

Season's Greetings ore solutions

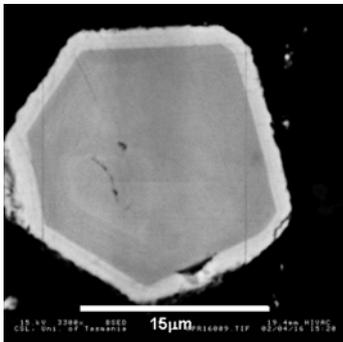


Newsletter of the Centre for Ore Deposit Research, an ARC Special Research Centre at the University of Tasmania

Gold-rich pyrite rims in a Carlin Au deposit: application of the laser ablation ICPMS technology at CODES

LA-ICPMS analysis at CODES has revealed the incredibly gold-enriched rims (up to 1200 ppm Au) on the ore-stage pyrite characteristic of Carlin gold deposits. These rims testify to a short-lived, but critically important, late-stage Au-As-Sb-Tl hydrothermal event that concentrated gold in the Carlin ore systems.

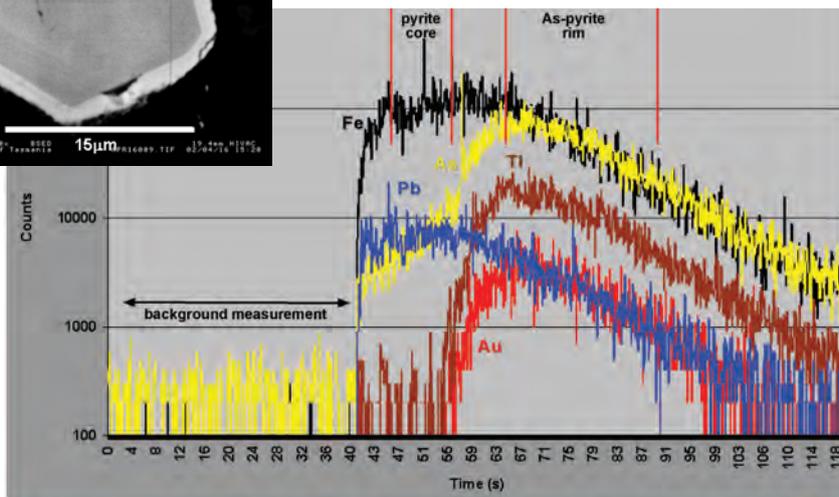
Backscattered electron image of an euhedral pyrite grain with As-rich pyrite (light grey) rimming an As-poor core.



Carlin-type deposits represent one of the most important sources of gold in the world. In over 40 years, more than 2000 metric tonnes of gold have been produced from the deposits in the Great Basin region of Nevada and Utah, USA. (Thompson, 2002). The ore in these deposits typically consists

of gold-rich arsenian pyrite or arsenian marcasite, which commonly occur as fine (<5 µm) rims on coarser grained diagenetic pyrite. It is the fine-grained nature of the ore and gangue mineral assemblages in Carlin-type deposits that have hindered analytical investigations into the ore paragenesis of these deposits. Analytical methods with low detection limits (e.g., SIMS) have relatively low spatial resolution, whereas those with high spatial resolution (e.g., electron microprobe) have relatively high detection limits. Laser ablation ICPMS can overcome these problems by providing low limits of detection at high spatial resolution. With this in mind, a pilot study was undertaken to determine the sites of element residence in the pre-ore and ore related pyrite from a Carlin-type gold deposit, and to obtain a qualitative analysis of the arsenian pyrite rims. This was done at CODES using an Agilent HP 4500 quadrupole ICP-MS with a UP213 Nd:YAG laser probe with a beam resolution as low as 5 µm.

The Deep Star Au-deposit is located in the northern part of the Carlin Trend, Great Basin, N. Nevada. As of 2000 the deposit had produced 37.8 t of gold, with an average grade of 34 g/t Au (Heitt et al., 2003). The dominant ore mineral is arsenian pyrite-marcasite, which rims (<5 µm width) diagenetic pyrite euhedra. The Deep Star sample used in this study, which was kindly donated to the CODES collection by Noel White, is an orpiment-realgar, clastic siltstone containing finely (<50 µm) disseminated pyrite (<2% volume). Assay data was not available. Initial work using back-scattered SEM imaging revealed the euhedral pyrite crystals to have As-rich rims.



The analytical counts spectrum from a LA-ICPMS spot analysis of a Deep Star pyrite crystal similar to that seen in the backscattered electron image of pyrite. After initial measurement of the background, ablation of the pyrite core shows elevated counts for Fe, Pb and As. As ablation reaches the lower As-rich rim of the pyrite, counts for As, Tl and Au all increase. For simplicity, counts for Cu, Sb and Zn have been omitted. Cu and Sb increase in the pyrite rim, Zn remains at background levels.



