ore solutions

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

Vale Professor S. Warren Carey

Emeritus Professor S. Warren Carey, foundation professor of the Department of Geology at the University of Tasmania, died in Hobart on 20 March 2002 aged 90.

Professor Carey was the driving force behind the success of earth sciences as one of the internationally recognised areas of strength at the University of Tasmania. His controversial and world-leading ideas on continental drift and the expanding earth, and his inspirational style of teaching and leading the Department will be remembered by all graduates of geology and geophysics.

Professor Carey graduated Doctor of Science from the University of Sydney, and received Honorary Doctorates from the Universities of Papua New Guinea and of Urbino (Italy).

Professor and Mrs Carey pictured at the 50th anniversary celebrations of the Geology Department/School of Earth Sciences at the University of Tasmania in 1996.

He served as president of the Geological Society of Australia, and President of the Australian and New Zealand Association for the Advancement of Science, as Chairman of the Schools Board of Tasmania, Chairman of Trustees of the Tasmanian Museum and Art Gallery, and Chairman of the Professorial Board of the University of Tasmania.

He was an Honorary Life Fellow of the Geological Society of Australia, the Royal Society of New South Wales, the Geological Society of London, the Geological Society of America, the Australian and New Zealand Association for the Advancement of Science, and the Indian National Science Academy.

He was convenor and editor of six international symposia on *Glacial Sedimentation, Continental Drift, Genesis of the Lyell Schists, Dolerite, Syntaphral Tectonics,* and *The Expanding Earth*.

He is author of *The Expanding Earth* (Elsevier), *Theories of the Earth and Universe* (Stanford University Press) and *Earth Universe Cosmos* (University of Tasmania).

He was awarded the Clarke Medal of the Royal Society of New South Wales, the Johnston Medal of the Royal Society of Tasmania, the Browne Medal of the Geological Society of Australia, and Gondwanaland Gold Medal of the Mining, Metallurgical and Geological Society of India, and the Weekes Gold Medal of the Australian Petroleum Production and Exploration Association.

He was a Fellow of the Australian Academy of Science.

He was an Officer of the Order of Australia.

An obituary written by a group of his friends, and a funeral oration delivered by Professor Ross Large, can be found in this Newsletter.

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MEMORIAL GATHERING

A memorial gathering will be held at CODES on Sunday, 16 June 2002, to celebrate the life and work of Professor S. Warren Carey. Please contact Tanzi.Lewis@utas.edu.au or phone (03) 6226 1863 for details. All colleagues and graduates most welcome.

Professor S. Warren Carey AO

(1911–2002)

An obituary assembled by a group of his friends

Professor S. Warren Carey died peacefully on 20 March 2002.

He will be missed by a large community of Australian geologists who were either his students, those who worked for or with him, or who were influenced by his many ideas on the way the earth works.

Samuel Warren Carey was born near Campbelltown, New South Wales on 1 November 1911. His schooling was at Campbelltown and later at Canterbury High School where he was a high achiever. From here, he entered the University of Sydney in 1929, during the Depression years, enrolling in chemistry, physics and mathematics, taking geology as a fourth, fill-in subject on the advice of one of his high school teachers James ('Jerry') Jervis. Here he came under the influence of the retired Sir T.W. Edgeworth David, a leading participant in Ernest Shackleton's 1907-1909 Antarctic expedition. Carey graduated with First Class Honours in geology in 1932 and received the Science Research Scholarship which allowed him to go to a Master of Science degree. This was conferred, in 1934, for work in the Werrie Basin of northern New South Wales. In addition to his studies, he was a member of the University regiment and active in rowing. He founded the Students' Geological Society and was its first president.

From academia, he joined Oil Search in Papua New Guinea and explored many areas where white men had not been seen. He was an outstanding field geologist, very concerned for the welfare of his field staff, the local people and his equipment. He showed in this period his dedication to the small details that made the exploration effort successful. This was a lifetime attitude. His activities in New Guinea convinced him of the dynamic nature of the earth and stirred the lifelong interest in tectonics (science of large-scale movements of the earth - continental drift and the like). He moved from Oil Search to the Australasian Petroleum Company and wrote a thesis entitled "Tectonic Evolution of New Guinea and Melanesia" which earned him a Doctor of Science degree from the University of Sydney. The drama of the transport of this thesis overseas for examination is a story in itself and reflects the transport and communications problems of a world at war.

During this time, in June 1940, he married Austral Robson.

He remained in industry until 1942 when events in New Guinea led to evacuation of the Careys to Melbourne. He joined a special unit - Z-Force - and returned to Port Moresby to recruit and train personnel for work behind enemy lines and in preparation for a raid on Rabaul. He also became a paratrooper. Here again, his attention to detail in design of boats and field equipment, came to the fore. He was involved in the famous dummy limpet mining of ships in Townsville Harbour, written up in R. McKie's "The Heroes" and dramatised some years ago by ABC radio.

With the winding down of the war effort, Carey returned to Melbourne and moved to Tasmania to take up the position of Chief Government Geologist for Tasmania. He retained this position until 1946 when he was appointed the Foundation Professor of Geology at the University of Tasmania. It was from this position that he made his name, building on all the earlier experiences.

While the University of Tasmania was a small university in an isolated state of small population, it developed an outstanding reputation and large geology student body, due almost entirely on the drive of Carey and a very few well-chosen initial staff. Carey insisted on giving the first year lectures and in consequence had a very high recruitment to second year because of the quality of his teaching. Many distinguished geologists were attracted to the discipline through Carey's approach to teaching. He was the God-Professor and drove his department rather than simply managing. He was a real leader in the academic environment and a respected thorn in the side of many a vice-chancellor.

