds in this respect, as they have access to the exceptional range of equipment at CODES and the UTAS Central Science Laboratory (CSL), which is augmented by external collaborations with a number of exceptional national and international organisations. For example, they have managed to secure sought-after Fourier Transform Infrared Spectroscopy (FTIR) beamtime at the Advanced Light Source at the Lawrence Berkeley National Laboratories in California, USA, and also at the Australian Synchrotron in Clayton, Victoria. The use of a synchrotron FTIR is critical, as the light is extremely bright and can be treated as a point source, which equates to high spectral and spatial resolution.

This bright light facilitates measurements at small spatial scales (3–5 microns) of both melt inclusions and volcanic glass.

The collaborations will help the two researchers to conduct studies in a number of pioneering directions. For instance, the work will include the first time that S-FTIR measurements have been taken of water speciation in silicic submarine volcanic glasses, making it possible to separate magmatic volatiles and meteoric/seawater volatiles that have been added due to post-eruption water resorption. This data can then be used to constrain magmatic volatile budgets of silicic submarine products with known eruptive depths, and provide



inputs to models on their potential to contribute to mineralisation.

"The main goal is to improve the knowledge and basic understanding of how magma ascends and degasses in submarine silicic eruptions. I believe that such fundamental knowledge of the Earth's processes will provide critical data for future models of post-eruption mineralisation processes. The involvement of external collaborators, such as JAMSTEC, Lawrence Berkeley and the Australian Synchrotron, is integral to the success of this project and I wish to thank them immensely for their help and support," says Rebecca.



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.

A team of researchers, led by Professor Ross Large, has settled a long-running debate over the origins of the world's largest and deepest gold deposit, with a surprising result – both sides of the argument have been proved to be correct.

For well over a century, geologists have argued over the genesis of the renowned Witwatersrand ore deposit located in South Africa's Highveld region. This remarkable ore body, known as a super-giant because of its size, is big by any standards. Although the gold runs in a narrow conglomerate reef just a few centimetres thick, it extends to a length of over 500 kilometres and runs to a depth of at least 4 kilometres. It has been one of the cornerstones of South Africa's economy, producing over 40,000 tonnes of gold since its discovery in 1884. To put this figure in perspective, that is enough gold to fill the vaults of Fort Knox over eight times.

Not surprisingly, there has been a lot of interest in how this geological phenomenon occurred. Generally speaking, the theorists fell into two camps: the 'placerists' and the 'hydrothermalists', with each side adamant that their version of events was

correct. The 'placerists' held the view that the gold had been eroded from nearby mountain ranges, and transported by major rivers to be deposited in conglomerate placers, or heavy mineral layers, within a sedimentary basin. This theory is similar to how gold is known to accumulate in current river systems, near their mouth. The 'hydrothermalists' argued that the gold was transported in hot watery solutions, named hydrothermal fluids, which came from depths of 15 to 20 kilometres and transported the gold along cracks in the rocks before it was finally deposited in the conglomerate reef.

The team examined what seemed like diametrically opposed explanations and were able to determine that both theories were correct, but the processes had occurred at different times in the evolution of the ore body. They found that the 'placerists' were correct in how the initial concentration of gold had formed in the conglomerates about 3 billion years ago, but then, about 800 million years later, the reef was hit by a pulse of gold-rich fluids, which supported the 'hydrothermalists' theory.

The researchers were able to achieve their breakthrough by developing a novel analytical technique that scans an extremely narrow laser beam across the gold and associated minerals to

determine the trace elements, isotope ratios and timing of the input of the gold. Very few laboratories in the world have this technological capability. For this reason, the CODES team was invited by AngloGold Ashanti, one of the largest mining companies operating on the reef, to assist in resolving the debate.

"It was a very satisfying outcome. Major advances in science are commonly borne from debates and controversies of this type. However, the outcome usually comes down on one side of the fence. In this case, we were able to prove that the results of the excellent research carried out over many decades, by hundreds of geologists, had proved right on both sides of the argument. This result also explains why the Witwatersrand deposit is the biggest and richest in the world – two major geological events added gold to the deposit, producing a double concentration effect," said Professor Large.