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LA-ICPMS technology at CODES, from page 1

Prior to analysis by LA-ICPMS, the pyrites were analysed by electron microprobe to obtain a Fe concentration that could be used as an internal standard. The pyrites were then analysed by LA-ICPMS for Fe, As, Sb, Au, Pb, Cu, Zn, and Tl. Using a laser beam diameter size of 8 µm, the analytical approach was to ablate the core of a rimmed pyrite crystal and, given the compositional contrast, recognise from the counts spectrum when ablation reached the As-rich rim directly beneath the surface. The results show the pyrite core to contain high counts for Fe, As and Pb, whereas the highest counts for As, Tl, Au, Sb and Cu are in the arseniferous rim (see page 1). From this single spectrum it is possible to obtain qualitative analyses from those parts of the spectrum that correspond to different regions of the pyrite crystal.

	Core (ppm)	Rim (ppm)
Fe ¹	451 600	397 800
As	2 640	35 850
Tl	14	1 600
Au	6	1 200
Sb	20	1 000
Cu	66	730
Pb	600	350
Zn	bd	bd

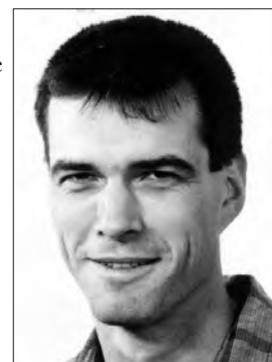
¹ Fe analysis done by electron microprobe; bd - below detection

The calculated results show the diagenetic pyrite core to contain the highest concentrations of Pb (600 ppm) with 2640 ppm As. The arseniferous rims contain 3.6 wt% As, 1600 ppm Tl, 1200 ppm Au, 1000 ppm Sb, 730 ppm Cu and 350 ppm Pb. The extraordinary composition of these pyrite rims highlight the critical importance of the late stage Au-As-Sb-Tl hydrothermal

event that concentrated gold in the Carlin ore systems. These results compare well with other analytical studies of ore-related pyrite from Carlin-type deposits. A previous study using electron microprobe analysis has shown Au concentrations as high as 3700 ppm from Deep Star pyrite ore samples (Fleet & Mumin, 1997). Electron microprobe and SIMS analyses of ore pyrites

from the Getchell Au deposit show concentrations as high as 2400 ppm Au and 8–11 wt% As (Cline, 2001). More recently, Emsbo et al. (2003) undertook LA-ICPMS analysis of ore-stage pyrites from the Meikle Au deposit where ranges of 1.2–4.7% As and 620–3560 ppm Au were found. The pilot study done here at CODES shows that, given compositional contrast, it is possible to obtain qualitative analyses of ultra-fine pyrite bands using LA-ICPMS at high spatial resolution.

For more information on gold analyses of pyrite contact Dr Andrew Rae (andrew.rae@utas.edu.au). Laser Sulfide Team at CODES: Garry Davidson, Leonid Danyushevsky, Andrew Rae, Ross Large and Sarah Gilbert.



Andrew Rae

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NEWS

The Director of CODES, **Ross Large**, will take on the Presidency of the Society of Economic Geologists in January 2004. Ross said he is very proud to be elected to the position. "It is an honour to be leading such a prestigious and truly international Society." Ross will visit the Denver head office of SEG to meet the staff and review operations in early March 2004, to be followed by an SEG Council meeting at the PDAC Conference in Toronto.

Ross Large gave the invited Keynote Address for the joint meeting of the International Geochemical Exploration Society and the North Atlantic Minerals Symposium held at University College, Dublin, in October this year. The title of his talk was 'Collaborative research and exploration ventures to assist the global exploration industry.'

Michael Solomon has been appointed Visiting Professor at the University of Tasmania. He recently visited the Iberian Pyrite Belt to develop further the brine-pool models for volcanic-hosted massive sulfide deposits. Mike undertook sampling at the Neves Corvo deposit, and further advanced the current projects on Feitais and Tharsis deposits with Carlos Inverno (Instituto de Geologico e Mineiro) and Fernando Tornos (Instituto de Geologico y Mineiro). He also lectured at the Instituto de Geologico in Lisbon, at the University of Huelva, at ETH in Zurich, and at the Imperial College of Science and Technology, London, on the brine-pool concept as applied to VHMS deposits.

Bruce Gemmell has been appointed Head of the School of Earth Sciences at the University of Tasmania for a five-year term, starting January 2004.

Modern and Ancient Mineralizing Seafloor Hydrothermal Systems



At the 2003 Geological Society of America annual meeting in Seattle, USA, Bruce Gemmell (CODES) and Cornel de Ronde (IGNS, New Zealand) co-convened the Society of Economic Geologists Special Session entitled *Modern and Ancient Mineralizing Seafloor Hydrothermal Systems*. Invited speakers compared recent research results on modern submarine mineralising hydrothermal systems in a variety of plate tectonic settings (e.g., back arcs, intra-oceanic and island arcs, seamounts, sediment free ridges, sedimented ridges) to ancient volcanic- and sediment-hosted ore deposits.