He ensured that there were good working relationships between the University, Geological Survey, the geological branch of the Hydro-Electric Commission and industry. This led to co-operative development of research projects for the many students who went on to higher degrees. But his interest in Papua New Guinea remained and in the 1960s he had a group of PhD and Honours students who conducted a series of complementary research projects covering a large area of that part of the world.

At about the same time, Australia recognised the need to find its own hydrocarbon resources. Lewis Weeks, based on his knowledge of the Lakes Entrance Oil Shaft and Carey's sketch map of anticlines extending in to the offshore Gippsland Basin, led BHP to take up exploration acreage. At a meeting in Launceston in 1984, Geoffrey Blainey pointed out that the Weeks/Carey association was of historical significance.

He retired as Professor of Geology in 1976 and was made an Officer of the Order of Australia (AO) in 1977.

He was not a narrow scientist but one who saw geology as the great integrating science and used this philosophy to pull together a vast amount of knowledge into his tectonic theories. These theories commonly were controversial and not fully accepted internationally but they have stimulated a large professional interest and study. Many of his ideas are now mainstream and are used by scientists who may not even realise the source of a concept they employ on a daily basis.

He was an extrovert and enjoyed the controversial limelight.

He convened a series of international symposia at the University of Tasmania. The driving force behind each one was the existence of a geological debate that was best addressed by calling the various schools of thought together. Perhaps the most influential of these was the 'Continental Drift Symposium' of 1956 (results published in 1958) which influenced many of the workers in the field, and helped cement his international reputation.

While concerned mainly with large scale geological features, Carey never lost sight of the human dimension and was an active participant in Legacy, and ready to speak to any small group of people who

wanted a talk on geology, or weather, or any area of science in which he felt qualified to speak. He was a great publicist for science in communities beyond the normal scientific arena.

He is renowned as a provocative generator of new major integrative hypotheses that are revolutionary but highly credible and concern the dynamics of our earth. In addition he made major contributions to our understanding of deposition of sediments in a glacial marine environment. Many of his ideas were well ahead of their time and influenced the direction of tectonic studies globally. Idea generation was supported by a very strong personality dedicated to promotion of those ideas.

He will be remembered as one who initiated ideas, stimulated students at all levels, and produced an impressive community of leading scientists in geology and geophysics. Many came from leading overseas universities. All speak glowingly of the influence of Carey in their scientific development.

He 'retired' in 1976 but retained a very active scientific lifestyle. He is recognised by many awards nationally and internationally.

He pursued enthusiastically the promotion of science to the public through personal involvement with organisations such as the Geological Society of Australia, Royal Society of Tasmania, and the Australian and New Zealand Association for the Advancement of Science, to which he dedicated very significant energy over many years.

The scientific world was very much the better for his presence.

He is survived by wife Austral, their four children Tegwen, Harley, Robin and David, grandchildren Krista, Sam, Warren, Sarah, Eleanor, Sean and Geoffrey. And great grandchildren Caitlin and Phoebe.

A Tribute to Professor S. Warren Carey

'Disbelieve if you can'

Professor Ross Large spoke at the funeral of Professor S. Warren Carey, about an academic known for challenging ideas.

I was a student in the University of Tasmania's Geology Department in the late-1960s, and I would like to share with you a few thoughts about Professor Carey as a teacher, from the students' perspective.

Samual Warren Carey, or 'the Prof.' as we all knew him, and will always remember him, was not only an exceptional scientist and leader, but also an inspirational and much-respected teacher.

He was like no other teacher, lecturer or Professor I have ever known. He was way ahead of his time in tectonic theory. Many were vehemently opposed to his ideas, but others followed his insights with a passion.

Prof.'s philosophy of science was 'disbelieve if you can'. He demonstrated this through his own scientific research on global tectonics, where he disbelieved the current dogma and proposed his own theories of firstly continental drift, and then the expanding earth.He encouraged all of us to 'disbelieve if we can', to develop "multiple working hypotheses" and to challenge currently accepted ideas.He firmly believed that as a professor of Geology he should take a major role in teaching and leading the department by example. He delivered all our first year lectures and a large segment of the second and third year. Each was a performance, not just a lecture, and we came away fired by his enthusiasm and his intellect. He often said, "You need to have fire in your belly, my boy".

His success as a teacher is clearly shown by the long list of students from the University of Tasmania Geology Department who have gone on to have very significant international careers in their own right. I could not name any other Australian academic geologist who has had such a profound influence on the thoughts and careers of his students. Fourteen Professors of Geology have come from the ranks of Carey's Department and been inspired by his teachings.

He was also a great field geologist and field teacher. He led many of our excursions in both first and second year. He introduced the dreaded 'field test'. Prof. always had his whistle on excursions, to get us out of the bus and to start and stop the field tests.

I can vividly remember the occasion in the Central Highlands on an Easter weekend field excursion for second year students. It was an overcast, bitterly cold day. The bus had pulled up at a field stop just as it started to rain. In fact, the rain was pelting down. Prof. got out of the bus; we were aghast at the idea of going out into the pouring rain and stayed in our seats. We looked out of the bus to see the Prof. standing at the side of the road in his suit and tie and grey plastic raincoat staring back at us with a determined expression. He then took out his whistle and blew one long blast. That was all it took; we all got out of the bus into the pouring rain where he described the geology of the surrounding country side; which we of course could not see because of the heavy rain and mist. Not to be content with a short discourse on the regional geology, we then had another blast of the whistle to signify the start of a field test on the outcrop down the road. The rain was still pelting down. We rapidly learnt the problems of trying to take notes and make geological sketches on sopping wet notepaper.

