

ore solutions



Newsletter of CODES, the ARC Centre of Excellence in Ore Deposits at the University of Tasmania

Ores in Sediments: New Directions, New developments workshop an outstanding success

Over three days in mid-November 2006 more than one hundred people gathered to attend the CODES 'Ores in Sediments: New Directions, New developments' workshop. The meeting was convened by Peter McGoldrick from CODES and presented new information and the latest research results for several styles of ore deposits found in sedimentary basins. It was held at the Wrest Point Convention Centre and attended by industry, government and university geologists.



Attendees at the CODES 'Ores in Sediments' workshop held in Hobart in November 2006.

Over the three days, invited speakers from industry, international universities and CODES gave 26 individual presentations grouped into a series of commodity-focused sessions. The first morning began with an overview from Kurt Kyser (Queens University) of ore-related processes that occur in sedimentary basins. Kurt's talk set the scene for a series of talks on uranium from Dave Thomas (Cameco), Paul Polito (Anglo American) and Kurt (again).

The famous Zambian Copperbelt was the topic for the first afternoon session. Research results of AMIRA Project P544 (CODES/CSM collaboration 2000-2003) were presented by

Murray Hitzman (CSM) and CODES researchers (David Selley, Peter McGoldrick, Ross Large, Rob Scott, Lyudmila Koziy and Stuart Bull).

The second day, largely devoted to sedimentary zinc deposits, kicked off with two reviews: northern Australian Proterozoic sedex Zn deposits (Ross Large), and ore fluid chemistry and sulfide precipitation controls (David Cooke, CODES). Peter McGoldrick then described evidence for a

cont. page 2



ARC Centre of Excellence in Ore Deposits
University of Tasmania
Private Box 79
Hobart Tasmania Australia 7001
Tel: 03 6226 2472
Fax: 03 6226 7662
www.codes.utas.edu.au

IN THIS ISSUE

Promotions	2
Cruising the Pacific	3
Canadian alkalic research	5
No fool's gold	6
New CODES publication	9
PhD projects available	10

and more

MOVING UP ...



Introducing Associate Professor Ron Berry (left) and Professor Bruce Gemmell — their well-deserved promotions were announced in November 2006. Professor Gemmell has also been appointed Deputy-Dean of the

MOVING IN ...

Welcome back to Katrina Keep (PA to the Director), who has returned to CODES after maternity leave.

New PhD students

Andrea Agangi: Program 1 project on felsic magmas, supervised by Jocelyn McPhie, Sharon Allen and Dima Kamenetsky

Jacqui Blackwell: “Characteristics and origins of breccias in an alkalic epithermal gold deposit: Ladolam, Lihir Island, Papua New Guinea”, supervised by Jocelyn McPhie and David Cooke

Adel Vatandoost: GEM^{III} project to establish geophysical proxies for metallurgical parameters, supervised by Mike Roach and Steve Walters

Sarah Gordee: Program 1 project with Jocelyn McPhie and Sharon Allen

Anita Parbhakar: Environmental geochemistry, supervised by Steve Walters

Nathan Fox: Cadia porphyry Cu-Au project, supervised by Anthony Harris and Dave Cooke

New Honours students

Welcome to new Honours students: Laura Frankholm, Ian Woodward (bound for Siberia), Janeta Wellard (bound for Zeehan), Cameron Hamilton, James Akiel, Karen Adams (bound for Queenstown), Tom Lorimer, Alyce Brownlie and Meg Humphries.

MORE BABIES!

Sharon Allen and Jocelyn McPhie are the most recent of CODES’ staff to become parents, continuing the trend set by Katrina Keep (new baby Laura), Anthony Harris (new baby Matthew) and Cari Deyell (new baby Aidan). Sharon and Jocelyn’s twin boys, Reuben and Zachary, were born late October 2006.

from page 1

low-S Palaeoproterozoic ocean and the implications this has for sedex deposits. These overview talks were followed by series of deposits case studies, with Rod Maier (CODES), Ken Chapple (Gold Aura Ltd), Mick Skirka (Zinifex) and Peter McGoldrick describing Bluebush, Mehdiabad, Duddar and Red Dog, respectively. The penultimate presentation on day two was from Poul Emsbo (USGS) who argued that major Phanerozoic sedex events had ocean-scale chemical effects, notably on coeval seawater Sr isotope signatures. Day two concluded with a provocative talk from David Rickard (Cardiff University) discussing the merits of equilibrium versus kinetic approaches to understanding pyrite formation.

Day three saw a second pyrite talk from David Rickard and two presentations from Ray Coveney (University of Missouri–Kansas City) describing nickeliferous black shales from central USA and southern China. The workshop ended with two gold talks. One from Poul Emsbo presented a Sedex model for the Rodeo deposit in Nevada and one from Ross Large describing new laser ablation and textural studies of the giant Sukhoi Log deposit in Russia.

Plenty of time was allowed in the program for discussion, and most talks stimulated many questions. All questions (and answers) were recorded, and transcripts of these will be included in a workshop proceedings volume to be published as a CODES Special Publication in 2007. **Peter McGoldrick**



Some of the presenters at the Ores in Sediments workshop (from left) Paul Polito, Rod Maier, Kurt Kyser, Ross Large, Oliver Warren, Poul Emsbo, Lyudmyla Koziy, Ray Coveney, Rob Scott, David Rickard; (front row) Peter

CONGRATULATIONS ...

... to Lyudmyla Koziy and Carlos Rosa who have submitted their PhD theses, and to Kate Bull, Dale Lewis and Maya Kamenetsky, who have all been awarded their PhDs.