The morning session started with an overview paper by Mark Hannington discussing the fluids in the VMS environment concentrating on the relative role and importance of magmatic vs seawater fluids in seafloor hydrothermal systems. The diversity of modern hydrothermal systems on sediment-free ridges and ultramafic-hosted systems was discussed by Sven Petersen and Deborah Kelly, respectively. Randy Kski followed with a comparison to ancient ophiolite-hosted deposits. Presentations on the massive sulfide deposits formed in modern (Wayne Goodfellow) and ancient (Jan Peter) sedimented rift settings set the scene for a comparison of the ancient sediment-hosted McArthur River (HYC) and modern Atlantis II Deep deposit in the Red Sea by Ross Large.

Recently much of the modern seafloor research and exploration has been concentrated on intra-oceanic, back and fore arcs and the afternoon session concentrated on these environments. Cornel de Ronde presented the recent results of mapping the submarine volcanoes and associated hydrothermal systems along the Tonga-Kermadec arc; while Gary Massoth discussed the hydrothermal plumes and their characteristics from these hydrothermal systems. Three talks concentrated on the results of drilling programs on



Delegates to the recent SEG Special Session (L to R): Bruce Gemmell, Ross Large, Cornel de Ronde, Ray Binns, Sven Petersen, Jan Peter, Mark Hannington, Wayne Goodfellow, Gary Massoth, Richard Herrington, Randy Koski. Absent: Deborah Kelly, Junchiro Ishibashi

the modern seafloor: PACMANUS in the eastern Manus basin, PNG (Ray Binns), Suiyo Seamount in the Izu-Bonin arc, Japan (Junshiro Ishibashi) and the epithermal-like, Au-rich system at Conical Seamount, Tabar-Feni fore-arc, PNG (Sven Petersen). Two examples of the diversity and spectrum of VHMS deposits in ancient submarine volcanic belts were presented by Richard Herrington (South Urals in Russia) and by Bruce Gemmell (Mount Read volcanic belt in Australia).

The session was attended by over 150 academic and industry geologists and generated lively discussion on the parallels between modern, active seafloor hydrothermal systems and their ancient analogs. Overall, the session was an excellent review of the state-of-play in modern and ancient seafloor hydrothermal systems.

Christmas comes early to CODES

IRGS GRANTS (University of Tasmania)

Sharon Allen, Anthony Harris

Flood lavas — How do hundreds of cubic kilometres of high-silica magma originate? \$12,000

Leonid Danyushevsky

Magma generation processes under the Southeast Indian Ridge and the Australian-Antarctic Discordance, Southern Ocean.

\$16,254

Khin Zaw

Genesis and source of sapphires in NE Tasmania: Constraints from mineral chemistry and melt/fluid inclusion characteristics.

\$17,000

ARC DISCOVERY GRANT

Sharon Allen

\$460,000 over 5 years including an ARC Research Fellowship
Submarine explosive eruptions of silicic magma: constraints on products and processes from modern sea-floor examples, ancient successions and experiments.

ARC LINKAGE GRANTS

David Cooke, Bruce Gemmell, Cari Deyell, Noel White

\$330,000 over 3 years

Project: Transitions and zoning in porphyry-epithermal districts: Indicators, discriminators and vectors.

Partner Organisations: AMIRA International (AMIRA P765) — AngloGold, Placer Dome, TeckCominco, Goldfields, Newcrest Mining, Anglo American, Normandy.

Khin Zaw, Sebastien Meffre, Wally Herrmann, Sue Golding,

Mark Barley, Anthony Harris

\$270,000 over three years

Project: Geochronology, metallogenesis and deposit styles of Loei Foldbelt in Thailand and Laos PDR.

Partners: Kingsgate Consolidated, Pan Australian Resources, Oxiana Resources.

Milos volcanology research results presented at international conference

Milos, Greece, is part of the southern Aegean active volcanic arc and, during September, was the venue for an international conference on research into Aegean volcanism, tectonics and ore deposits. The volcanic succession on Milos has been the focus of Volcanology Program research for the past four years. The island is composed of felsic submarine and subaerial volcanic facies and is host to important gold and base metal ore deposits.

Prior to the conference, Jocelyn McPhie and Andrew Stewart led a field workshop presenting some of the results of their research on submarine explosive volcanism. The workshop was sponsored by the IAVCEI Commission on Explosive Volcanism and attracted participants from Australia, USA, Germany, Italy, Switzerland, Mexico, Portugal and Greece. A series of lectures by Jocelyn and Andrew was followed by field days inspecting some

of the spectacular coastal outcrops. At the conference, Andrew presented a new model for the facies architecture and evolution of Milos, including new U-Pb in zircon dates. Kate Bull has recognised pumice-rich facies in the Devonian Ural Volcanics in NSW that are similar to those on Milos, and also presented a paper on this aspect of her PhD research at the conference.

