

AMIRA INTERNATIONAL 2008-2009

looking to
the future
with innovative
solutions



AMIRA International Limited

ABN 60 176 687 975
ACN 004 448 266

Australia

AMIRA International Limited
Level 2, 271 William Street
Melbourne VIC 3000
Phone +61 3 8636 9999
Fax +61 3 8636 9900
Email: australia@
amirainternational.com

Africa

9th Floor, 5 Hollard Street
Johannesburg 2001
Phone +27 11 498 7649
Fax +27 11 498 7203
Email: africa@
amirainternational.com

Latin America

Casilla 5217
Renaca
Vina del Mar, Chile
Phone +56 9 9821 2343
Email: latinamerica@
amirainternational.com

North America

15005 E Layton Place
Aurora Denver
Colorado 80015
Phone +1 303 400 3982
Fax +1 303 680 0523
Email: northamerica@
amirainternational.com

www.amirainternational.com

contents

Executive Chairman's Report	4
Board	6
Organisational Charts	7
Contract Activities	9
Members	10
Research Providers	11
Project Index	12
> Geoscience	13
> Mine Engineering	21
> Mineral Processing	23
> Extractive Metallurgy	32
> Sustainability	36
> Multi-disciplinary	37

our vision

To be the best provider of collaborative research to the resources industry.

our mission

We develop and manage collaborative initiatives for the benefit of the resources industry.

our values

Zero harm to ourselves, others and the environment

Creativity: The essence of innovation

Excellence: The standard we set for ourselves in all we do

Ethical behaviour: We demonstrate integrity, transparency and sensitivity in all our activities.

Collaboration: We respect cultural and individual differences of all participants and work together to achieve mutually rewarding results.

our key strategies

Building Relationships: Nurturing and developing the global resources industry network for our members and the research community.

Delivering Value: Maximise the benefit of our services to all our stakeholders.

Success through People: Ensuring attraction and retention of energetic talented people.

Achievement through leadership and collaboration

executive chairman's report



To August 2009

This year marks the fiftieth of operation for AMIRA International Limited. The foresight and efforts of the eleven original subscribers, ten companies and one University, that signed the original Memorandum of Association in Melbourne, Australia in 1959 has blossomed into a model for collaborative research known and respected throughout the 'minerals' world.

Today, AMIRA has sixty five industry members. Fifty per cent are companies located in Africa, North America, South America and Europe, illustrating the traction that well administered collaborative research, utilising best-in-class research facilities, is achieving.

AMIRA's mission is to provide leading edge, cost effective solutions to technological issues of interest to our members. This is achieved by working with world-class university, government and private based researchers.

The breadth of AMIRA membership continues to expand. In 2008 -2009 AMIRA was pleased to welcome three new members from the petroleum sector. Their involvement brings a new sectorial focus to our activities with the new technical issues associated with the Canadian oil sands operations in which they are involved.

Our task of providing workable solutions for these new members will follow the principles that have provided successful outcomes for our members for over 50 years. AMIRA International's activities will continue to be driven by four objectives:

- > to provide the highest quality research outcomes for the research dollar – regardless of where that research expertise may reside
- > to have representatives available to serve our members and research providers in the key regions where our members operate
- > to foster and support local research where feasible
- > to foster the local development and retention of world-class researcher personnel when feasible.

The AMIRA collaborative research model benefits our members in several ways. The foremost benefit is achieving quality research outcomes in pre-competitive technology activities at lower cost to members by leveraging through shared sponsorship and in-kind contributions from participating research facilities and governments.

AMIRA's international research community engagement assists in the identification of world-class solutions to technical issues of concern to members. We work closely with research groups to ensure the provision of innovative and relevant proposals for consideration by our stakeholders. AMIRA provides project administration and coordination of intellectual property

and contractual obligations for member subscribed projects. This coordination can be material in scope when several member and research stakeholders, sometimes from different legal jurisdictions, are involved in the programs. Technology transfer to sponsor champions during projects is a focus, with the option available of further technology transfer at company operations.