This episode typified Professor Carey; nothing would stop him from leading and teaching on that or any other excursion – this was how you became a geologist.

I would like to finish by saying I will remember Prof. for his stimulating lectures, his capacity to generate new ideas, his compassion and understanding of our student issues, and the impressive community of leading international scientists that he produced. Most of all, I will remember him for showing us the way to 'disbelieve if you can', and challenge the orthodoxy of science.

On a personal level, I am very proud to be known as a student of Carey's Department, and to be able to remember the Prof. as a mentor and a friend.

Ross R Large
Director of CODES

Toronto PDAC Book Prize Winner

University of Toronto PhD candidate, Yannick Beaudoin, was the lucky winner of the CODES book collection when his business card was drawn at the PDAC Trade Show in Toronto, Canada, recently.

Yannick was one of hundreds who visited the CODES stand in the Australian pavilion at PDAC.

"The books will be useful references for my study, plus I'm coming to Australia to meet Professor David Groves of the University of Western Australia [co-author of *The Geology and Origin of Australia's Mineral Deposits* with Mike Solomon of CODES]," Yannick said.

Yannick Beaudoin …winner of the CODES books.

The books won by Yannick, which are all published by and available from CODES, included:

- *Volcanic Environments and Massive Sulfide Deposits*. Edited by J.B. Gemmell and J. Pongratz. 234 pp.
- *Basins, fluids and Zn-Pb ores*. Edited by O. Holm, J. Pongratz and P. McGoldrick. 2nd edition. 168 pp.
- *Volcanic Textures: A guide to the interpretation of textures in volcanic rocks.* J. McPhie, M. Doyle and R. Allen. 196 pp.
- *The Geology and Origin of Australia's Mineral Deposits*. M. Solomon and D.I. Groves. Revised edition. 1002 pp.

New PhD student

From Canada to CODES

Canadian Rob Duncan (pictured) has started researching his PhD thesis on the 'Age and genesis of alteration and iron oxide Cu-Au mineralisation across the granulite Mt Woods Inlier, and its relationship to the Olympic Dam Cu-Au system 200 km to the southeast'.

Rob completed his Bachelor of Science, Honours (Geology) and Master of Science (Geological Sciences) degrees at the University of British Columbia, Vancouver, Canada. Rob's MSc research was part of a UBC Mineral Deposit Research Unit project 'Regional and system-scale controls on the formation of Cu and/or Au magmatic-hydrothermal mineralisation'.

Rob has worked as a geologist based in Vancouver exploring for VHMS, SEDEX, and Au-porphyry deposits in the Yukon, Manitoba and the North West Territories for the last five years, with Inmet Mining Corporation, Rio Tinto PLC and Expatriate Resources Ltd.

Visitors

Associate Professor Xianbio Lu

Dr Yoshihiko Goto

Associate Professor Xianbio Lu, from the Faculty of Earth Resources, China University of Geoscience, has come to CODES for one year under a visiting Research Fellowship program funded by Chinese Government.

Dr Lu will be collaborating with David Cooke and Khin Zaw on skarn and porphyry-type ore deposits research.

In China, Dr Lu is based at Wuhan City, Hubei, China, where he has been undertaking ore deposit research in southern China on the formation of Tongshankou-Wushan skarn Cu-Mo deposit, Hubei, China; fluid inclusion microthermometry, stable isotope (S, H, O) and Sr-Rb ages of Manaoke deposit, Sichuan; geological setting and isotopic characteristics of Jimmuda gold deposit, Sichuan; ore fluid chemistry of Porphyry Cu at Dexing deposit, Jiangxi Province, China; and genesis of Yongping Cu deposit, Jianxi Province, South China with Dr Ni Pie from Nanjing University.

Dr Lu said that he was fortunate to get the chance to visit Tasmania and was particularly impressed by the facilities, academic atmosphere and high-quality ore deposit researchers at CODES.

Japanese volcanologist Dr Yoshihiko Goto, of the Department of Geoscience and Technology at Tohoku University, returned to Tasmania for two months to continue research with Jocelyn McPhie. Their research involves fieldwork on the northwest coast of Tasmania near Stanley, studying a complex sequence of Tertiary submarine basalts.

Tony Crawford Recognised with Personal Chair

Deputy Director of CODES, and Leader of Program 1 (Tectonics, magmas and fluids), Tony Crawford, has been awarded a Personal Chair by the University of Tasmania in recognition of his contribution to research in petrology, geochemistry and tectonics. The promotion grants him the title of Professor; he was previously an Associate Professor.

Professor Tony Crawford

Professor Crawford, who graduated from the University of Melbourne, came to Tasmania in 1983 to take up a two-year post-doctorate position in the School of Earth Sciences at the University of Tasmania. He was subsequently awarded a QEII Fellowship to work with Professor David H Green on ocean floor magmatism and tectonics in the southwest Pacific and Southern Ocean.

From 1988–91, he was the Director of the Ocean Drilling Program's Australian Secretariat. In 1992 he won a five-year Australian Research Council Senior Research Fellowship to work at the University of Tasmania on western Pacific magmatism and tectonics, and magmatism in the Tasman Fold Belt system.

CODES appointed him as an academic staff member in 1997. His main interests include fundamental petrology and geochemistry of magmatic rocks and links to igneous rock-hosted mineralisation; geology and composition of rocks from the seafloor in the south west Pacific and around Australia; and the tectonic evolution of mountain belts, and the continental crust of eastern Australia in particular.