The project on Milos has been generously supported by the Institute of Geology and Mineral Exploration, Athens, and two companies involved in mineral exploration on the island, Silver and Baryte SA and Royal Gold Inc. So far, output from the project comprises Andrew Stewart's PhD thesis, a paper in the *Journal of Volcanology and Geothermal Research*, a paper in the *Bulletin of Volcanology*, a field guide and three conference abstracts.



Kate Bull, Andrew Stewart, Jocelyn McPhie and Caze Rosa, resting in front of a giant pumice clast in submarine mudstone on Milos during the Milos submarine explosive volcanism workshop.



Participants in the IAVCEI field workshop on submarine explosive volcanism, led by Jocelyn McPhie and Andrew Stewart, on Milos, Greece.

NEW RESULTS ON THE VOLCANOLOGY OF THE IBERIAN PYRITE BELT IN PORTUGAL

Carlos ("Caze") Rosa has completed a second, very productive field season on the volcanic setting of massive sulfide ore deposits in the Iberian Pyrite Belt. He mapped in detail sections through the volcanic succession in one well-exposed, only weakly deformed area (Albernoa), and logged drill core sections at the Neves Corvo massive sulfide mine where deformation and alteration are locally more intense. The succession appears to be dominated by submarine felsic lavas and thick units of felsic pumice breccia. In contrast to other parts of the Iberian Pyrite Belt, peperite is only a minor component of the facies architecture. Caze's research is conducted in collaboration with the University of Lisbon and is also supported by the Institute for Geology and Mining, the Portuguese Fund for Science and Technology, and Somincor.



Caze Rosa logging core at the Neves Corvo mine, Iberian Pyrite Belt, Portugal.

New volcanology collaboration with Japan

This year, Sharon Allen was awarded a joint grant with the Australian Academy of Science and the Japanese Society for the Promotion of Science to support six weeks of travel and research into submarine pumiceous pyroclastic deposits in Japan. Sharon spent the first three weeks with IFREE, the Institute for Frontier Research on Earth Evolution, aboard the research vessel *Kaiyo* and was involved in undertaking deep-tow camera studies of sea floor volcanoes along the Izu-Bonin Arc. A direct result of this cruise is a collaborative study on giant pumice from submarine eruptions with Dr Yoshihiko Tamura (Group Leader, IFREE) and Dr Richard Fiske (senior volcanologist, Smithsonian Institution, USA). The final three weeks were based at Niigata University under the guidance of Professor Katsuki Kurokawa and Dr Norie Fujibayashi, and involved field studies on widespread submarine pumiceous mass-flow deposits and rhyolite lava. Sharon logged and sampled a number of submarine pumice-rich units that record large explosive eruptions sourced on land. The field data will provide a framework for interpreting the textural characteristics of analogue deposits generated by experimental simulations. Sharon also undertook field work on a well-exposed submarine rhyolite lava. A variety of textures and structures are preserved, including large and small ropy wrinkles and folds, and through structural analysis, will allow the mechanisms of lava flow advance to be determined. We look forward to the results of the exciting research and in strengthening collaborative studies with Japan.



Dr Norie Fujibayashi with ropy wrinkles in rhyolite lava, Japan

Andrew Stewart's PhD submitted

Andrew Stewart submitted his PhD thesis in early July. He studied the volcanic facies architecture of Milos, Greece, and the setting of gold and base metal ore deposits on the island. Milos is a volcanic island in the South Aegean Volcanic Arc, and has a volcanic history beginning about 3 million years ago and continuing to historical times. Much of the early volcanism was submarine and explosive, generating spectacular beds of giant pumice. The island also features complete cross-sections through submarine-emplaced cryptodome volcanoes, accessible only by boat.

Andrew spent two field seasons mapping and completing sections on Milos, and followed up with textural studies, petrography,



Andrew Stewart logging sections through submarine pyroclastic units on Milos, Greece

geochemical analyses, and geochronology at CODES. He generated a great deal of new information on submarine volcanic facies, some of which has been published in the *Journal of Volcanology and Geothermal Research* and the *Bulletin of Volcanology*. Andrew's thesis is under examination and he is now in Mongolia working as an exploration geologist with Ivanhoe Mines.

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Out with the old and in with the new ...

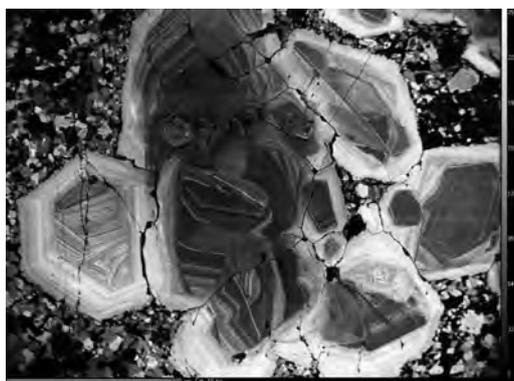
or ... "Au revoir Madame Cameca, bonjour Mademoiselle Cameca"

Out with the old and in with the new.....