The other members of the team were Stuart Bull, Leonid Danyushevsky, Sarah Gilbert, Shaun Inglis*, Maya Kamenetsky and Sebastien Meffre from CODES, plus Karsten Goemann from the UTAS Central Science Laboratory.

*Shaun has now left the team to pursue a PhD via the UTAS School of Maths and Physics.



Masters Program evolves and grows

The Master of Economic Geology program continues to be the course of choice for industry-based geoscientists, who are attracted by the opportunity of studying for an internationally recognised degree, while still being able to pursue their careers in the minerals industry. One of the keys to the success of the program is its ongoing evolution, which ensures that it remains at the forefront of developments in the industry and the geosciences. This progression was once again evident earlier this year when the Centre held its inaugural Geometallurgy short course – the first course of its type in Australia.

New geometallurgy course

There is an increasing focus on geometallurgy in the mining industry, mainly due to the significant impact that this important field of the geosciences has on key operational areas such as risk management, efficiencies, profitability and environmental factors. CODES recognised this trend and, using the substantial knowledge and experience it had gained through its GeM^{III} project, developed a 12-day course as part its

Masters Program. This intensive course covers a comprehensive range of topics including all the major aspects of this specialised field, such as rock properties, mineralogy, sample selection, statistical techniques, comminution, mineral processing, environmental issues, data analysis and modelling. The course aims to provide participants with the skills and practical knowledge to help reduce technical risks and improve forecasting, economic optimisation of mineral production, and sustainability at their operations.

Included in the 12-day schedule are lectures, practical and computer-based exercises, and an excursion to a mining site, which this year was to the Rosebery Zn-Cu-Ag-Au mine.

Red Metal symposium

Three to four day symposiums have been a highlight of many previous

Ore Deposit Models and Exploration Strategies short courses, and this year the theme was Red Metal. This colourful topic addressed recent developments in research and exploration in relation to copper and copper-gold deposits. Deposits covered included Archean Au, Central African Copperbelt, Olympic Dam Cu-Au-U, and epithermal and porphyry deposits of the SW Pacific region. Although the world's economy is currently in the doldrums, the long term outlook for these important metals remains bullish. However, with new discoveries in rapid decline, many are questioning how our future needs for these metals can be met. This intriguing issue was the motivating force behind the Red Metal symposium, which addressed the fundamentals of copper and copper-gold deposits: geochemistry, metallogeny, genesis and exploration.



Tests for acid generation being conducted during the new Geometallurgy course.

Top, left: San Pedro, with basaltic scoria in the background. Top, right: Students on the Volcanology course visiting White Island, New Zealand.

Old favourites remain popular

In addition to the new items on the calendar, a couple of the regular courses have also been held since the last issue of *Ore Solutions*. Ore Deposit Models and Exploration Strategies followed on immediately after the Red Metal symposium, with most delegates attending both events. This popular biennial unit provided an up-to-date synopsis of a range of ore-deposit types and their characteristics, including important features that relate to their genesis and exploration. Deposit styles covered included VHMS, sediment-hosted Cu-Pb-Zn, orogenic gold, Carlin-type deposits, Witwatersrand gold, magmatic Ni sulfide and PGE, IOCG and U deposits. The course was led by Robert Scott, supported by a team of experts from CODES, Monash University and the minerals industry.

Earlier in the year, Jocelyn McPhie, Bruce Gemmill and Andrew McNeill once again led a team to the North Island of New Zealand to examine modern volcanic systems as part of the 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 highly hands-on course provides an 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 included.

Exploration in data-rich environments, close to existing mines, has become a preferred method of increasing company resources in recent years. Subsequently, this has led to an increased interest in the Exploration in Brownfields Terrains course, which is designed to bring participants up to date with the latest exploration techniques in these areas. The most recent of these popular courses was held in June, led by Andrew McNeill. The course covered cutting-



Participants studying porphyry display samples during a break in the Red Metal Symposium.



Students in the Brownfields course.

edge technologies in geophysics, geochemistry and 3D visualisation, using real data from world-class mineralised districts and was presented by expert teaching staff from CODES and the minerals industry. A notable feature of this particular cohort was that it included a record number of participants (23) that are taking the full Minerals Geoscience Masters Program.