Cruising the Pacific

Leonid Danyushevsky from CODES and Trevor Falloon from the School of Earth Sciences and Centre for Marine Science were co-chief scientists of research voyage SS08/2006 aboard the Australian research vessel RV *Southern Surveyor*. The science party also included Pat Quilty and Michael Roach from CODES/SES; Pavel Plechov from Moscow State University; Andrew Stacey, an SES postgraduate student; and Michelle Farran, a UTAS undergraduate student. The voyage took place in the south-west Pacific between 19 August and 11 September, starting in Suva, Fiji and finishing in Noumea, New Caledonia.



Bob Beattie (CSIRO), Leonid Danyushevsky, Brooks Rakau (Vanuatu Geological Survey), Michael Roach, Michele Spinoccia (Geoscience Australia), Lindsay MacDonald (CSIRO), Pat Quilty, Trevor Falloon, Pavel Plechov, Michelle Farran and Andrew Stacey

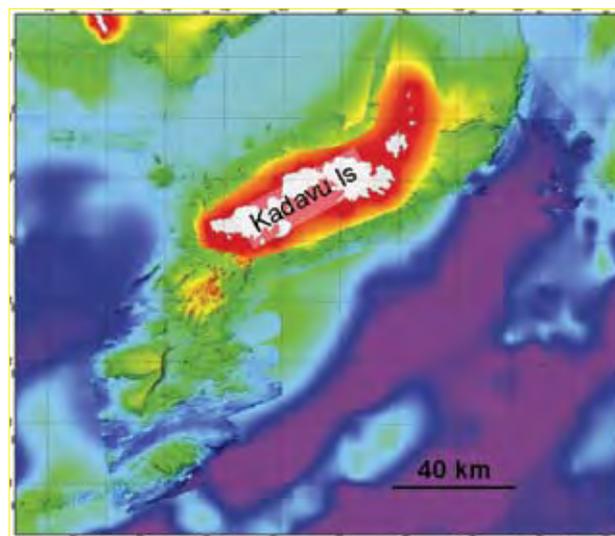
The voyage research program consisted of two parts. Firstly, they conducted seafloor mapping and rock dredging around Kadavu Island. The island, which is around 60 km long, is located at the south-west end of the Fijian archipelago and contains the youngest volcanic rocks known on Fiji (the youngest eruptions are dated at 500,000 years ago). The volcanic rocks on Kadavu belong to an adakite magmatic series, which are not known from any other Fiji islands. Thus the researchers' aims included revealing the lateral extent of adakite magmatism on the seafloor around Kadavu and gaining an understanding the structural relationship between the island and the submarine Hunter Ridge, which extends for approximately 450 km to the south-west between Kadavu and the southern end of the Vanuatu island arc.

The ship spent eight days in the waters around Kadavu. They found no clear structural boundary between the northern termination of the Hunter Ridge and the western end of the island. The Hunter Ridge crust in this area is extensively faulted by several generations of cross-cutting faults, similar to its structure at the western end of the ridge. There are a large number of small young volcanic cones on the slopes of the Kadavu island, on the Hunter Ridge, and on the seafloor of the North Fiji backarc basin west of Kadavu. Of 16 dredges

conducted in this area, 13 were located around the western end of Kadavu and on the Hunter Ridge, and three were on the eastern slopes of Kadavu. Thirteen dredges at the western side of Kadavu recovered basaltic rocks with variable proportions of olivine, plagioclase and clinopyroxene phenocrysts. Sedimentary rocks were also recovered in 10 dredges. Three dredges at the eastern side of Kadavu recovered only volcano-sedimentary rocks.

In the second part of the cruise they conducted swathe mapping, magnetics surveys, wax coring and dredging around the western end of the Hunter Ridge. In this area, the Hunter Ridge crust is undergoing extensive rifting caused by southern expansion of the North Fiji Backarc Basin manifested by south propagating spreading centres. Their aims in this area included gaining a better understanding the distribution of different magmatic rocks within the rift, determining the rate of spreading and propagation of the North Fiji Basin spreading centre, and revealing the extent of magma chemistry variations along the spreading centre.

The ship spent 12 days in this area. Mapping was focused around the propagating spreading centre, where it was combined with approximately 75 hours of the magnetics survey across the spreading centre, and at the western end of the study area, east of the Hunter island, where an incipient rift has been discovered.



The Kadavu Island area

This rift splits the southern termination of the Hunter Ridge in the WSW-ENE direction. Out of 23 dredges conducted in this area, six are located on the spreading centre, seven on the Hunter Ridge crust, and 10 within the rift zone. All dredges recovered mainly basaltic and also some andesitic lavas with variable proportions of olivine, plagioclase, clinopyroxene and orthopyroxene phenocrysts. Sedimentary rocks were also recovered in 12 dredges. They also conducted 23 successful wax core sampling stations which recovered fresh volcanic glass from the spreading centre.

The volcanic and sedimentary rocks recovered during the voyage are currently under investigation. **Leonid Danyushevsky**

ORE DEPOSITS OF SOUTH AMERICA

18 - 31 March 2007

A geological trip through some of the hottest exploration ground in the world, visiting some of the great mines of Chile and Peru!

Leaders

Ass. Prof. David Cooke, Prof. Bruce Gemmell and Dr Tony Webster

Dates

Commences on Sunday, 18 March in Copiapo (northern Chile) and finishes on Saturday, 31 March in Lima (Peru)

Featuring

The world's largest open pit and underground Cu mines
Fe-oxide Cu-Au deposits
Epithermal gold deposits
VHMS and MVT deposits
Regional geology, structure and tectonics

Visiting the following deposits

Manto Verde Fe-oxide Cu-Au
Candelaria Fe-oxide Cu-Au
El Penon low sulfidation epithermal Au
Mantos Blancos Fe-oxide Cu-Ag
Sierra Gorda porphyry Cu-Mo
Chuquicamata porphyry Cu-Mo
Mina Sur exotic Cu
El Teniente porphyry Cu-Mo
Los Bronces porphyry Cu-Mo
Perubar VHMS
San Vincente MVT Zn-Pb
Colquijirca high sulfidation epithermal Au
Cerro de Pasco high sulfidation epithermal Au

PARTICIPANTS MUST BOOK THEIR OWN INTERNAL FLIGHTS IN CHILE

A detailed itinerary and flight details are shown on the back of this flyer.