The 2008-2009 fiscal year has been rewarding in many ways but has also raised significant challenges. The year marked the launch of the second largest dollar value of new projects in AMIRA's fifty year history – some A\$18 million in new projects bringing the total value under administration to A\$68 million. However, AMIRA's activities have also been influenced by the consequences of the collapse in world economies. We recognise that the economic crisis is adversely impacting our members' priorities for infrastructure and research expenditure. Anticipating the prospect of lower project activity in the 2009-2010 fiscal year, AMIRA has responded by making the difficult decision to reduce operating costs. Those reductions have, most regrettably, included rationalisation of staff. We were sad to wish them farewell and thank them profoundly for their loyal and capable service during their careers with AMIRA. Included in those reductions were four long serving employees – David Nairn, Bruce Fraser, Kerry O'Sullivan and Peter Camburn to whom we owe special thanks and best wishes.

Peter Gaylard, the initial Research Director for South Africa, retired from AMIRA and the University of Cape Town earlier this year. Peter was the key to our initial growth in South Africa and a respected contributor to AMIRA's activities.

Rob La Nauze retired as Chairman of the Board, having served with distinction in that capacity in 2006-2008 and 2000-2002. The past year also saw resignation from the Board of Ray Shaw, Bobby Danchin and Rob Krcmarov all of whom were valued contributors and early supporters of AMIRA's international expansion.

We also bade farewell to AMIRA's Chief Executive Officer, Deming Whitman who worked diligently and capably to expand AMIRA's international presence during his five years with the Company. We offer our sincere thanks for his efforts and those of all the staff that left during the year.

Looking to the future

The AMIRA model of collaborative research has demonstrated its enduring value for fifty years. However, our quest to improve service delivery to our members and research providers never ceases. The recently implemented restructuring presents the opportunity to undertake an energetic review and evaluation of our mechanisms for the delivery of outstanding collaborative research. Exciting outcomes to accrue from this endeavour will ensure AMIRA's stakeholders are well served in the coming years.

AMIRA remains strong and will grow in its capability to serve an expanding demand for its services. That is our commitment to you.

Douglas Magoon



board

As at August 2009



Executive Chairman
Mr D H (Douglas) Magoon
Technical Advisor
Teck



Senior Vice Chairman
Mr D (Dave) Olney
Vice President,
Technology –
Global Refining
Alcoa World Alumina



Deputy Vice Chairman
Mr J D (Joe) Pease
General Manager –
Xstrata Technology
Xstrata Copper Australia



Immediate Past Chairman
Dr R D (Rob) La Nauze
Consultant



Dr B E (Brian) Smith
Global Manager R & D
BHP Billiton Limited



Mr S (Rick) Gilbert
Vice-President,
Technology
Freeport-McMoran
Mining Company



Mr M (Marc) Le Vier
Senior Director,
Metallurgical Research &
Development Services
Newmont Mining
Corporation



Mr P (Peter)
Charlesworth
Consultant
Anglo Platinum



Mr G (Gary) Johnson
Managing Director
Norilsk Process
Technology



Mr S (Steve) Burks
Chief Technology
Officer
Bateman Engineering
Pty Ltd



Dr Juan Carlos Salas
Manager of Innovation
Antofagasta
Minerals S.A.



Mr C (Calvin) P Treacy
Executive Director



Mr J (Johan) Theron
Group Consulting
Metallurgist
Impala Platinum Ltd



Dr W (Walter) Valery
Senior Vice President
- Global
Metso Process
Technology &
Innovation