Forthcoming courses in 2013

It is hard to believe that nearly two years have passed since the last Ore Deposits of South America course, but in March it is time for David Cooke and Bruce Gemmill to lead a new team of participants half way round the world for this ever-popular unit. This exciting field-based course in the magnificent Andes covers all the major ore deposit types of South America, including porphyry Cu-Mo, high sulfidation epithermal Au, and iron-oxide Cu-Au. Mines to be visited include El Teniente, the world's largest underground mine, and Chuquibambilla, the world's largest open pit. Along the way, the group will

have the opportunity to meet with researchers and exploration geologists working in the region, who will give a series of talks covering the geology, tectonic-setting and important exploration criteria for each deposit style.

David Cooke is also the leader for the Ore Deposit Geochemistry, Hydrology and Geochronology course, which is to be held in late June to early July. This unit covers a variety of geochemical and geochronological techniques used to interpret environments of ore formation and processes of ore genesis. It also discusses the implications of these datasets for mineral exploration. Topics include Ar-Ar, U-Pb and Re-Os geochronology, whole rock and trace element chemistry of igneous rocks, sulfide trace element chemistry, stable and radiogenic isotopes, fluid inclusions and hydrothermal geochemistry.

Julie Hunt and Ron Berry will lead the second Geometallurgy course in October, which will then be held at this time, once every two years.



Gisela Cobenas with the San Pedro volcano in the background. Photo taken during the popular Ore Deposits of South America course.

Lecture in the Solomon style

The CODES SEG Student Chapter was pleased to secure Professor David Groves to deliver the second Mike Solomon Lecture, held in August. David is a highly respected geologist who has an outstanding research record, and is known by generations of students for his exceptional teaching and mentoring skills – much like Mike. David received the prestigious SEG Penrose Medal in 2010, one of many accolades during his distinguished career. Once again, there are parallels with Mike, who received the SEG's highest award in 2007. However, one of the strongest links between the two is in David having been one of Mike's first graduate students at UTAS – conceivably the first supervisor and student pairing to both receive the Penrose Medal.

In true Mike Solomon style, David delivered an informative and entertaining lecture that addressed the problems that can be encountered when assessing whether mineral claims are worthy of investment or are too high risk. His presentation covered both the macro- and micro-scale, which enabled the audience to see the

factors that need to be understood when investing in the minerals sector.

"It was a fascinating lecture, especially for the younger people in the audience who may not have had the chance to see where the money for exploration comes from, and what investors ultimately want geologists to produce", said the then Student Chapter President, Dan Gregory, after the lecture.

This lecture is an annual event in honour of the popular, and highly regarded, UTAS

/ CODES teacher and researcher, Mike Solomon, who passed away in 2009.



Top: Mike Solomon receiving the 2007 Penrose Gold Medal from David Groves.
Bottom: David Groves delivering the Mike Solomon Lecture. Slide in the background shows old photo of Mike (far left).

Visitors to CODES

Below is a selection of just a few of the recent visitors to CODES who have conducted seminars.



Jim Gill from the University of California at Santa Cruz (USA) giving a presentation titled: Youngest and Oldest Volcanism of the SW Pacific.



Professor Jeremy Richards from the University of Alberta presenting his talk on subduction and post-subduction related porphyry systems.



SEG Lindgren Award winner (2012), Dr Patrick Mercier-Langevin, from the Geological Survey of Canada, was one of the invited speakers at the Red Metal Symposium, held at the end of October.



The 2012 SEG Distinguished Lecturer, Dan Wood, delivering a talk entitled 'Crucial Challenges to Discovery and Mining – Tomorrow's Deeper Ore Bodies'.

Three decades of research at your fingertips

Did you know that CODES has a comprehensive range of special publications covering many of the major research outputs from the Centre and UTAS School of Earth Sciences, spanning over three decades?

Topics include the pioneering pre-CODES research on plate tectonics from the late S Warren Carey, through to the groundbreaking work on the interpretation of volcanic rocks and a host of titles covering some of the world's major ore deposits – plus much more.

The full complement of titles available totals 17, which includes three publications from external authors with a close association with the Centre.