(or....."Au revoir Madame Cameca, bonjour Mademoiselle Cameca".)

The CAMECA SX50 electron microprobe was decommissioned on 18th August 2003 after nearly 15 years of operation, producing over 120,000 mineral analyses during that period. The new CAMECA SX100 electron microprobe arrived in late August and was successfully installed and commissioned in September 2003. The \$1.2M instrument is equipped with 5 wavelength dispersive (WD) spectrometers allowing the rapid quantitative multi-element spot analysis of a wide range of minerals. The addition of 2 high sensitivity/high count rate WD spectrometers facilitates lower detection limits by a factor of two for many elements of interest to CODES and Earth Sciences investigators. Mineral identification prior to spot analysis is facilitated by the qualitative high count rate Rontec EDS system.

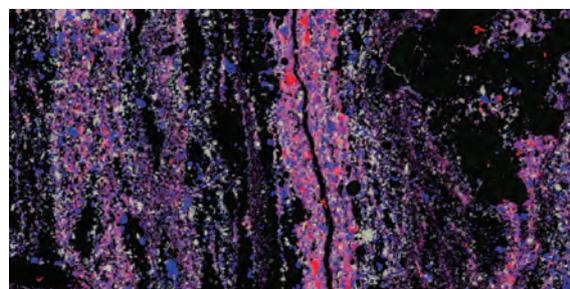
Qualitative and quantitative x-ray mapping for spatial chemical information can be performed at either individual mineral scale or on larger thin section/polished block scales using the new instrument. The imaging and x-ray mapping software supports the construction of multiple image/map mosaics, phase identification and automated particle search and quantitative analysis.



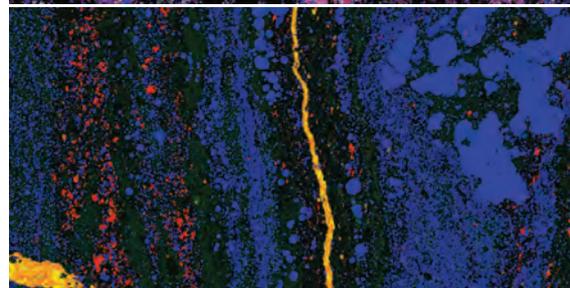
Cathodoluminescence image of quartz in comb-quartz layered texture, Bajo de la Alumbrera porphyry Cu-Au deposit, NW Argentina. Although the quartz in this texture appears optically continuous, scanned cathodoluminescence imaging reveals internal complexity: well-defined luminescence bands of varying widths commonly define concentric growth zones in coarse-grained prismatic quartz. This image highlights the important role cathodoluminescence plays in the recognition of primary growth zones, so critical to meaningful melt and fluid inclusion studies.

The new probe has much improved SEM (SE, BSE) imaging capabilities compared with the old probe. In addition it is equipped with a cathodoluminescence (CL) detector allowing the observation of trace level elemental zoning in a wide range of minerals (e.g. zircon, apatite, quartz, feldspars, carbonates). The CL detector can also provide information on crystal growth (e.g. vein quartz).

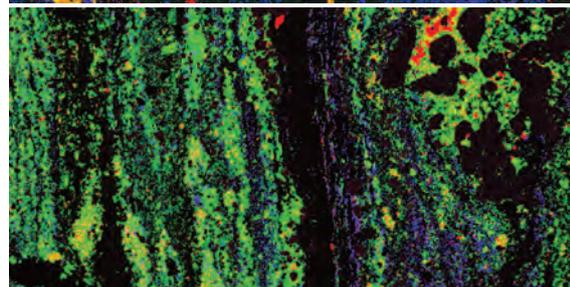
The Rontec EDS system is due to be integrated with the WDS system late this year or early 2004 further enhancing the instrument's capabilities for x-ray imaging and quantitative elemental mapping.



*K - green
Al - red
Si - blue*



*Fe - blue
Mn - red
Ca - yellow*



*Cu - red
Pb - blue
Zn - green*

Pseudocolour images of element maps from HYC sulfide ore. This image was acquired with 1 micron steps (pixel size) across a 2 mm-wide section showing the typical fine scale banding. The high Cu, Pb and Zn shows distribution of chalcopyrite (red), galena (blue) and sphalerite (green). The high Ca and Mn is located in carbonates, and the K and Al is in illite (red) and K-feldspar (white).

CODES Publications 2003

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ORE DEPOSITS OF SOUTH AMERICA (week one)



November 2003 saw the commencement of the second “Ore Deposits of South America” course, and, as befits the second running of anything, the plan was for a much more extensive trip and wider range of deposits than in 2001.

The group comprising 24 people met in Lima for the initial briefing and then set out for Huaraz ~~by bus~~ early on a Sunday morning. There were several new faces to get to know, as well as some interesting stories from the pretrip-trips that many had been on. One of the best adventures was Brett ‘Evil Kneivel’ Butlin’s motorcycle stunts, which saw him have two collisions with stationary objects within the first 100 m of his journey. Still as befits an Aussie bloke, Brett bore his injuries with great stoicism at the back of the bus and was only heard to moan in pain infrequently.