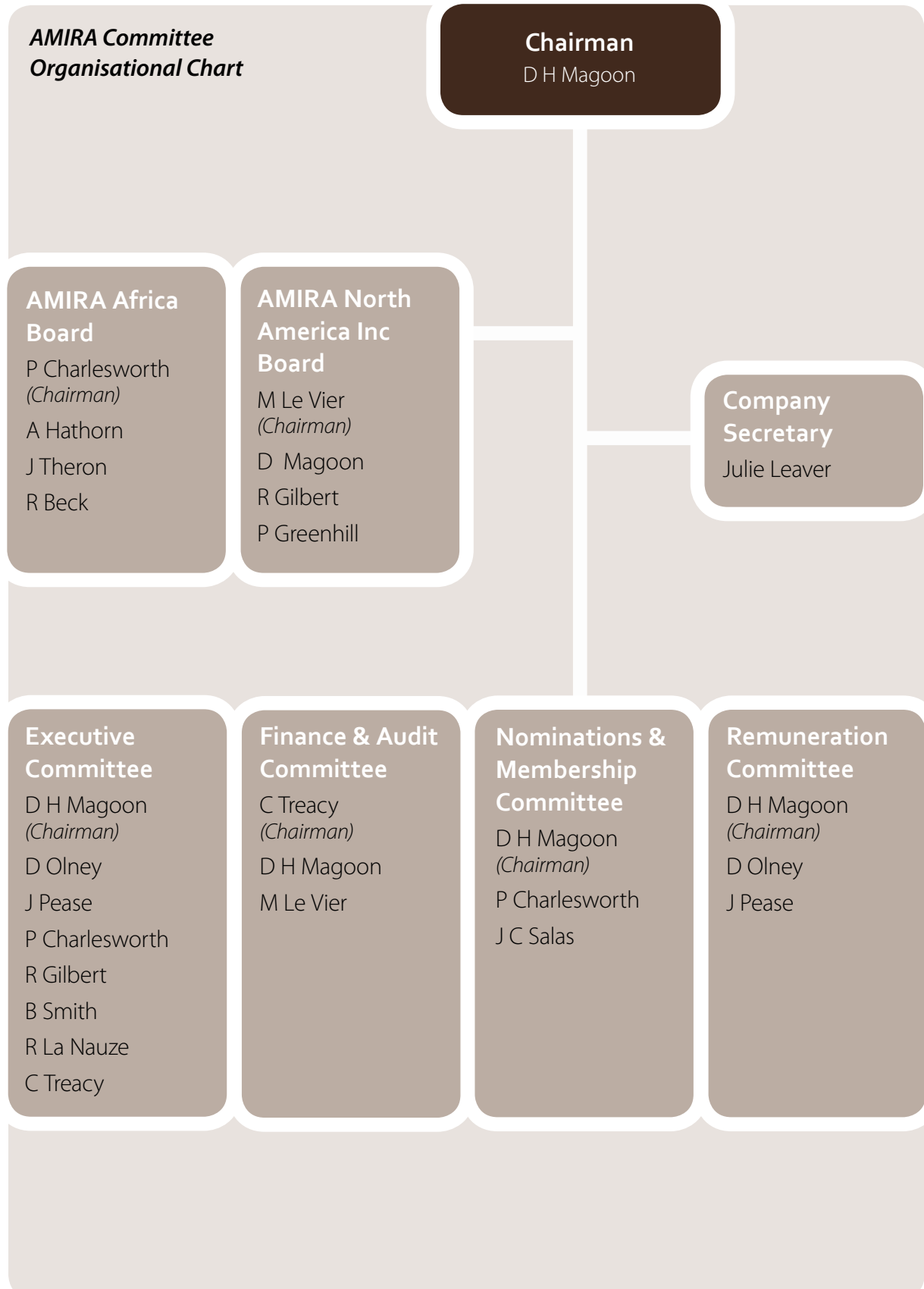


Mr R (Rob) Krcmarov
Senior Vice President
Global Exploration
Barrick Gold
Corporation
[Resigned August 2009]