Professor Crawford has published more than 80 refereed papers, edited the book 'Boninites and Related Rocks' (Unwin Hyman 1989), and won in excess of $2.9 million in competitive grant funding since 1987.

Professor Crawford coordinates the CODES PhD program, and has supervised/co-supervised 20 PhD students. He has served several times on the University's Small Grants/IRG Committee, and also on the Central Science Laboratory 2000 Review Committee. He has been a member of the Editorial Board of the *Australian Journal of Earth Sciences* since 1992, and a member of the four-person Editorial Executive of this journal since 1997. He is also on the Editorial Board of *The Island Arc* (Journal of the Geological Society of Japan) and was on the Editorial Board of *Mineralogy and Petrology* from 1992-99.

CODES Director Professor Ross Large said that Professor Crawford's elevation to a Personal Chair was clear recognition of his outstanding research contributions in petrology, geochemistry and tectonics.

"Tony is a valuable asset to both CODES and the School of Earth Sciences and has been the driving force behind developing the very successful collaboration between the fundamental petrology researchers in the School and the applied ore deposit researchers in CODES," Professor Large said.

Luisa Rigs a New Lifestyle

Earth Sciences Honours student Luisa D'Andrea (pictured right) has been employed as a graduate Data Acquisition Field Engineer with Halliburton Energy Services, based in Perth, Western Austalia. The position began with six weeks' training in the Gulf of Mexico. Luisa's work roster is split into three-week shifts based on an oil rig in the Timor Sea and in Perth between shifts.

The job involves mud-logging and wire-line logging to test the viability of oil wells. "It's going to be an exciting and interesting experience and very different to what I've done before. It will provide a good opportunity to learn different things," she said.

Luisa's Honours thesis was 'An interpretation and verification of an airborne electromagnetic survey in the Zeehan District, Western Tasmania'.

Luisa was pleased to secure work as a geology graduate given the current economic climate. "It's hard to get work. I'd been trying for about three months, but if you've got your mind set to find work, you will," Luisa said.

Chapman Conference 2002

Explosive Subaqueous Volcanism

The American Geophysical Union Chapman Conference on explosive subaqueous volcanism, held in Dunedin, New Zealand, was well attended by CODES staff and postgraduate students. CODES' Leader of Program 2, Associate Professor Jocelyn McPhie; Research Fellows Drs Sharon Allen and Cathryn Gifkins; PhD graduate Ali Raos, and PhD students Kate Bull and Andrew Stewart all participated in the conference.

Volcanologists, geophysicists and marine geoscientists interested in the formation of volcaniclastic successions on the modern and ancient seafloor contributed to the success of this conference. There was a wide variety of presentations on the theoretical constraints and properties of explosive magma-water interaction as well as examples of modern and ancient explosive subaqueous eruptions. Modern examples included descriptions of subaerial observations of subaqueous eruptions, marine surveys, and deep-sea submersible mapping of recent deposits. Ancient examples of subaqueous volcaniclastic successions, which include the products of explosive eruptions such as voluminous pumice breccias, highlighted the difficulties in interpreting the origin and environment of eruption of pumice-rich facies in the ancient rock record.

CODES staff and postgraduate students gave excellent presentations.

Sharon Allen presented a paper titled 'Submarine eruption, transport and deposition of a young, thick, coarse, pumice breccia at Yali, eastern Aegean, Greece'. Sharon described thick pumice breccias, which comprise large and small pumice clasts, on the southern part of Yali Island. The large pumice clasts are interpreted to be the products of spalling and explosive fragmentation of a submarine, pumiceous lava. The smaller pumice clasts were produced by a combination of passive disintegration of larger clasts and phreatomagmatic explosions. Structures in the pumice-rich facies are consistent with deposition by a combination of water-settled fall from suspension and gravity flows.

The Chapman Conference field trip to the Oamaru volcanic complex on the southeast coast of the South Island, New Zealand.

Cathryn Gifkins gave a paper on the 'Voluminous, submarine, intracaldera pumice breccia generated by explosive eruptions; the Cambrian Mount Black and Kershaw pumice formations, western Tasmania'. Cathryn described thick, pumice breccia units that occur in the northern part of the Mount Read Volcanics. The stratigraphic position, large volume, proximal facies characteristics, inferred below wave-base environment of deposition and the presence of syn-depositional faults suggest that these pumice breccias are syn-eruptive products of large felsic explosive eruptions that may have occurred in a submarine, intracaldera setting.

Ali Raos presented a paper titled 'Syn-eruptive submarine pumice and shard-rich deposits from ~1 Ma explosive trachydacitic eruptions: Efate Pumice Formation, Vanuatu'. Ali presented the volcanology and sedimentology of a succession of non-welded pumice breccia and shard-rich silt and sand beds currently exposed on the island of Efate. The pumice breccias were deposited in a below-wave-base environment, mainly from turbidity currents and debris flows of waterlogged pumice clasts. However, the location of the vent or vents of the eruption remains unknown.

Jocelyn McPhie presented a talk on behalf of herself and PhD graduate, Kirstie Simpson, 'Fluidal-clast breccia generated by submarine fire fountaining: a Cambro-Ordovician example, Queensland'. This talk presented research from Kirstie's Phd thesis describing fluid-clast breccia associated with coherent and brecciated basaltic-andesite in the Mount Windsor Subprovince. The fluid-clast breccias are interpreted to be the products of fire fountaining in a below-wave-base setting. They are distinguished from subaerial fire fountain breccias by thick glassy margins on the fluidal clasts, the lack of welding and agglutination, the association of

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Another volatile PhD

When South African exploration geologist, Vanessa Lickfold, saw an advertisement to study for a PhD with CODES she discussed it with a colleague. "I was finishing my Masters and his advice was that I should apply but I laughed and said hopefully the answer will be 'no'," Vanessa said. But it wasn't to be. The answer was "yes" prompting Vanessa to pack up and come to Australia.