CODES

University of Tasmania, Australia
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Perubar
Cerro de Pasco
Golquijirca
San Vincente
LIMA

Chuquicamata
CALAMA
Sierra Gorda
Mantos Blancos
El Penon

Manto Verde
COPIAPO
Candelaria

Los Bronces
SANTIAGO
El Teniente

Registration Cost

Masters students enrolled at G3 institutions \$1500 (plus enrolment fees)

All other participants \$6500

This cost includes all accommodation, breakfast and lunch during of the course and all on-ground transport. It does not include any commercial flights.

Limited Places

\$1000 deposit to secure your place

Contact

For more information on ORE DEPOSITS OF SOUTH AMERICA or the National Masters Program contact Tony Webster

awebster@utas.edu.au
Ph +61 3 62261942

Part of the MCA National Masters Program

CANADIAN ALKALIC RESEARCH UPDATE:

Three months at the Mt Polley Cu-Au porphyry deposit, BC, Canada



Heidi Pass, CODES PhD student, in the field.

This is a brief profile of my PhD research at the Mt. Polley alkalic porphyry Cu-Au system in British Columbia, Canada. This project is a part of the broader CODES-MDRU alkalic porphyry and epithermal system initiative. This portion of my research aims to establish the paragenesis of hydrothermal breccia infill/veining and alteration of Mt. Polley through a combination of core logging fieldwork and geochemical laboratory work. We hope the results will contribute to the understanding

of sources and composition of mineralizing fluids, principal ore forming processes, understanding genetic links between alkalic porphyry and epithermal environments and also to assist in vectoring towards ore within and around such systems.

This year's field program involved logging a long section through the Northeast Zone (NEZ) of the Mt. Polley Cu-Au deposit. Mt Polley is located in central British Columbia and is one of a series of Late Triassic alkalic Cu-Au porphyry deposits in western Canada. The deposit is hosted by a polyphase magmatic-hydrothermal breccia and intrusion complex. The long section in this study traversed the host rocks, a variety of matrix-dominated and sulfide-cemented hydrothermal breccia facies, pre- syn- and post- breccia intrusions, and allowed lateral and vertical observation of peripheral regions of the deposit. Thirteen diamond drill holes were logged at 1:200 scale for a total of 2327m. Core logging was conducted using a combination of three logging/mapping techniques: the Anaconda Method of Einaudi modified for drill core, graphic logging using the method of McPhie et al. and the Imperial Metals on-site logging classification codes for the clastic and coherent units at Mt. Polley. These three techniques were combined to produce detailed, color-coded graphic logs that recorded lithology, grain size, key textures, contact relationships, alteration, vein mineralogy, breccia infill (cement, matrix and open space) and paragenetic relationships. Using geochemical data provided by the mine, trace element (Au, Ag, As, Pb, Zn and Cu) distributions were evaluated in terms of lithology and alteration. Initial results indicate that Cu distribution is related to variations in breccia facies and breccia cement.

The detailed drill core logs provided the framework in which to collect well-constrained samples for further analyses. Samples were collected to address questions concerning variations in type

and distribution of hydrothermal cement, alteration mineralogy, and paragenesis. A visual core library for each drill hole consisting of scanned images of each rock type, key contacts/textures and samples collected was also made.

Following fieldwork, cathodoluminescence (CL) petrography was conducted at the University of British Columbia to reveal and document carbonate infill sequences from the early (truncated veins), main and late stages of the hydrothermal system in preparation for microprobe analyses at UTas. CL exposes textural (e.g. growth zones) and chemical variations in carbonates that are not otherwise readily visible and thus can reveal subtle but important paragenetic information.

Initial results of the study have enabled development of a preliminary paragenetic framework for Mt. Polley. Relative to the main-stage breccia-formation, four mineralization and alteration events have been recognized in the NE Zone: pre-, main-, late- and post-mineralization stages. Evidence of early hydrothermal activity is preserved as altered and veined clasts within the breccia. Main-stage breccia formation is associated with cementation and alteration of clasts. Main stage alteration and mineralization are



Pre-brecciated (truncated) magnetite vein with carbonate and chlorite halo in a monzonite clast with syn-breccia alteration halo.



Polymictic breccia: K-spar megacrystic clast contains truncated pyrite and magnetite. Banded chalcocopyrite, chalcocite, open space and banded carbonate are main stage infill.

zoned laterally and vertically through the breccia body. Chalcopyrite is ubiquitous on the section examined, with local increases in abundance towards the center. Within these chalcopyrite-rich zones, spatially restricted bornite-rich, pyrite-poor cores are associated with high-grade ore. In contrast, the outer margins of the chalcopyrite zone are associated with elevated pyrite and low copper grades. Late-stage mineralization and alteration is recorded by Cu-sulfide bearing veins and associated alteration selvages that have cut the breccia and post-breccia monzonite intrusions. Post-mineralization carbonate and sulfate veins have cut all previous hydrothermal features and lack Cu-sulfides.

This was my last field season at Mt. Polley and after weeks of data collation, and the arrival of several kilograms of rock samples, I am now settling in to Hobart for several months of data processing and interpretation. In late 2007 I plan to head to New South Wales to undertake a comparative study of the alteration and vein geochemistry of the epithermal E42 gold deposit at Cowal. I am expecting to complete my thesis in December 2008 and am looking forward to a

challenging and rewarding career in the minerals industry.

I would like to thank everyone at the Mt. Polley mine and Imperial Metals for helping to make my field season so successful.