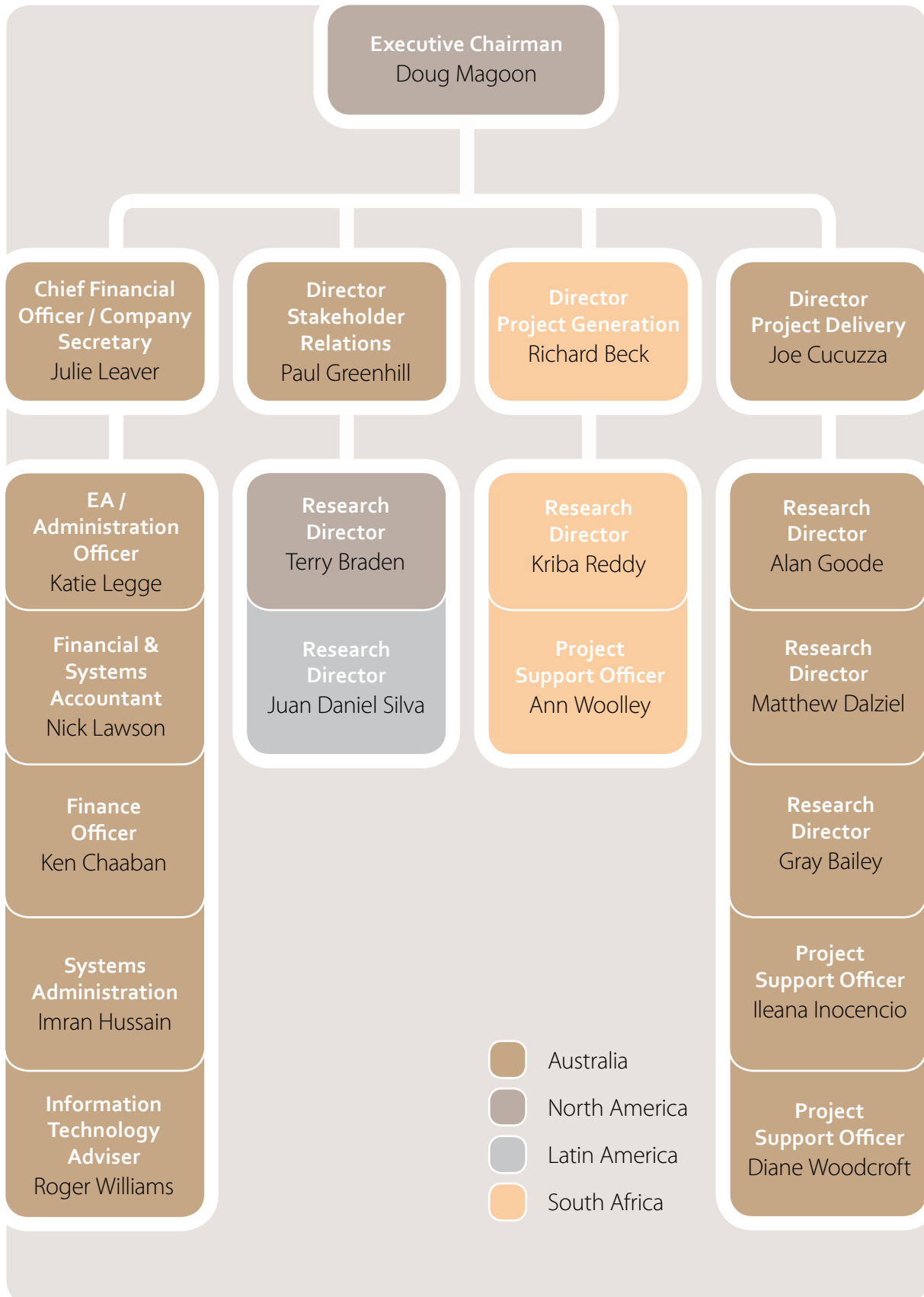
Mr A (Alex) Hathorn
Head of Technical
Services
Anglo Coal Global