Three years and nine months later, Vanessa has handed in her PhD thesis on 'The intrusive history and volatile evolution of the Endeavour porphyry Cu-Au deposits, Goonumbla district, New South Wales', and has returned to South Africa to continue her career as an exploration geologist with Kumba Resources in Pretoria.

"Completing the PhD has been very rewarding. It was great to finally hold the thesis in my hands and realise that all the effort was worthwhile," she said. Vanessa said PhD study would be beneficial to her position in South Africa doing project evaluation in the economic geology division.

"I will approach my work in a far more holistic manner than I did previously, as I know so much more about geology. Being in a research environment and attending regular CODES seminars has broadened my outlook on so many different aspects of geology, and understanding all these aspects that has been most valuable."

Vanessa said she enjoyed studying in Australia, which included about seven

Vanessa Lickfold

months in the field. "The guys at Northparkes Mines Limited made sure my field work was as hassle-free as possible. However, I really need to thank many people at CODES, because it's been an incredible experience," Vanessa said.

Vanessa's PhD superviser was David Cooke.

highly vesicular, fluidal clasts with non-vesicular, angular, blocky clasts, and the host submarine succession.

Andrew Stewart presented research from his ongoing PhD 'Subaqueous eruption and emplacement of the Filakopi pumice breccia, Milos, western Aegean, Greece'. He described thick pumice breccia beds on the island of Milos, which contain giant pumices. The large volume and highly vesicular nature of the pumice clasts suggest that they were produced by an explosive eruption. Bedforms and a lack of evidence for reworking indicate that their deposition was essentially syn-eruptive and that they were emplaced into relatively shallow water by a combination of water-settled fall and gravity flow.

The conference was complemented by a half-day field trip to the Late Eocene Oamaru volcanic complex on the southeast coast of the South Island, New Zealand. Here participants debated the mechanisms of explosive eruptions and transport processes operating in a shallow marine setting.

Down south among the capybaras

CODES researchers, together with collaborators at the Geothermal Institute, University of Auckland, are studying epithermal deposits and geothermal systems in Australia, New Zealand, Papua New Guinea, Indonesia and Argentina as part of CODES: AMIRA P588 'Epithermal Au–Ag deposits: Geological, geochemical and isotope vectors to target major deposits'. Robert Scott is collaborating with Robina Sharpe in the study of an extensive low-sulfidation epithermal Au–Ag vein system, at Cerro Vanguardia, Patagonia, Argentina. The epithermal veins, hosted by rhyolitic ignimbrites of the Chon Aike Formation, crop out over an area of at least 510 km^2. Robert's studies specifically address the structural setting of the veins, and structural controls on their development and the distribution of gold along them. Robina has established a new stratigraphic framework and produced a new geology map of the district. She is also working to define the geochemical and isotopic signatures of both high- and low-grade portions of the epithermal system. Robina is currently on a two-month field stint at Cerro Vanguardia.

Robert Scott measures fault striations developed along the Concepcion Vein, Cerro Vanguardia (48°S), Argentina.

Giant Ore Deposit Workshop - Update

The forthcoming Giant Ore Deposits Workshop has generated great interest within the exploration community. More than 70 people have already registered to attend this exciting three-day forum.

The workshop will be held at the University of Tasmania 17-19 June 2002.

Twelve keynote speakers will tackle the key issues pertaining to the characteristics, genesis and exploration for giant deposits of copper, nickel, gold and zinc.

Convenor David Cooke said CODES was pleased to announce there would be six additional speakers from industry and academia to lead the one-hour exploration forums. They will give 20-minute presentations to launch the forum sessions:

•John Thompson (TeckCominco) – porphyry Cu

•Tony Belperio (Minatour) – Mt Woods: Exploration strategies leading to a new Fe oxide Cu-Au discovery at Prominent Hill

•Graeme Broadbent (Rio Tinto) – Sediment-hosted Zn-Pb

•Greg Hall (Placer) – Carlin Au: Discovery of the Pipeline orebody

•Tony Rovira (Jubilee) – Discovery of the Cosmos Ni-sulphide deposit

•David Groves (University of Western Australia) – The long-time opposing views on the Witwatersrand: what are the implications for exploration models?

"When planning the program we wanted to encourage discussion amongst the workshop participants. To help facilitate this, the Society of Economic Geologists Student Chapter has put together a great social program involving a wine tasting on the Monday night (17 June) and workshop dinner on the Tuesday (18 June)," David Cooke said.

The workshop will be followed by a field trip, 19-22 June, to western Tasmanian mineral deposits — Renison Sn, Rosebery Zn-Pb-Ag-Au, Mt Lyell Cu and Henty Au mines.

The CODES short course 'Ore Deposit Models and Exploration Strategies' (17-28 June), continues after the field trip, and includes a special session on intrusion-hosted Au deposits and lode Au deposits by John Thompson, Tim Baker and David Groves on 23 June.

The Giant Ore Deposits Workshop is sponsored by Rio Tinto, Anglo American, Anglo Gold, Barrick, BHP Billiton, and MIM, whose support is gratefully acknowledged.