Immediately upon leaving Lima the climb into the Coastal Cordillera begins and, for flat-landers like myself, the spectacle of such huge mountains is one that never ceases to amaze. The town of Huaraz, nestled between the Cordillera Blanco and the Cordillera Negro, is a well-known destination for adventure traveller and hikers alike, but importantly for the group, it is the closest town to Antamina (a Cu-Zn skarn deposit) and Pierrena (a high-sulfidation gold deposit).

Eric Lipten, the Chief Geologist at Antamina, gave an excellent presentation on the geology of Antamina late on the Sunday night; everyone went to bed excited at the prospect of seeing some of the strange skarn assemblages he had told us about. However it wasn’t to be! A disturbance over political issues amongst the local communities effectively blocked the road to the mine and the visit was cancelled on the Monday morning. Not the greatest start to the trip! At short notice a visit to the Huarascaran National Park to look at Andean scenery was organised, and while spectacular it was not what we had hoped for.

Fortunately, Enrique Garay the chief geologist at Barrick’s Pierina gold mine, got the trip back on a good footing with a great visit to his mine. Enrique has only four geologists on his team, and Pierina produces approximately 850,000 oz of Au per annum. This is a remarkable effort and the professionalism of his staff including Hector Aspajo and Carmen Quispe was evident during a very informative visit. The exploration geo’s on the trip were particularly excited about the discovery history of the deposit, which was outcropping yet only found in the mid-1990s through basic exploration, target generation and mapping. A quick flight back to Lima had us out and about sampling the local cervaza late into the night.

Day three was a day spent with Les Oldham, a local contractor working out of Lima with a fantastic knowledge of the local geology and a broad Manchester accent. Our trip from Lima to Tarma took most of the day with several stops to look at various

parts of the stratigraphy, structure and alteration typical of the Andean margin. Tarma a small provincial town best known for its flower growing, was to be our home base for the next couple of days while we visited the giant Cerro De Pasco system and the intriguing Colquijirca. Over a few beers that evening it was announced that nine people would be able to go underground at Cerro de Pasco the following day, the rest would visit the open pit. There was fierce competition amongst the group for the right to go underground and in the end names had to be drawn from a hat! Thanks to Phill Harris for providing the hat and setting a shining example to us all!

The visit to Cerro De Pasco started early (0430 hours for reveille); again, Les Oldham was able to accompany us and introduce us to the local geological staff — Lucho Fuentes, Romilo Suni, Pere Hernandez and Victor Gobitz — who greatly



Breakfast.

assisted in our visit. Due to the early start, a few sleep-deprived people managed to miss breakfast and at Les’ suggestion we stopped en route and indulged ourselves in the traditional local dish of ‘Monster Frog’. The frog is served whole on a bed of rice and a couple of prime examples were presented to us prior to preparation. Of course, not everyone is up for ‘Monster Frog’ at that time of the morning and several people had to be excused from the restaurant.

Cerro De Pasco is a complex system that exhibits elements of high sulfidation and low sulfidation characteristics. This led some in the group to suggest it may be an intermediate sulfidation system and thus incur the wrath of Dave Cooke, our pointy-headed geochemical boffin.

Friday saw our final mine visit in Peru, and the team of Ivan Monteagudo Gonzales, Carlos Yacila, Rolando Ligarda and Augustin Chang from Colquirica gave an excellent presentation on the geology, metal zonation, ore grades and controls on mineralisation. Colquirica is a classic zoned system with an inner high-sulfidation Au zone at Marcapunta accompanied by a stratabound carbonate replacement deposit in the north which has a copper–enargite–gold-rich core grading out into a lead–zinc-rich zone and a major Pb–Zn resource to the south of Marcapunta named San Grigore. All-in-all a fantastic day accompanied by the sights of the high Andes, including Inca ruins and a currently active transtensional depression ‘the Junin Basin’.

This effectively ended week one of the ‘Ore Deposits of South America’ trip. Week two saw the group head south to Chile to

look at the giant porphyry-copper deposits and the adventures there will be detailed in the next edition of *Ore Solutions*.

Many thanks to all the geo's who helped us out during our time in Peru, especially Tim Coughlan and Andrew Davies from AngloGold, who apparently also have shares in several alehouses in Lima. Also thanks the participants on the trip, in no particular order: Dave Cooke, Nicki Pollington and Fernando DellaPascua (UniTas), Len Kolff, Steve Lewis, Leon Bagas, Adrian Fabris, Dan Power, Allan Ignacio, Brett Butlin, Anthony Johnston, Rob Hutchison, Dave Nixon, Alvin Dalmaida, Ross Raichney, Peter Pring (Masters students) and Nick Steven (Rockwater), Phill Harris (Angloamerican), Joe Lograsso (Ivanhoe) Lisa Gibbons (Newmont), and Aletha Buschman and Enrique Garay (Barrick), and Bruce McQuitty (Gympie Gold).