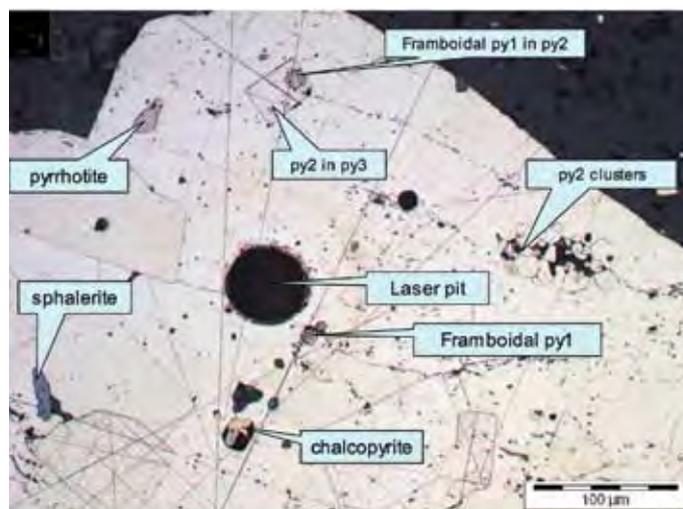
Heidi Pass

No fool's gold

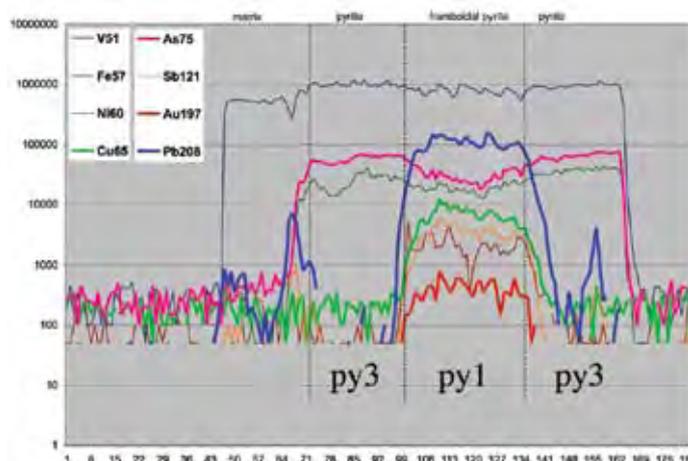
To the untrained eye, pyrite, with its metallic lustre and brassy yellow colour, can be mistaken for gold, thus its nickname: fool's gold. Ironically pyrite commonly does contain small, and occasionally very large quantities of gold (up to 1000s ppm). The gold, as well as a great many other trace elements, may occur either as small inclusions of separate mineral phases (Figure 1) or locked within the pyrite crystal structure. In addition, pyrite is spatially associated with many types of gold deposit; and sometimes, as is the case for the economically important Carlin deposits of north-eastern Nevada, it forms the primary ore mineral. More commonly however, pyrite occurs either as an associated (gangue/alteration) mineral or as an existing constituent of the host-rocks.

The current CODES/AMIRA Project P923: Controls on the formation and sulfide trace element signatures of sediment-hosted gold deposits was designed to investigate the relationship between pyrite and gold. The three-year research project, which commenced in January 2005, is being done in collaboration with CODES researchers, Dr Poul Emsbo from the USGS and Professor Valeriy Masslenikov from the Institute of Mineralogy at the Russian Academy of Science. The work is jointly funded by CODES and industry sponsors Barrick, Newcrest, Newmont, Perseverance and St Barbara Mines. The research is underpinned by the use of CODES' LA-ICPMS facility, which enables the low-level quantitative determination of over 40 trace elements in sulfides with a spatial resolution down to 8 microns. The deposits being studied for the project are Gold Quarry and the periphery to the giant Post-Betze-Screamer deposit in the Carlin District, Sukhoi Log in Siberia, Bendigo and Fosterville in central Victoria and Lefroy in north-east Tasmania. The researchers aim to develop new approaches for terrane selection and deposit characterisation, as well as longer-range, more robust deposit proximity indicators.

In the Carlin district, existing diagenetic and hydrothermal pyrite in the Siluro-Devonian sedimentary host rocks are known to provide nucleation sites for the thin rims of 'ore-stage' auriferous pyrite, which formed during later (early Tertiary) hydrothermal activity. However, recent studies on the Northern Carlin Trend by Dr Poul Emsbo and co-workers indicate that some early-formed pyrite in the host rocks may have played a more fundamental role in the genesis of these gold deposits. Poul showed that early diagenetic pyrite at several levels in the stratigraphy (including favoured sites for the later Tertiary mineralisation) is anomalously enriched in gold, and that some of these horizons may extend laterally for many kilometres. The association led Poul to argue that gold, initially incorporated in the host-rocks during sedimentation, may have been remobilised during later hydrothermal events. Potentially a significant proportion of the gold contained within the Tertiary arsenian



Reflected light photomicrograph showing a polished and acid-etched section through a large crystal of pyrite (Py3) from the Sukhoi Log deposit, Siberia. Pyrite 3 has overgrown earlier generations (Py1 and Py2) of framboidal, anhedral and euhedral pyrite, which are still clearly visible within the host grain. Small inclusions of sphalerite, chalcopyrite and pyrrhotite are also contained within the Pyrite 3. The black hole just left of centre is the pit left after a laser ablation analysis using a 55 micron diameter beam.



Raw counts data versus laser ablation analysis time for selected trace elements in a multi-stage pyrite grain from Sukhoi Log (similar to that depicted above). During this analysis, the laser beam traversed from the edge of a large grain of cubic pyrite across a 60 micron aggregate of earlier formed framboidal pyrite overgrown by the larger grain. The LA-ICPMS data reveal that the framboidal pyrite is significantly enriched in lead (Pb), copper (Cu), antimony (Sb), vanadium (V) and gold (Au) and slightly depleted in arsenic (As) and nickel (Ni) compared with the later formed euhedral pyrite.

pyrite rims may have actually been sourced from the immediate wall-rocks.