To register contact: Lynne.Vaudrey@utas.edu.au

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- **Membership of the CODES Science Planning Panel**

Black Smokers of Russia's South Urals

Svetlana Maslennikova

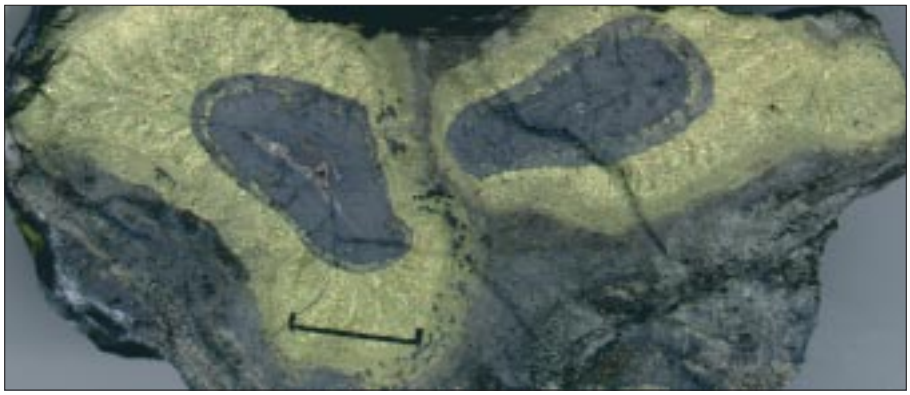
Valeriy Maslennikov

The Director of Science at the Institute of Mineralogy at the Russian Academy of Science, South Urals University, Dr Valeriy Maslennikov, and PhD student, Svetlana Maslennikova, are visiting CODES for six months to study the chemistry of black smoker chimneys in the Southern Urals of Russia.

Hydrothermal vent chimneys and the products of their destruction, resedimentation and sea-floor alteration are the major foci of their study at CODES.

Well-preserved fossil chimneys are uncommon. More than 20 years ago, Valeriy found a few enigmatic chalcopyrite-sphalerite chimneys associated with silicified brachiopods, in rock piles at the shaft of the Early Devonian Oktyabrskoe VHMS deposit. Another chalcopyrite-sphalerite sample resembling a chimney was collected from drill core of the Middle Devonian Alexandrinskoe deposit 10 years later. The colloform outer walls of all of these chimneys were largely replaced by secondary chalcopyrite. Despite this alteration, Valeriy and Prof. Zaykov proposed a black smoker origin for them. Chalcopyrite tubes associated with vent fauna in the Silurian Yaman-Kasy deposit, originally described as vent conduits, were also recognised as possible black smoker chimneys by Richard Herrington (Natural History Museum, London) during an international field trip organized by Prof. Zaykov in 1995. In the following five years, the mineralogy of a number of chimneys was detailed in fruitful collaborative studies between Valeriy and Richard Herrington. Last year, a very productive field trip by Svetlana and Valeriy yielded more than 500 extremely well-preserved vent chimneys from the Yaman-Kasy and Alexandrinskoe deposits in the Southern Urals. These chimneys are notably variable, and are classified according to their mineralogical composition.

The outer walls of vent chimneys are well preserved and composed of primary colloform pyrite partly replaced by marcasite, sphalerite or chalcopyrite. The main types of chimneys are grouped according to the composition of their outer walls: pyrite-rich, marcasite-rich, chalcopyrite-rich or sphalerite-rich. The inner walls of chimneys are always formed by drusy chalcopyrite, which sometimes shows relict textures of intermediate solid solution copper sulfide phases. The axial conduit zones of chimneys are often filled by quartz, pyrite, marcasite, chalcopyrite-bearing sphalerite and other non-stoichiometric iron sulfides; or barite, galena, and calcite. Puzzling laths in the outer walls of some chimneys were possibly pyrrhotite or anhydrite, replaced by fine-grained pyrite or marcasite.



Silurian vent chimneys from Yaman-Kasy VHMS deposit. Sphalerite conduit (dark grey), chalcopyrite encrustation (yellow) with an outer wall of colloform pyrite. Scale bar = 1 cm.

The mineralogical zonation of the various chimney types is consistent with those documented in modern black smoker chimneys. However, the Yaman Kasy chimneys contain abundant tellurium-bearing phases, which are also common in other Ural VHMS deposits. Tellurides form thin rims in the outermost or innermost chalcopyrite domains. Tellurium minerals include, altaite, sylvanite, hessite-stuetzite (aka 'g-phase'), coloradoite, tellurobismuthite, volynscite, goldfieldite, benleonardite, cervelleite, telluriam cobaltite, native tellurium, unresolved tellurium oxides and (Au,Ag,Fe,Pb)(Te,As,S)-sulfosalts and rare native gold. The gold and galena assemblages are more common in sphalerite-rich chimneys. In chimneys from the Alexandrinskoe deposits, the association of native gold and galena is found in sphalerite conduits, but tellurides are rare (hessite) or absent. However, tennantite and sometimes bornite are relatively common in these chimneys.

The mineralogical zonation may be interpreted in terms of temperature and redox zonation across the chimney wall during formation. The broad sulfide zonation and specific sites of tellurium-bearing phases can then be interpreted in terms of the extreme gradients of oxygen and sulfur fugacities, as well as temperature, across the vent chimney walls. The high gradients are due to the interaction between high-temperature reduced hydrothermal fluids in the central conduit of the chimneys and the cold, oxidized seawater outside the external walls. The researchers anticipate they will also discover 'grey' or 'white' smoker chimneys in the Urals VHMS deposits.

Seafloor Search Not Plain Sailing

Russell Fulton, on board the RV Franklin*, sailing past Tavurvur Volcano shortly before docking in Rabaul. Tavurvur erupted violently in 1994, destroying a large part of Rabaul.*

Studying the seafloor took CODES PhD student, Russell Fulton, on a tropical voyage away from the tourist trails and near remote islands inhabited by people who rarely see Europeans. It was quite a contrast to his PhD research field area on rugged Admiralty Island in southeastern Alaska.