On the way to Cerro de Pasco.



Hector Aspajo describing the scenery at Barrick's Pierina Au mine to Len, Steve, Phill and Lisa.

A new vision of western Tasmania

CODES researchers Cathryn Gifkins, Wally Herrmann and Bronwyn Kimber have compiled and re-interpreted the volcanic and alteration facies and whole-rock geochemical data for the Cambrian Mount Read Volcanics in western Tasmania. The results are interactive GIS maps that combine observed attributes with interpretations. These maps show the distribution of the volcanic facies associations, location of volcanic centres, hydrothermal alteration zones and whole-rock and mineral compositions.

This work identified 35 Cambrian volcanoes in the Mount Read Volcanics. These volcanic centres vary in volume, composition, eruption styles and setting. All the major ore deposits in the Mount Read Volcanics were found to be associated with kilometre-scale, strong, pervasive quartz + sericite + pyrite alteration zones. Another major outcome is the recognition that all known ore deposits and most hydrothermal alteration zones are spatially associated with volcanic centres and their vent-proximal facies associations. This is consistent with volcanic or magmatic processes playing an important role in volcanic hosted massive sulfide (VHMS) genesis. These outcomes suggests that a combined alteration facies, volcanic facies and geochemical approach to VHMS exploration could help to define prospective areas, increase the target size, prioritise targets, provide vectors to ore and discriminate between deposit styles.

This was part of a larger project to compile open-file geoscientific data, and produce the first 3D model of Tasmanian geology. This model was constructed by the pmd.CRC at Melbourne University and Fractal technologies in collaboration with Mineral Resources Tasmania and CODES, and was launched in October by the Deputy Premier of Tasmania Paul Lennon. The model is a very effective tool for visualising geological, geochemical and geophysical data, and should stimulate and aid new mineral exploration and research in the state.



Wally Herrman and Cathryn Gifkins reviewing Mount Read Volcanics geology.

A passage to India



Stuart Bull

Before I joined CODES I had a two-year stint as an exploration geologist, and on my first day a gnarled and much travelled old hand passed on the distilled wisdom of decades in the industry to the new boy. The key to security, prosperity and exploration success he said, was to take all

available opportunities to experience different types of mineral deposits in different parts of the world, but never to work in countries the names of which included the term 'democratic' or ended in 'stan'. Having enjoyed a visit to Anvils Dikilushi mine in the DRC earlier in the year, I was afforded the opportunity to go for double jeopardy when Professor Harendra Nath Bhattacharya known universally as 'Bappa', invited me to visit the Zawar Zn deposit in Rajasthan.

My first port of call in India was Calcutta where I was to meet Bappa and give a lecture at Presidency College on the stratiform sediment-hosted Zn deposits of northern Australia. After the lecture Bappa gave me a whirlwind tour of some of

(loose pants) and punjab (frock/shirt) so I was able to deliver the lecture correctly attired.

The area of Rajasthan in which the Zawar cluster of deposits is located is quite beautiful, comprising a series of cultivated valleys and lightly forested hills where goats and monkeys roam freely. The silicified dolomite unit that hosts the Zn deposits forms the most prominent ridge, and there are numerous lines of centuries old workings targeting galena veins. Ruined temples and hill forts testify to the long period of prosperity that the mining operations have provided to the local community. The local people are brightly dressed and friendly and the food consists almost entirely of delicious vegetable curries.

Our work involved a series of field traverses to examine the basin stratigraphy that Bappa has already documented in some detail. Having come from early spring in Tasmania, a pull up one of the 300 m ridges the first afternoon gave me the impression it was fairly warm. While sampling the local beer (8% alcohol) back at the ranch, I stupidly put my newly acquired fancy travelling alarm clock with built-in thermometer in the shade



light and would ring my room at 1.30 am. He duly rang me at

not uncharitably disinterested in what we were up to

4.10 am and cheerily announced that it was 4.30 and time for me to get up!

Bappa and I then flew to Udaipur via Delhi, and it is worth mentioning that in these days of heightened security the Indians have things well in hand. Before every flight they search all hand luggage twice and body search you as well, but it is all done with efficiency and courtesy, more that can be said of the airport security staff of a certain global superpower I have visited recently. We were picked up at the airport and driven the 40 or so km to Zawar, where the Indian Geological Survey have a training institute. It turned out to be quite busy as there was a class underway at the time, but they kindly went out of their way to accommodate us. To put the scale of the Indian geological community in perspective, the national Geological Survey employs more than 2000 geologists, and together with district surveys and state and privately owned mining companies, there are more than 8000 working geologists in India. All of the survey geologists receive a one year training course when they join that involves field visits to institutes such as the one at Zawar scattered all around the country. It turned out that a condition of our stay was that I would give the Australian Zn talk again, and Bappa had bought me the traditional Indian costume of pyjama