organisational charts



AMIRA Organisation Chart

As at August 2009



contract activities

	2009 A\$m		2008 A\$m	
Total Research Commitment				
Geoscience	8.02			6.80
Mine Engineering	3.35			3.71
Mineral Processing	30.04			25.13
Extractive Metallurgy	5.38			5.19
Sustainability	1.42			1.42
Multi Disciplinary	19.82			16.69
Total	68.04			58.95
Annual Research Spending (by market)				
Geoscience	2.37			2.15
Mine Engineering	1.09			1.05
Mineral Processing	5.23			4.27
Extractive Metallurgy	2.09			2.67
Sustainability	0.31			0.50
Multi Disciplinary	3.51			3.44
Total	14.60			14.08
Annual Research Spending by (researcher type)				
Universities	11.15			9.14
CSIRO	1.66			3.11
CRC	0.59			0.51
Other	1.20			1.32
Total	14.60			14.08
	No.		No.	
Project Numbers				
Contracts in progress	34	68.04	34	58.95
Contracts commenced and additional sponsors	9	18.19	11	17.65 *
Contracts completed	9	5.59	16	19.36
Membership				
Members	65		64	

This is a summary of AMIRA's activities for the year. The figures presented have not been audited and include variable exchange rate adjustments. Direct comparisons between years should only be taken as indicative.

* This figure does not include additional sponsorship for current projects.

members

Group A (Less than \$US2bn market cap)

Boliden Minerals AB
 Cayleli Bakir Isletmeleri A.S.
 Independence Group NL
 Jabiru Metals Limited
 Nyrstar
 St Barbara

Group B (\$US2bn - \$US10bn market cap)

Alcoa World Alumina
 Impala Platinum
 Minerals and Metals Group Ltd
 OZ Minerals
 Teck

Group C (Over \$US10bn market cap)

Anglo Platinum Management
 AngloGold Ashanti
 AREVA NC
 Barrick Gold Corporation
 BHP Billiton
 Codelco
 Freeport McMoran Mining Company
 Newcrest Mining Limited
 Newmont Australia Limited
 Rio Tinto Limited
 United Company RUSAL
 Vale
 Xstrata Technology

Group E (Explorers Only)

Equinox Resources Limited

Individual Membership (IM) (Single Operation)

ALUNORTE – Alumina do Norte do Brasil S/A
 Queensland Alumina Limited

Group K ("Concession")

Antofagasta Minerals S.A.
 Cameco Corporation
 Compania de Minas Buenaventura
 Exxaro Resources Limited
 First Quantum Minerals Ltd
 GFL Mining Services Limited
 Hydro Aluminium Metal Products
 Kinross Gold Corporation
 LKAB
 Lonmin Platinum
 Norilsk Process Technology Pty Ltd
 Servicios Industriales Penoles
 Shell Canada Energy (Albian Sands Energy Inc)
 Syncrude Canada Ltd
 Total E & P Canada Ltd
 Votorantim Metais Ltda

Group S (Suppliers)

Amdel Limited
 Ausenco
 Australian Gold Reagents Pty Ltd
 Bateman Engineering Pty Ltd
 Boart Longyear Pty Ltd
 Ciba Speciality Chemicals Australia
 CP Kelco Oy
 Cytec Australia Holdings Pty Ltd
 FL Smidth Minerals Inc
 Hatch Australia Pty Ltd
 Huntsman Corporation Australia Pty Ltd
 Kemix (Pty) Ltd
 Magotteaux Pty Ltd
 Metso Minerals
 Nalco Australia Pty Ltd
 Orica Mining Service
 Outotec
 Penford Australia Limited
 Russell Mineral Equipment Pty Ltd
 Sandvik Mining & Construction Australia Pty Ltd
 Senmin South Africa (Pty) Ltd
 Tyco Flow Control Pacific P/L