The voyage, aboard the CSIRO's RV *Franklin*, sailed from Cairns to Rabaul via China Strait, the Solomon Sea, Vitiaz Strait and the Bismarck Sea. Operations took place predominantly in the western Bismarck Sea between Umboi Island and Vokeo Island, north of Wewak.

Russell said CODES researchers regularly participated in these expeditions because Bruce Gemmell has had a 10-year association with CSIRO research cruises. The aim of such research, led by CSIRO Mining and Exploration, is to study modern seafloor hydrothermal ore-forming activity in order to develop a better understanding of massive sulfide genesis and improved methods of exploring for ancient VHMS deposits.

The specific aims of this cruise were to locate, study and sample submarine volcanoes with active hydrothermal systems in the Western Bismarck Island Arc of Papua New Guinea, in particular at sites having highly potassic characteristics and where summit calderas occur.

The RV *Franklin* operated in depths of 50-2700 m and used a variety of research methods to determine the character of the sea-floor. Systematic echosounder traverses were conducted to map sea floor features. A CTD transmissometer was lowered from the ship to measure temperature, depth, and density and to test for the presence of particulate matter. Water samples were collected at varying depths for post-cruise analysis to determine the presence of metalliferous hydrothermal material. Rock samples were taken from the seafloor using a dredge and a sediment corer was used to take cores of soft sediments. A Smith-McIntyre grab was used to obtain both sediment and rocks. A video camera was also used to bring back images of the sea floor.

Russell said it was hard work at times. "It's a 24-hour operation where teams of three people do two four-hour shifts per day."

The trip was not smooth sailing due to overcast weather, rain and monsoonal squalls of up to 50 knots."A sediment-corer was lost over board in rough weather, a dredge was lost on the bottom of the ocean and the seal of the video camera housing failed resulting in salt water in the camera."

At several locations, the inhabitants of small, remote islands ventured out in their dug-out outrigger canoes to visit the *Franklin*. A highlight of the trip was several hours spent at Garove Island where the *Franklin* was able to sail into the centre of a large caldera through a passage created by the collapse of a small part of the caldera rim.

The principal investigator on the voyage was CSIRO Exploration and Mining Chief Scientist, Dr Ray Binns. Other scientists involved in the expedition were from CSIRO Exploration and Mining in Sydney, CSIRO Marine Laboratories in Hobart, several Australian universities, and from institutions in Papua New Guinea, Korea, Indonesia and Portugal.

Publications: January-April 2002

Recent publications by CODES researchers include a series of papers presented at the 'Melt inclusions at the millennium: Toward a deeper understanding of magmatic processes' conference held in Grenoble, France, in March 2000.

- **Danyushevsky, L.V.**, McNeill, A.W. and Sobolev, A.V., 2002. Experimental and petrological studies of melt inclusions in phenocrysts from mantle-derived magmas: an overview of techniques, advantages and complications. *Chemical Geology* 183: 5-24.
  Although melt inclusions in phenocrysts are a potentially powerful tool in petrological research (they supply direct information on the physical and chemical parameters of crystallisation), they can be affected by processes such as volatile dissociation, oxidation and/or partial re-equilibration with their host, both during natural cooling and homogenisation experiments. This work suggests possible solutions of problems in melt inclusion studies.
- **Norman, M.D.**, Garcia, M.O., **Kamenetsky, V.S**. and Nielsen, R.L., 2002. Olivine-hosted melt inclusions in Hawaiian picrites: equilibration, melting, and source characteristics: Chemical Geology 183: 143-168.
  Olivine-hosted melt inclusions in tholeiitic picrites from five Hawaiian volcanoes (Koolau, Mauna Loa, Kilauea, Loihi, and Hualalai) have major and trace element compositions that illustrate the magmatic characteristics of ocean island volcanoes and the nature of mantle plumes. The geochemistry of these melt inclusions reflects the well known geochemical features that distinguish Hawaiian shield volcanoes, but with considerably greater diversity than whole rock compositions, providing a higher resolution of the magmatic processes contributing to Hawaiian plume magamatism.
- **Kamenetsky, V.S.**, **Davidson, P.**, Mernagh, T.P., **Crawford, A.J.**, **Gemmell, J.B.**, Portnyagin, M.V. and Shinjo, R., 2002. Fluid bubbles in melt inclusions and pillow-rim glasses: high-temperature precursors to hydrothermal fluids? *Chemical Geology* 183: 349-364.
  Hypotheses for the formation of many types of hydrothermal ore deposits often involve the direct contribution of magma-related fluids. However, the chemical and phase compositions of such fluids remain largely unknown. This paper reports on a comprehensive study of fluid bubbles trapped inside glassy melt inclusions in primitive olivine phenocrysts and pillow-rim glasses from basaltic magmas from different tectonic environments.
- **Kamenetsky, V.S.**, Sobolev, A.V., Eggins, S.M., **Crawford, A J.** and Arculus, R.J., 2002. Olivine-enriched melt inclusions in chromites from a low-Ca boninite, Cape Vogel, Papua New Guinea: evidence for ultramafic primary magma, refractory mantle source and enriched components. *Chemical Geology* 183: 287-303.
  The composition of primary magmas and their mantle sources can be successfully inferred from the study of melt inclusions trapped in spinel phenocrysts. This is particularly true in the case of severely altered rocks, in which spinel and spinel-hosted melt inclusions usually retain primary magmatic information. In this study the method was applied to unique Palaeocene low-Ca boninites from Cape Vogel, Papua New Guinea.