with the old drill cores out the back. He was about to dismiss us and get on with his paperwork when I could see he registered that I was visiting from Tasmania, engendering an abrupt change of attitude and an invitation to come in and sit down. There was some work related small talk until the inevitable tea arrived, whereupon he came to the point "David Boon, magnificent cricketer" he said. Yes, I have some bad news for the Australian test-captain-in-waiting, he is not even on the radar in India; Booney and Steve Waugh reign supreme. After some verbal fencing on the merits of both sides and the prospects for the upcoming one-day and test series, he delivered the coup de grace, "and you, sir, look quite a lot like Shane Warne". Well, there was really no come back to that, so I assured him my legspinners went straight on and my mobile phone didn't work in India, and left to look at core.

The orebodies at Balaria (15 Mt @ 6.07% Zn & 1.25% Pb) occur in massive silicified and sericitised carbonate and consist of fracture-controlled veins/stringers of sphalerite and minor galena. Texturally at least, the material we examined resembled some of the styes of mineralisation in the Irish-type deposits, and parts of the Garpenberg system in central Sweden. Apart from the nature and origin of the Zawar cluster of deposits, the main question in

Rajasthan is their relationship, if any, to the higher grade (in all senses) and more economically viable deposits such as Rampura Agucha, 70 km to the northeast.

When we completed our fieldwork we returned to Udaipur for my last night in India. The manager of the Rajasthan branch of the Mining, Geological and Metallurgical Institute of India had heard I was about and written via the survey to request that I address their group. This consisted of some more Indian Geological Survey staff and exploration personnel from Hindustan Zinc and Anglo American, and you guessed it, they heard a lecture on the zinc deposits of northern Australia. On my last day Bappa showed me the edited highlights of Udaipur in a whirlwind moto-taxi ride. The most impressive is the maharajahs winter palace, but his smaller summer palace that entirely covers a small island in the lake is more famous because it featured prominently in the James Bond film Octopussy. I had a great time on my first visit to India, and as Bappa is visiting CODES



for the next few months to address some of the questions regarding the setting and origin of the Zawar deposits, I look forward to returning some of his generous hospitality.



17th Australian Geological Convention

8-13 February 2004
Wrest Point Convention Centre
Hobart, Tasmania



GOLD DEPOSIT WORKSHOP

14–16 June 2004

CODES, Hobart, Australia

A three-day workshop on gold deposits, comprising six half-day sessions on specific deposit types

LODE GOLD
PORPHYRY COPPER-GOLD
LOW SULFIDATION EPITHERMAL GOLD
VHMS GOLD
HIGH SULFIDATION EPITHERMAL GOLD
CARBONATE REPLACEMENT GOLD

each addressing ore deposit characteristics and the anatomy of a giant ore deposit discovery.

Confirmed speakers: Francois Robert (Barrick Corp.), Mark Hannington (Geological Survey of Canada), Doug Kirwin (Ivanhoe Mining), Jeff Hedenquist (Colorado School of Mines), Larry Meinert (Washington State University), Jean Cline (University of Nevada at Las Vegas), Noel White, Bruce Gemmel, David Cooke (CODES).

CODES SHORT COURSE PROGRAM

Volcanology and Mineralisation in Volcanic Terrains

14–28 March 2004

A two-part short course on volcanology and mineralisation in volcanic terrains for geologists interested in a review of current approaches to mapping, facies analysis and mineralisation in ancient and modern volcanic successions. The course is field-based on the North Island of New Zealand and in western Tasmania. Course leaders: Jocelyn McPhie and Bruce Gemmell.

Ore Deposit Models and Exploration Strategies

14–25 June 2004

Ore Deposit Models and Exploration Strategies is an up-to-date synopsis of ore-deposit types and their characteristics. Important features which relate to their genesis and exploration will be discussed and exploration models will be presented for each style. A team of Australian and international experts will cover VHMS, Broken Hill type, Proterozoic Cu-Au, porphyry Cu-Mo-Au, skarn deposits, sediment-hosted massive sulfides and epithermal Au-Ag deposit styles. Course leader: Professor Ross Large.

These courses form part of the National Geoscience Teaching Network, supported by the Minerals Council of Australia and DETYA. The course is offered jointly between CODES, the University of Western Australia, James Cook University, Monash University (VIEPS) and CRC LEME (University of Canberra).

Units offered by University of Western Australia:
Ore deposit models
Computer applied exploration techniques
Management for exploration and mining
Applied structural geology and field mapping
Ore deposit field trip to South Africa

Units offered by James Cook University (EGRU):
Advances in ore genesis
Resource definition: Theory and practice
Business and financial management
Advanced field training
Exploration techniques in ore search



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Ore Solutions banner: Colloform jasper vein and breccia infill, Mount Muro, Kalimantan, Indonesia.



'Warnie' enjoying a drink in Zawar.