Coincident with Poul's work on the Carlin Trend, preliminary laser ablation ICPMS studies of pyrite in Ordovician turbidites from central Victoria led CODES researchers to conclude that

The hydrothermal history of Macquarie Island ocean crust

Just to clear up a couple of things from a previous article, I'm from the central west of New South Wales, not Queensland; still it's dry, hot and flat at home, which is about as different as you can get from Macquarie Island in the sub-Antarctic. Also I am the only wintering scientist here, though the summering scientists are arriving on 22 November via the first tourist ship of the season, *Spirit of Enderby*.

I've spent about three months in the field so far, working along two sections of the east coast. It took about three weeks to get my eye in; the place is heavily faulted and composed of similar rock types, all the same basic colour. At that time, winter, there were only six hours of daylight, which meant three to four hours of data collection a day; all travel is done on foot. I was intending to conduct a magnetic survey over the escarpment to fill in some gaps from the 2004–05 data collection effort. This proved to be too inefficient, considering the ruggedness, over the time period the escarpment is open for access. Still, I did score a brass, non magnetic ice pick to help me climb the slopes. The dieso/fitter here made it and I've got permission to take it home as a memento.

Since April I have managed to undertake field training, familiarise myself with the tracks and my field areas, repair and test the magnetometer and field gear, deliver 80 kg of equipment

and supplies to various field huts via boats but mostly on foot, produce six maps by merging previous maps, download the available literature, collect about 95 line km of magnetic data, map 8 km of outcrop along the coastline, take and georeference about 5100 photographs from 1300 observation points, produce two maps on the ground, collect 180 pages of field notes and structural data and 40 samples from 29 sites.

I discovered an association in a magnetically quiet zone, along the southernmost east coast, with extensive silicification. I'm looking forward to the analysis of my samples from that area because there is a lot of information about cooling rates and hydrothermal history to be won from them. Many blocks, the size of houses, are structurally isolated, and talus breccia is concentrated along the coastline, so structurally the place could be described as a 'dog's breakfast'.

I'm heading out to the field as soon as the *Spirit of Enderby* has gone, until the *Aurora Australis* comes to get us in April 2007 (except for Christmas and New Year's and a couple of weeks here and there). The company's great and it's an interesting sociological experiment being isolated for a year with 13 others. It is an amazing place, geologically and aesthetically. Most people get hooked on the wildlife here but, while it's wonderful, as a geologist I'm blown away by the landscape. **Paul Ferguson**



A small section of Paul Ferguson's field area — Macquarie Island

early gold enrichment in the sedimentary host rocks may have also played a role in the later development of the auriferous reef systems such as those at Bendigo and Ballarat.

The early development of gold enriched pyrite in both the Carlin District and Central Victoria could be a coincidence, unrelated to the development of the younger epigenetic deposits. Alternatively, it may reflect the operation of more fundamental processes in the terranes which have the greatest potential to host large sediment-hosted gold deposits.

The P923 research has shown that pyrite is commonly texturally and compositionally robust through successive episodes of hydrothermal alteration, with earlier generations of pyrite

(including diagenetic pyrite) overgrown and preserved within later generations of pyrite. By coupling spatial, paragenetic, trace element and isotopic data for the various generations of pyrite, the researchers are gaining unprecedented insights into the development of the gold deposits in their study areas. AMIRA Project P923 research is clearly demonstrating that when it comes to exploring for and understanding the formation of sediment-hosted gold deposits, fool's gold has much to offer. The fools may well have been on to something after all.

Robert Scott

For further information contact: Ross Large (Ross.Large@utas.edu.au) or Robert Scott (Robert.Scott@utas.edu.au)

Salt, diamonds and a new ‘solution’ for ore deposit theory

CODES has hosted three visiting researchers for the past 10 weeks. They are all working with Dima Kamenetsky, collaborating on several different projects.



Victor Sharygin

Victor Sharygin, from the Russian Academy of Science at the Novosibirsk State University in Russia, started working with Dima three years ago, supplying kimberlite samples from a huge kimberlite province in the middle of Siberia.

Kimberlite pipes are the main source of diamonds and come from at least 150 km below the earth’s surface. We

still know very little about the origin of diamonds apart from the fact that they form under conditions of high pressure and temperature. All kimberlites known to date have been very altered and contaminated by the rocks they travelled through when the pipes were formed. Victor has investigated the Udachnaya kimberlite, which has been mined to 700 m below surface level, exposing kimberlite that is very fresh. Samples of this fresh rock are being investigated by Dima at CODES.

An exciting part of this research involves the fact that this fresh kimberlite is very salty. Dima and Victor are investigating the possible relationship between salt crystals and diamond formation. They hypothesise that diamonds may crystallise around salt crystals in the kimberlite melt. Victor has brought a new collection of kimberlites with him on this trip, including some large hand-sized specimens of salt crystals from the Udachnaya kimberlite pipe.

Another project Victor is undertaking is the study of unusual potassium sulfides found in the Udachnaya kimberlite. Potassium sulfide was first found in 1966 in meteorites. The only place they have been found on earth is in kimberlite samples. Kimberlites are our deepest probes into the earth, and they provide us with information about the composition of the mantle.



Sergey Smirnov

Sergey Smirnov teaches mineralogy and crystallography at the Russian Academy of Science at the Novosibirsk State University. CODES has provided funding for his project, which is an exciting new initiative that could revolutionise some fundamental beliefs about economic geology, specifically the theories about the transportation of

metals in solutions.