research providers

ACeSSS, University of South Australia
 Alford Mining Systems
 AMC Consultants
 ANSTO
 Australian National University
 Bryan Research Centre,
 University of Queensland
 Cape Peninsula University of Technology
 G-Core
 Centre for Exploration Targeting,
 University of WA
 Centre de Tecnologia Mineral (CETEM)
 CMLR, University of Queensland
 CODES Centre of Excellence,
 University of Tasmania
 Colorado School of Mines
 CRC for Sustainable Resource Processing
 CSIRO
 Curtin University
 e2v Technologies
 ECN
 Energetics Ltd
 Geoscience Australia
 Hacettepe University
 Ian Wark Research Institute,
 University of South Australia
 Institute of Experimental Mineralogy,
 Russian Academy of Science
 Institut de Recherche pour le
 Développement (IRD)
 Julius Kruttschnitt Mineral Research Centre,
 University of Queensland
 Lakehead University
 Laboratoire des Mecanismes et
 Transferts en Geologie (LMTG)
 Levay & Co
 McGill University
 MINTEK
 MIRARCO
 Monash University
 Murdoch University
 National Research Council Canada,
 Wear and Corrosion Group
 Newcastle University
 Parker Cooperative Research Centre
 Pontificia Universidad Catolica de Chile
 RMIT University
 Sustainable Minerals Institute,
 University of Queensland
 Technologies in Structural Engineering P/I
 Universidade Federal do Rio de Janeiro
 Universidad de Chile
 Universidad de Concepcion
 University of British Columbia
 University of Cape Town
 University of Melbourne
 University of Nottingham
 University of Ougadougou
 University of Pretoria
 University of Sao Paulo
 University of South Australia
 University of Stellenbosch
 University of Utah
 University of the Witwatersrand
 US Geological Survey
 Vernadsky Institute, Moscow

project index

	<i>page</i>		<i>page</i>
P009O	23	P872	16
P260E	24	P879A	29
P266F	25	P884	21
P420C	32	P891	16
P498B	26	P903A	40
P498C	26	P924	41
P507C	33	P931	41
P521C	33	P933	36
P575B	34	P934	17
P599B	37	P961	42
P667B	27	P962	18
P705A	34	P968	30
P710A	13	P970	30
P740B	13	P972	18
P754	37	P981	19
P765A	14	P986	35
P778	15	P992	22
P780A	27	P996	31
P791A	36	P1004	20
P813A	38	P1014	20
P843	38		
P843A	40		
P868B	28		

geoscience

P710A Controls on Platinum Group Element Variation in Mafic and Ultramafic Magmatic Systems

Value

\$504,000

Commencement

August 2005

Duration

3 years

Research Director

Joe Cucuzza

This project builds on the work of Dr Marco Fiorentini and AMIRA P710 in developing fertility indicators for magmatic systems. It focuses on:

- > Application of the new fertility indicator/vector discovered in P710 to more evolved magmatic systems
- > Understanding of the scale of the NiS ore-formation process in variably mineralised belts
- > Applicability of PGE as a vector towards mineralised environments within mineralised sequences
- > Investigation of PGE systematics in a range of petrogenetic environments.

Sponsors

BHP Billiton Minerals Exploration; BHP Billiton Nickel West Ltd; Independence Group NL; Lake Johnston Ltd; Minerals & Energy Research Institute of WA

Research Providers

Centre for Global Metallogeny - University of Western Australia, Professor Mark Barley; Australian National University; Centre for Exploration Targeting - University of Western Australia; CSIRO Exploration and Mining; GEMOC

Project completed

P740B pmd*CRC Stage 3

Value

\$520,000

Commencement

July 2007

Duration

1 year

Research Director

Joe Cucuzza

Stage 3 of the pmd*CRC from July 2007 to June 2008 has been primarily a delivery year focused on sponsor requirements to assist uptake and utilisation of research outputs and outcomes.

Sponsors

Alkane Resources Ltd; AngloGold Ashanti Australia Limited; Ballarat Goldfields NL; Barrick Gold of Australia Limited; BHP Billiton; Cazaly Resources Ltd; CopperCo Limited; Department of Industry, Fisheries and Mines, Northern Territory; Department of Mines and Energy Qld; Fosterville Gold Mine Pty Ltd; Geological Survey of NSW; Geological Survey of Western Australia; Geoscience Victoria; Gold Fields International Services Ltd; Geoinformatics Exploration Inc; OZ Minerals; Primary Industries & Resources South Australia (PIRSA); Xstrata Copper Exploration

Research Providers

CRC Predictive Mineral Discovery, Dr Robert Haydon

P765A
Geochemical and Geological halos in Green Rocks and Lithocaps: The Explorer's Toolbox for Porphyry and Epithermal Districts