Other recent publications:

- **Kamenetsky, V.S.**, van Achterbergh, E., Ryan, C.G., Naumov, V.B., Mernagh, T.P. and **Davidson, P.**, 2002. Extreme chemical heterogeneity of granite-derived hydrothermal fluids: An example from inclusions in a single crystal of miarolitic quartz. *Geology* 30: 459-462.
  The samples of magmatic fluids represented by fluid inclusions in a single zoned quartz crystal from a miarolitic cavity within a porphyritic leucogranite hosting the Industrialnoe Sn-deposit, NE Russia, were studied using Raman spectroscopy and PIXE. Phase and chemical compositions of individual brine inclusions demonstrate significant compositional heterogeneity of high-temperature magmatic fluids accumulated in the miarolitic cavity in terms of absolute concentrations and element ratios. The fluids leaving a crystallising magma may have very variable initial compositions that are subsequently modified by fluid-rock reactions in transit to, and processes in a miarolitic cavity, such as mixing, crystallisation and boiling. The inferred chemical diversity and fractionation of granite-derived fluids implies that fluids entering hydrothermal system are extremely complex and their metallogenic signature may differ from that of related ore deposits.
- Holliday, J.R., **Wilson, A.J.**, Blevin, P.L., Tedder, I.J., Dunham, P.D. and Pfitzner, M., 2002. Porphyry gold-copper mineralisation in the Cadia district, eastern Lachlan Fold Belt, New South Wales, and its relationship to shoshonitic magmatism. *Mineralium Deposita* 37: 100-116.
  This paper presents a review of the styles of porphyry gold-copper mineralisation present in the Cadia district and examines its relationship to late Ordovician shoshonitic magmatism. The Cadia porphyry gold-copper district is the largest hydrothermal, intrusion-related gold deposit in eastern Australia. Porphyry deposits show a close spatial association with shoshonitic monzodiorite to quartz monozonite dykes and stocks of the Cadia Intrusive Complex. Hydrothermal alteration associated with mineralisation is potassic, which is overprinted by selectively pervasive propylitic and silica-albite assemblages. The Cadia district is considered to be an excellent example of the association of alkaline, potassic magmas and gold copper porphyry style mineralisation.
- **Solomon, M.**, Tornos, F. and Gaspar, O.C., 2002. Explanation for many of the unusual features of the massive sulfide deposits of the Iberian pyrite belt: *Geology* 30: 87-90.
  Massive sulfide lenses in the Iberian pyrite belt were possibly formed from fluids that on reaching the sea reversed buoyancy and ponded in basins ('brine pools'). The process of sulfides quenching in a brine pool provides a relatively efficient trapping mechanism for metal in the fluids and effectively excludes ambient seawater. Deposits formed by this mechanism tend to have large size, sheet-like form, and pyrite-arsenopyrite assemblage. Relict chimney structures are absent in this case. The lack of sedimentary source for the high salinity fluids implicates magmatic intrusions, possibly similar to those related to Sn-W mineralisation.

Upcoming Short Courses

Ore Deposit Models and Exploration Strategies

17–28 June 2002

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. Deposit styles covered include VHMS, Broken Hill type, Proterozoic Cu-Au, porphyry Cu-Mo-Au, skarn deposits, sediment-hosted massive sulfides and epithermal Au-Ag.

Volcanology Short Course

17–30 November 2002

A two-part field 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. Includes field geology in New Zealand and western Tasmania.

Ore Deposit Geochemistry, Hydrology and Geochronology

3–14 March 2003

The basic principles of ore fluid chemistry, ore fluid hydrology, fluid-rock interaction, stable isotopes and geochronology are covered in week one. The second week starts with lead isotopes and fluid inclusion basics, and is followed by a series of case studies which discuss the applications of the various geochemical, isotopic and dating techniques to the genesis and exploration of the three important ore deposit styles.

Exploration in Brownfields Areas

30 June–11 July 2003

This course is a laboratory- and field-based unit that looks at exploration in and around mine sites where there is often abundant data. The compilation of these large data sets can present a challenge for any geologist. The course will cover GIS applications and the interpretation of geochemical and geophysical data at various scales. Practical exercises will involve the integration of multiple data sets from world-class mineralised districts. A field excursion to the west coast of Tasmania will examine real-life exploration issues at several mine sites.

Ore Deposits of South America

3–14 November 2003

An exciting field-based course in the Andes covering the major ore deposit styles of South America — deposit types include porphyry Cu-Mo, high sulfidation epithermal Au and iron-oxide Cu-Au. Mines visited include El Teniente (the world's largest undergfround mine) and Chuquicamata (the world's largest open pit). A series of presentations by researchers and exploration geologists working in South America will address the geology, tectonic setting and important exploration criteria for each deposit style.

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Hyaloclastite composed of green cuspate basalt fragments in a chloritic mudstone matrix (altered palagonite?). Clasts show jigsaw fit or are partly rotated and have thin quenched margins. Hyaloclastite is juxtaposed against orange K-feldspar altered dolerite. Sample from the Proterozoic Gold Creek Volcanics, McArthur Basin. Stanton Cu-Co-Ni prospect, near the Northern Territory-Queensland border in the Gulf of Carpentaria.

Taking the waters

Who said geologists never have fun? CODES PhD students Andrew Stewart and Andrew Wurst relaxing in a hydrothermally heated pool at Pamukkale, Turkey, after the SEG Student Chapter 'Thracian Odyssey'.