Two hard-to-explain aspects of popular ore solutions theory are that most ore deposits contain more quartz than sulfides, and that salt minerals are never found in ore deposits. Researchers have needed to find something that dissolves and transports

silica better than it does metals. Part of Sergey’s study will investigate fluid inclusions in quartz or other minerals which contain dissolved silica. In an experimental part of the study gold samples, quartz and various solutions will be put into an autoclave over days or months. Preliminary results show that aqueous solutions interact with quartz to form greasy gel-like solutions which, when dehydrated, become solid like glass. This gel or colloid has the ability to concentrate a lot of metals. It is the proposed mechanism for dissolving metals, transporting and depositing them.

Sergey proposes an alternative explanation for economic geologists to consider: maybe ore solutions are not true solutions; maybe they are gels or colloids.

CODES Director, Ross Large, did some research on colloids in ore genesis in 1969 and is very interested in Sergey’s work. CODES has also supported John Elliston, who has done a great deal of work in this area. He will be invited to contribute to this study. Sergey and Dima are planning to publish a paper about their work in *Nature*.

Sergey and Dima are also working to understand the origin of gemstones in pegmatites. Cavities in pegmatites contain valuable gemstones such as emeralds, topaz, tourmaline, aquamarine and amethyst.



Georg Zellmer

Georg Zellmer is visiting us from the Academia Sinica in Taiwan. While he is very adept at uranium-series isotope studies and innovative geospeedometric methods, he has come to CODES to learn methods for investigating fluid and melt inclusions.

He says that, ‘CODES has a terrific lab and the best laser ablation equipment’, and he was excited about the opportunity to work with Dima, one of the experts in this area.

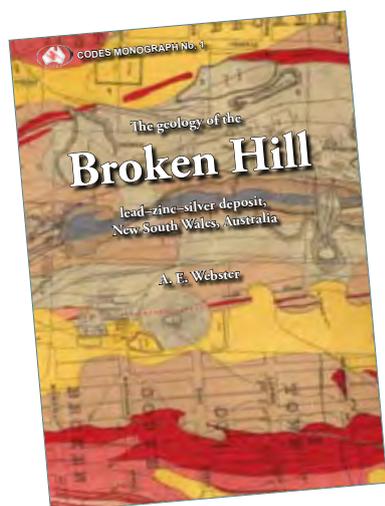
Georg studies the rates and chronologies of magma production, ascent and storage, notably at sites of active volcanism. He is working with Dima on two projects. One investigates the hydrothermal system at a volcano in New Zealand’s Kermadec arc. The other looks at melt inclusions from the Jorullo arc, a basaltic cinder cone that erupted in Mexico in 1759.

He is also involved in three other projects. Georg runs the isotope geochemistry lab in Taipei, where he will analyse some of Dima’s samples and do isotope work on samples from Karoo and Udachnaya.

Georg’s work marks the beginning of a collaboration between CODES and the Academia Sinica. He hopes to return to Tasmania for a sabbatical next year. He and his wife have enjoyed their time in Tasmania, particularly their first taste of spring after living in the tropics for many years. **Dima Kamenetsky**

NEW CODES PUBLICATION

'The geology of the Broken Hill lead-zinc-silver deposit, New South Wales, Australia' by A. (Tony) E. Webster — the first in the CODES series of publications on world-class ore deposits — was launched at the 'Ores in Sediments' conference held in November 2006. The book totals 290 pages and 79 colour figures are featured in the book and in PDF on the accompanying CD. The CD also contains geological maps of all major Broken Hill underground mine levels.



Extract from the preface: *'The geology of the Broken Hill lead-zinc-silver deposit'* is a detailed description of the Broken Hill mineralised system that is written from the point of view of a mine geologist. ... The early 1990s saw a resurgence of research interest in the geology of the Broken Hill mining field. ... Very little of the new research effort was focussed on detailed aspects of the geology and structure of the Broken Hill mineralised system and there was no formal geological research work undertaken in the mines. Working as one of the mine geologist in the Pasmaenco Southern Operations, and later as a mine lease exploration geologist, the author found it difficult to identify evidence to support many of the new structural and syn-metamorphic theories that were being proposed for Broken Hill by the new round of research.... As a result, the mapping project grew into a critical review of the new structural and genetic models (or re-invigorated old models) then being proposed by the researchers and company geologists working off the mines.

To work in detail on one part of the Broken Hill mineralised system is not to understand the entirety of this immense deposit. Before he could comment on structural models proposed by others, the author was constantly led into asking questions about the geology of long-abandoned and inaccessible areas of the mining field. What was needed was a means of testing structural models developed in parts of the orebodies where observations could be made in other regions of the field. The only way to do this was to review the mine geological records for abandoned parts of the mine workings and to reinterpret the geology of these areas in detail. Luckily, such records exist at Broken Hill and the existing mapping and drilling data document the observations of others. Mine records allowed new observations to be placed in a geological context at stope-, mine-, orebody- and mining field-scales. In the end, a complete review of the structure and stratigraphy of the mining field was required and the results are presented here. ... It is hoped that this work will form an entrance point to the geology of the Broken Hill mining field and act as a context for more detailed research studies.



Pictured at the launch of 'The geology of the Broken Hill lead-zinc-silver deposit' are (from left) Ron Berry (editor), Tony Webster (author), Dick

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CODES database project

Ruben Chan has been developing new software called ICPMSDb to store ICPMS data. This software will allow researchers to easily archive and manipulate their sample data in an electronic format.

Ruben's project is nearing its first test phase. The first phase of user testing will allow a researcher to register an account with the system and start uploading their raw data files into the system. Features such as record modification and keyword searching will be tested thoroughly in this phase.

In order to guarantee a secure and stable system, the database will be provisioned on brand-new servers employing the latest technologies. Testing will begin once these new servers arrive and have been configured.