Value

\$2,490,000

Commencement

January 2008

Duration

3 years

Research Director

Alan Goode

Porphyry-related mineral districts host many major ore deposits of diverse styles and metal associations. Exploration in these districts can be complicated by shallow-level alteration systems (e.g. lithocaps) and structural complexities. At deeper erosion levels, it can be difficult to identify the locations of productive ore zones that are interspersed between barren gaps of weakly developed hydrothermal alteration (green rocks). It can also be difficult to evaluate and appreciate the significance of unmineralised veins that occur in these environments. Porphyry – epithermal mineral districts are typically zoned, and zoning has been an important tool for exploration. However, the various mineral assemblages and textures that characterise each zone can be produced by barren hydrothermal systems or by non-mineralising processes such as regional metamorphism. Discriminating mineralised and barren systems, being able to locate well-mineralised hydrothermal centres and recognising the distal footprints of mineralisation continue to be great challenges to explorers. This research project will provide tools that help to extend the detection of the geochemical footprints of porphyry and epithermal deposits, and help to focus exploration activity in the altered domains that enclose and obscure mineralisation.

Sponsors

Anglo American Exploration Australia Pty Ltd; AngloGold Ashanti Australia Limited; Barrick Gold of Australia Limited; Codelco; Compania de Minas Buenaventura; Dundee Precious Metals Inc; Equinox Resources NL; Freeport-McMoran Exploration Corporation; Gold Fields International Services Ltd; Kinross Gold Corporation; Newcrest Mining Limited; Newmont USA Limited; OZ Minerals; Rio Tinto Exploration Pty Limited; St Barbara Ltd; Teck Resources Ltd; Vale Australia; Xstrata Copper Limited

Research Providers

Centre for Ore Deposit Research, Dr Zhaoshan Chang, Prof Bruce Gemmell, Professor David R Cooke; Imperial College of Science, Technology & Medicine; Lakehead University; University of Ottawa; University of Tasmania



P778
**Predictive
 Geochemistry in
 Areas of Transported
 Overburden**

Value

\$1,945,710

Commencement

May 2006

Duration

3 years

Research Director

Joe Cucuzza

As the discovery rate of world-class mineral deposits continues to decline, increased attention is being focused on geochemical exploration methods designed for covered terrains. If definitive, low cost surface or near-surface sampling surveys can be conducted in areas of shallow cover (say <30m), large areas can be tested and expensive unnecessary drilling can be reduced. In order to apply geochemical exploration methods confidently in a given area, or to be able to determine that such techniques are inappropriate, it is necessary that we understand the mechanisms by which surface expressions may form. Research is required that will determine which mechanisms can cause metal migration through post-mineralisation cover.

Sponsors

AngloGold Ashanti Australia Limited; Barrick Gold Corporation; BHP Billiton Minerals Exploration; Cameco Corporation; Codelco; Vale; Vale Inco Technical Services Limited; Heron Resources NL; Independence Group NL; Jabiru Metals Limited; Japan Oil, Gas and Metals National Corporation (JOGMEC); Newmont Australia; Rio Tinto Exploration Pty Limited; SGS Minerals ; Teck Resources Ltd; Xstrata Copper Chile SA

Research Providers

CRC - Landscape Environments and Mineral Exploration (CRC LEME); CSIRO; CSIRO Exploration and Mining, Dr David Gray, Dr Ravi Anand; Curtin University of Technology; Universidad de Chile; CSIRO - Land and Water



P872
**Cu-Co Mineralisation
 in the Congolese,
 Zambian and Central
 Australian Basin
 Systems**

Value

\$1,308,000

Commencement

October 2004

Duration

3 years

Research Director

Alan Goode

The Central African Copper Belt (CACB) contains the world's largest and highest grade accumulation of sediment-hosted copper and cobalt. The recently completed AMIRA-ARC P544 project provided significant new insight into the processes responsible for ore formation in the Zambian portion of the CACB. The new project aims to apply this knowledge in developing basin evolution and ore genesis models in the Congolese portion of the CACB, where the geometry, stratigraphic position, and alteration characteristics of ore are conspicuously different. Ultimately, a more comprehensive understanding of the CACB will lead to the development of exploration tools which will be transferable to other basin systems. Parallel studies of the Centralian Superbasin system will determine whether elements necessary to the metal endowment of the CACB are present.