Further details, including a price list and how to order, can be found at the CODES website: www.utas.edu.au/codes/publications or contact:

Caroline Mordaunt
Ph: +61 3 6226 1773 (Tues & Thurs am)
Fax: +61 3 6226 7662
Email: publications@codes.utas.edu.au



Leonid co-presents course in Italy

In October 2012, Leonid Danyushevsky again teamed up with long-standing CODES collaborators, Robert Bodnar – Virginia Tech, and James Webster – American Museum of Natural History, to present the annual 'Fluids in the Earth' short course at the University of Naples Federico II. The five-day course was attended by postgraduate students and postdoctoral researchers from across the breadth of Europe, including the UK, Italy, Germany, Russia and Turkey.

Leonid co-presented the opening session with Robert Bodnar, which provided students with an introduction to phase equilibria and thermodynamics. Later in the week he covered a number of sessions on a variety of topics related to melt inclusion studies.

Participants had a mid-week break from their classroom-based activities to visit the Solfatara Volcano in Campi Flegrei – a 13 kilometre wide active caldera situated to the west of Naples.



Graduations



Congratulations to Charles Makoundi (MSc) and Natalee Bonnici (PhD) who graduated at the August graduation ceremony.



Congratulations to PhD graduates (from left) Fiona Best, Chun-kit Lai and Nic Jansen, seen here after the December graduation ceremony.

Moving in



Daniel Bombardieri has been appointed as a Research Fellow in geophysics, working with Anya Reading, Michael Roach and Andrew McNeill in a collaborative study with Mineral Resources Tasmania. His work is bringing together diverse geophysical, petrophysical and geological information to form well constrained 3D models of western Tasmania. Daniel works three days per week at CODES and two days at MRT.



PhD student, Qiyue Huang, from China, is working with Jocelyn McPhie and Dima Kamenetsky on the Olympic Dam project. His research is focussed on the connection between the Gawler SLIP and spatially or temporally associated mafic igneous units, including the Gairdner Dykes and Roopena Volcanics, and their contribution to the giant Olympic Dam deposit.



PhD student, Margy Hawke, is working with Bruce Gemmill on the DeGrussa Cu-Au deposit in the Murchison Province, Western Australia.



PhD student, Wei Hong, is working with David Cooke on studies of granite-related tin deposits in western Tasmania.



PhD student, Olga Apukhtina, from Russia, is working with Dima Kamenetsky on the Olympic Dam project. Her research involves stable isotopes and halogens in gangue and ore minerals, and the evaluation of mantle and crustal contributions to mineralisation.



PhD student Sean Johnson, from Scotland, will be working with Ross Large and Sebastien Meffre, looking at how metamorphic grade affects trace element mobility in black shales. The research is focussed primarily on the Talvivaara Ni-Zn-Cu-Co deposit in Finland, plus deposits in Sweden and Estonia.



PhD student Richelle Pascual, from the Philippines, is working on colloidal silica fluids in the Grieves Siding Pb-Zn Prospect, western Tasmania, with Bernd Lottermoser and Dima Kamenetsky.



Wenyan Sun is visiting CODES for 18 months to complete her PhD studies under the supervision of Dima Kamenetsky. Wenyan is being sponsored by the China Scholarship Council.



PhD student Francisco Testa, from Argentina, is working on tourmaline breccia pipes in Chile and Argentina with David Cooke and Mike Baker.



Elena Lounejeva has been appointed as a Laboratory Analyst.



Professor Pavel Plechov, from Moscow State University, is visiting CODES until early February as part of the UTAS Visiting Scholars Program. He is working with Leonid Danyushevsky on modelling magma crystallisation processes and petrogenesis of arc lavas.



Chengbiao Leng, from the State Key Laboratory of Ore Deposit Geochemistry, Chinese Academy of Sciences, is visiting CODES until mid-2013, working with David Cooke on studies of apatites in porphyry Cu deposits and sulfides in Pb-Zn deposits in China.

Moving up



Associate Professor Ron Berry has been appointed Acting Leader of the Recovery Program (GeM^{III}).



Khin Zaw has been promoted to Professor and sole leader of the Ore Deposits of SE Asia Project.