If you are a regular user of ICPMS and would like to participate in the testing of the ICPMSDb system, send an email to Ruben.Chan@utas.edu.au to register your interest.

Exciting new PhD Scholarships

If you're thinking of taking the time to do some further study, consider one of these exciting new PhD projects. Contact the project supervisors for more information or see the CODES website: www.codes.utas.edu.au

Chalcophile and volatile contents and petrogenesis of primitive arc and backarc basin magmas (Hunter Ridge, SW Pacific): assessing potential magmatic contributions to volcanic-hosted seafloor mineralisation

CODES has an excellent collection of young volcanic rocks from a tectonic setting which is likely to be a modern analogue of ore-bearing volcanic sequences within foldbelts of eastern Australia. This project involves a petrological and geochemical study of the sample suite with direct implications for tectonic models.

Field work will involve participation in research cruise(s) on *RV Southern Surveyor*. The 2006 cruise 'Hot Subduction – recycling of oceanic crust in a dynamic W Pacific setting, Part 2' (from 18 August to 11 September; L. Danyushevsky, Chief Scientist) has been completed. The project will involve a large range of microbeam analytical techniques including electron microprobe analysis, FTIR spectrometry, LA-ICPMS at UTAS, PIXE at CSIRO, LA-MC-ICPMS at UMelbourne, and possibly X-ray microprobe at the Australian Synchrotron in the last stage of the project. Experimental methods will involve heating/freezing stage experiments with melt and fluid inclusions.

Supervisors: Leonid Danyushevsky, Tony Crawford and Trevor Falloon
Contact email: L.Dan@utas.edu.au

Genesis of platinum group element-rich, unconformity-style, hydrothermal mineral deposits, as inferred from a Northern Territory example

This project will examine PGE mobility under hydrothermal conditions in unconformity-style U-PGE-Au deposits, using one deposit (Coronation Hill, NT) to refine knowledge of the source of metals, the timing of PGE introduction, and the nature of mineral deposition. The project is funded by an APAI

scholarship for three years, and is only open to Australian and New Zealand citizens.

This is a focused single-deposit study that is well suited to an APAI research scope and time-frame. The project field work will fit into two major field seasons with intervening lab work, and a third major year of laboratory-based research and write-up, accompanied by a short follow-up field visit.

Supervisors: Garry Davidson, David Cooke and Stuart Bull
Contact email: Garry.Davidson@utas.edu.au

Volatile exsolution processes in silicic magmas: tracing magmatic fluids from source to sink in Tasmanian tin granites

Some highly evolved, relatively reduced granites are associated with important Sn mineralisation. Using micron-sized fluid inclusions, this project will develop a comprehensive understanding of the processes that operate in volatile-rich magmas and trace the evolution of the exsolved volatiles as they escape the magma and ascend through the upper parts of the earth's crust.

This project involves close collaboration with Mineral Resources Tasmania. The approach is threefold: (1) Specific field areas that represent different positions both vertically and laterally within Sn granites and associated magmatic-hydrothermal systems will be selected; (2) Combined structural/geometric, paragenetic, geochemical, mineralogic, microthermometric and isotopic techniques will be used to categorise the different ore fluid stages and relate them to specific magma batches (i.e. specific intrusive phases); and (3) Microanalysis will be conducted on the different fluid inclusion populations. Temporally constrained sample material is essential, which requires detailed mapping (historic and/or new) and sampling of the target field areas.

Supervisors: Anthony Harris, David Cooke and Geoff Green (MRT)
Contact email: a.harris@utas.edu.au

Microbial processes, ocean chemistry and the origin of sedimentary Zn-Pb deposits from the Carpentaria Zinc Belt, northern Australia

This project will investigate the role played by microbes in the formation of several important sediment-hosted Zn-Pb-Ag deposits from the Carpentaria Zinc Belt of northern Australia.

The project will use 'Carbonate Associated Sulfate' S isotopes, Degree of Pyritisation, C/S ratios and non-traditional stable isotopes (e.g. Mo, Fe, Zn) from samples from Australian Proterozoic deposits as proxies for seawater redox conditions. Purported microbial textures (particularly in pyrite) will be critically assessed.

Supervisors: Peter McGoldrick and Timothy Lyons (UCRiverside, USA)
Contact email: P.McGoldrick@utas.edu.au

Hydrological evolution in the Central African Copperbelt: a multidisciplinary study involving petrography, litho-geochemistry, geochronology, stable and radiogenic isotopes

This project is part of a larger research project on central African sediment-hosted copper deposits. It will concentrate specifically on hydrological evolution at both deposit and basin scales, using existing Zambian and Congolese datasets (structure and stratigraphy, whole rock major element and isotope geochemistry, geochronology).

The next two years of the project will focus on the Congolese deposits, with an ultimate aim of developing holistic models of basin evolution, hydrological history and ore genesis for the Central African Copperbelt. The study will be undertaken in conjunction with researchers at

CODES and the Colorado School of Mines, and will also involve collaboration with Kurt Kaiser's research group at Queens University, Ontario, which has excellent facilities for determining O and H isotopes from alteration phases and associated fluid inclusions.

The project is a great opportunity to work with world class research groups, as well as the world's major base metal explorers and producers. The scope of the project is well defined, and the quality and breadth of existing data ensure a rapid start up. We have an ARC funded PhD scholarship in place, with financial support for the technical program and travel.

Supervisors: David Selley and Stuart Bull
Contact email: D.Selley@utas.edu.au

Geological validation and constraints on geophysical inverse models of ore systems

This project will involve integration of measured physical property information for selected ore deposits together with inversions of available geophysical datasets, with the aims of both improving the accuracy of the inversion models and providing a framework for more reliable geological interpretation.

The project will mainly involve data processing, integration and interpretation and is likely to involve only a small component of additional field work to acquire extra targeted petrophysical data. The project will involve inversion and

modelling of a wide variety of geophysical datasets using code written by UBC, CSIRO, Loke, Fullagar and in-house software.

Supervisors: Michael Roach and Peter Fullagar (UQ)
Contact email: Michael.Roach@utas.edu.au

Geology, geochemistry and genesis of the sediment-hosted Gundaroo Ag-Pb-Zn project, Cobar Basin, NSW

Gundaroo is a significant new Zn-Pb-Ag discovery in the western Cobar Basin, NSW. This project will involve a detailed study of the nature of the mineralization and alteration with the aim of determining the source of the metals, fluid pathways and metal precipitation mechanisms. Recent drilling will form the basis of a study of the stratigraphy and sedimentology of the reef carbonate sedimentary package. Geochemical research on the mineralization will include LA-ICPMS trace element geochemistry, Pb, S, C and O isotopes and fluid inclusion studies to determine fluid chemistry and sources.

Cobar Consolidated Resources is providing a fully funded scholarship package of \$48,000 pa AUD. In addition the company will provide full time employment as a geologist at Gundaroo for the first 6 months.

Supervisors: Ross Large, Stuart Bull and Peter McGoldrick. Contact email: ross.large@utas.edu.au

CONTACTS

Director

Ross Large
Tel: (03) 6226 2819
Ross.Large@utas.edu.au

Deputy Director

Bruce Gemmell
Tel: (03) 6226 2893
Bruce.Gemmell@utas.edu.au

Leader, Program 1, Location

Tony Crawford
Tel: (03) 6226 2490
Tony.Crawford@utas.edu.au

Leader, Program 2, Formation

David Cooke
Tel: (03) 6226 7605
D.Cooke@utas.edu.au

Leader, Program 3, Discovery

Bruce Gemmell (interim)
Tel: (03) 6226 2893
Bruce.Gemmell@utas.edu.au

Leader, Program 4, Recovery

Steven Walters
Tel: (03) 6226 2804
Steve.Walters@utas.edu.au

Leader, Program 5, Technology

Leonid Danyushevsky
Tel: (03) 6226 2469
L.Dan@utas.edu.au

Education Program

Jocelyn McPhie
Tel: (03) 6226 2892
J.McPhie@utas.edu.au

PA to the Director

Katrina Keep
Tel: (03) 6226 2472
secretary@codes.utas.edu.au

Publications and Media Resource Centre

June Pongratz
Tel: (03) 6226 2479
june.pongratz@utas.edu.au

Communications and Technology Transfer

Donna Roberts
Tel: (03) 6226 2819
D.Roberts@utas.edu.au



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Cover pic: CODES gets into speleology: stalagmites in the Emmerugga Dolomite, McArthur Basin, northern Australia.

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Altered Volcanic Rocks

A guide to description and interpretation

Cathryn Gifkins, Walter Herrmann and Ross Large

A follow-up to the highly successful "Volcanic Textures"

Altered volcanic rocks is designed to be a practical guide for systematically describing and interpreting altered volcanic rocks, and determining their significance in terms of mineral deposit prospectivity. It discusses the processes and products of the common alteration styles in submarine volcanic settings, including diagenetic alteration, burial metamorphism, hydrothermal alteration and mineralisation, and intrusion-related alteration. It takes a multi-disciplinary approach combining alteration mineralogy, textures and intensity with lithochemistry to constrain the characteristics of different alteration styles. To emphasize the ore deposit context, the book includes a major chapter that uses innovative illustrated data sheets to describe the main alteration facies or zones associated with a variety of volcanic-hosted massive sulfide (VHMS) deposits. The final chapter describes and presents examples of how altered rocks and their characteristics may be applied to exploration for volcanic-hosted deposits.

The book contains 275 pages; 127 figures and 66 full-page alteration data sheets, which include 274 colour photographs that illustrate the textural and mineralogical characteristics of different alteration intensities, facies and styles.

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CODES

ARC Centre of Excellence in Ore Deposits



LEADER OF ORE DISCOVERY PROGRAM Professor/Associate Professor

The ARC Centre of Excellence in Ore Deposits (CODES) has five major research programs: LOCATION, FORMATION, ORE DISCOVERY, RECOVERY and TECHNOLOGY. The Leader of the ORE DISCOVERY program will develop, lead and manage a portfolio of innovative research projects related to improving the discovery of ore deposits. The projects will span the geological, geochemical and geophysical spectrum with a focus on discovery of "deep earth resources". Many of the research projects will be conducted in close collaboration with the minerals industry.

The successful candidate will have an international reputation in research and/or mineral exploration related to the discovery of ore deposits. Candidates with backgrounds in geophysics, geochemistry, geology or economic geology are invited to apply, and those with a track record of working across the geology-geophysics-geochemistry spectrum are particularly welcome. The successful applicant may come from an industry, government or academic background.

This position will be offered on either a contract or tenured basis. An attractive salary package will be negotiated with the successful candidate.

CODES is a world-renowned research centre in ore deposits funded jointly by the Australian Research Council, AMIRA International, University of Tasmania and the State Government of Tasmania. Other major collaborators include the JKMRU University of Queensland, University of Melbourne and ANU. Research collaborations involve a wide range of Australian and international mining companies, plus other international research groups including Colorado School of Mines, University of British Columbia, Johns Hopkins University and the Vernansky Institute.

Specific role responsibilities and position parameters can be directed to Ross Large (Director – CODES ARC Centre of Excellence in Ore Deposits) at the University of Tasmania on +61-3-62262819 or ross.large@utas.edu.au

For general information about the position please contact Michael Davies at Swann Global on telephone 61-3- 96213388 or email your curriculum vitae to swann@swannglobal.com quoting reference number 2006540.

The closing date for us to receive your application is 31 March 2007.



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