Professor David Cooke has been appointed Deputy Director.



Jocelyn McPhie has been appointed as Leader of the Location Program. She has also been appointed as Acting Head of the UTAS School of Earth Sciences.



Former PhD student Chun-kit (Kit) Lai has been appointed as a research fellow working on the Ore Deposits of SE Asia Project. His main areas of research include magmatic and metallogenic belts in Myanmar, and tectonic modelling in mainland SE Asia.



Former PhD student Abhisit (Masoe) Salam has been appointed as a research fellow working on the Ore Deposits of SE Asia Project. His main areas of responsibility include Indochina and Sumatra.



Dr Garry Davidson has been appointed Leader of the Discovery program.

Note: Bruce Gemmill's appointment as Director is covered in article starting on the front page of this newsletter.

Rejuvenated team mark midpoint of porphyry project

The team from the AMIRA P1060 (Enhanced Geochemical Targeting in Magmatic-Hydrothermal Systems) project gathered from far and wide in early December for what was its fourth sponsors' meeting. The meeting marked the halfway point in the project, which is progressing on schedule. The team, under the leadership of David Cooke and Bruce Gemmill, has been successfully rebuilt to full strength after losing a number of key members from the previous project (AMIRA P765A).



Cub scouts visit

The 10th Hobart Cub Scouts Group visited CODES in October and was taken on a tour of the Centre by Simon Stephens, who was ably assisted by PhD student, Qiuyue Huang.



Teachers' workshops

CODES has held further workshops as part of the Teacher Earth Science Education Program (TESEP). The professional development workshops are designed to help upper primary / lower secondary school teachers optimise the use of their time when teaching the earth sciences in their classrooms.



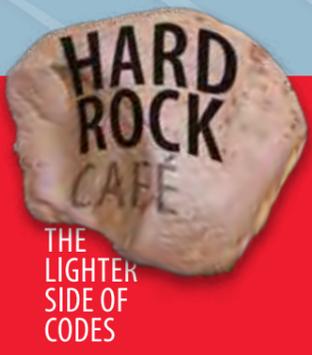
Talk for retiring types

Andrew McNeill educated and entertained a large group from the Glenorchy School for Seniors in October, with a talk entitled 'A geologist's life'.

Students experience science

Dave Hutchinson (white shirt) and Andrew McNeill (blue check shirt) taking the latest group of year-11 students on a microscopic 'tour' of rocks from around Tasmania. The visit was part of the ongoing Science Experience initiative aimed at encouraging students to continue their science studies.





Rock Bottom top

They may have started the latest SEG Student Chapter quiz as 'rock bottom', but by the end of the evening they were well and truly on top. The winning team, named Rock Bottom, are from left: Steve Calladine, Chris Large, Roisin Kyne, Dan Gregory and Selina Wu.



Waking the dead

Selina and Dan after celebrating their win in the quiz – or maybe just dragging their heels at the annual Hobart Zombie Walk.



The bottle half full

When you are going half way around the world, and plan to spend about half your time with a collaborating institution, it seems only right that you would get half a bottle of wine as a going away present. However, rather than getting a small bottle of wine, Bruce Gemmell spoke to Peter Cornish and Al Cuison to see if it was possible to split a bottle of wine down the centre. Through a combination of (careful) precision cutting and the wonders of clear casting resin, the bottle was split and reassembled with (half) the wine reinserted and perfectly sealed with half a cork at the top.

Bernd has taken up a position at the Environment and Sustainability Institute at the University of Exeter in the UK, and will be a Visiting Professor at CODES / the UTAS School of Earth Sciences (CRC ORE).



Head start for the Cup

A hat was one of the main (optional) entry requirements for this year's viewing of the Melbourne Cup in the Tearoom. Quite a few people joined in the spirit of things, with some hastily crafted creations and improvisations.



Boat Rockers on a roll

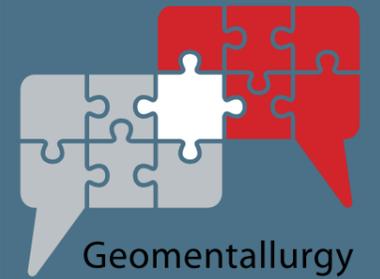
Also rans, and even runners-up, in years gone by, the dragon boat team from CODES / SES finally got its day in the sun when they beat a tough field of 17 teams (including Geography!!) at the annual dragon boat festival held on the River Derwent. The race was held a while ago now, but we couldn't let such a momentous victory pass by unheralded.



Jingle bell rock

The date of 12-12-12 certainly proved to be lucky for this year's Christmas BBQ, with everyone enjoying an idyllic summer's afternoon at the local Tarroona Scout Hall.

Merrymakers, including Rebecca Carey's friendly dog 'Bounty', pause while Bruce Gemmell and Jocelyn McPhie wish everyone the best for Christmas and talk briefly about the past, present and the road ahead.



Splitting headache

Two geologists on a field trip, far from civilisation, have just 10 litres of fresh water left in their supplies. Therefore, they decide to split the remaining water equally. But how can they do it? **The only things** that they have at their disposal are a 10-litre jug filled with water, plus an empty 3-litre jug and an empty 7-litre jug. How do they manage to split the water equally so that they are left with **exactly** 5 litres in the 10-litre jug and 5 litres in the 7-litre jug?

Please note that they cannot perform measurements by eye or based on the shape of the jugs.

Email entries to: steve.calladine@utas.edu.au by Friday, 22 February, 2013. The winner will have the choice of receiving either one of CODES' publications or a selection of corporate gifts to the value of \$50. The competition is open to readers in Australia and overseas.

SOLUTION TO PREVIOUS PUZZLE: The answer to the 'cryptic conundrum' in issue 28 was the letter G.

AND THE WINNER IS... The first name out of the hat was former CODES PhD student Martin Jutzeler, who chose one of CODES' publications.

CODES and School go top of the class in ERA Rating

CODES, in conjunction with the UTAS School of Earth Sciences, has scored the highest possible ranking of five in the latest Excellence in Research for Australia (ERA) evaluation round.

"We achieved a ranking of four in the previous ERA evaluation and, while that was a commendable performance, the aim has always been to achieve and maintain the top ranking. Our researchers have risen to this challenge and produced a result that is exceptional, especially considering the high volume of reports to industry that were produced in parallel with this academic output. I wish to thank and congratulate everyone involved," says Director, Bruce Gemmell.

The Australian Research Council's website defines the top ranking as being 'characterised by evidence of outstanding performance well above world standard presented by the suite of indicators used for evaluation'. ERA assesses research quality within Australia's higher education institutions using a combination of indicators and expert review by committees comprising experienced, internationally-recognised experts. This is the second ERA evaluation, which was introduced in 2010. Results for the 2012 evaluation were released by the Australian Government on 6 December.



Transcripts of publications in the CODES foyer.

New Geo-Logging course an Australian first

CODES has signed an agreement with international consulting group GHD to run the first Geo-Logging course to be held in Australia. The groundbreaking course will teach geologists how to take a comprehensive approach to assessing core samples, by looking beyond just the value of the ore and evaluating other key factors, such as how the rock is likely to break when extracted, the potential costs associated with mining in a particular area, the scale of engineering work required to establish a mine, and how to identify and mitigate environmental impacts.

"By taking a more holistic approach to factors associated with mining the ore body, we are filling a significant gap in the current courses available in Australia, and subsequently providing companies with the potential to save substantial amounts of money through better mine planning, enhanced risk assessment, and a more highly trained workforce," says CODES Director, Bruce Gemmell.

The partner in the initiative, GHD, is one of the world's leading engineering, architecture and environmental consulting companies. Established in 1928, the company employs more than 6,500 people across five continents and serves clients in the global markets of water, energy and resources, environment, property and buildings, and transportation.

Details of the course are being finalised, but it is envisaged that the first course will be run at CODES over a period of five days, in mid 2013. Teaching duties will be shared between GHD and CODES' geoscientists.

For further details, contact
Bruce Gemmell
+61 3 6226 2893
bruce.gemmell@utas.edu.au



From left, GHD staff Leon Rawson, Tony Hope and Matthew Daley with CODES Director, Bruce Gemmell after signing the agreement for the new course.