Sponsors

African Rainbow Minerals; Anglo American Corporation of South Africa Ltd; Anvil Mining Ltd; BHP Billiton World Exploration Inc; Vale; Entreprise Generale Malta Forrest; Equinox Minerals Limited; First Quantum Minerals Ltd; Gecamines; Phelps Dodge Exploration Corporation; Rio Tinto Mining and Exploration Ltd

Research Providers

Centre for Ore Deposit Research, Dr David Selley; Colorado School of Mines, Professor Murray W Hitzman; US Geological Survey

Project completed

P891
**Advancing Diamond
 Exploration – Novel
 Techniques for the
 Interpretation of
 Indicator Minerals**

Value

\$168,000

Commencement

March 2006

Duration

2 years

Research Director

Alan Goode

A fundamental of diamond exploration is the use of indicator minerals to both find individual kimberlite pipes and to also evaluate the geohistory of cratonic lithospheres in order to prioritise regions with regard to prospectivity, particularly in relation to potential diamonds grades in any pipes.

This project added to the petrological arsenal of tools to better assess this latter need. It made use of the excellent high pressure experimental and analytical facilities at ANU, together with X-ray beamlines on various synchrotrons.

Sponsors

BHP Billiton Minerals Exploration; De Beers Consolidated Mines; Rio Tinto Exploration Pty Limited

Research Providers

Australian National University, Dr Greg Yaxley; Imperial College London

Project completed**P934**
West Africa
Exploration Initiative:
Stage 1**Value**

\$625,163

Commencement

November 2006

Duration

1 year

Research Director

Joe Cucuzza

The overall aim of West Africa Exploration Initiative is to enhance the exploration potential of the Precambrian Leo-Man Shield through an integrated program of research and data gathering into its ‘anatomy’. The Leo-Man Shield includes: Burkina Faso, Guinea, Ivory Coast, Liberia, Ghana, Mali, Senegal, Niger, Sierra Leone and Togo. Key motivations for this initiative are to assist exploration companies in focusing their activities and to help local Geological Surveys in the region in their role of providing pre-competitive data and information. This was the first stage of the initiative in which a review of existing information was undertaken. A GIS was also built. Part of this stage was to undertake a gaps analysis and prepare a proposal for the subsequent stage.

Sponsors

Ampella Mining Ltd; Barrick Gold of Australia Limited; BHP Billiton SA Ltd; Bureau des Mines et de la Géologie du Burkina; Centre de Recherches Géologiques et Minières - Niger; Vale; Czech Geological Survey; Department of Mines and Geology of Togo; Direction de la Géologie Cote D'Ivoire; Direction Nationale de la Géologie République de Guinée; Direction Nationale de la Géologie et des Mines - Mali; Etruscan Resources Inc; Geological Survey Department - Ghana; Geological Survey of Sierra Leone; Golden Star Resources Ltd; Minerals Commission Ghana; Ministère des Mines et de L'Industrie Senegal; Ministry of Land, Mines and Energy - Liberia; Orezone Resources Inc; Red Back Mining Inc; Resolute Mining Limited; Rio Tinto Mining and Exploration Ltd; Riverstone Resources Inc; SEMAFO Inc; Teck Resources Ltd

Research Providers

Laboratoire des Mécanismes et Transferts en Géologie, Dr Mark Jessell; University of the Witwatersrand, Professor Kim A.A Hein; Bureau de recherches géologiques et minières, Dr Vincent Bouchot; University of Ouagadougou, Professor Martin Lompo



P962
**Ni-PGE Potential of
 Mafic and Ultramafic
 Magmas – A Combined
 Thermodynamic
 Modelling and Melt
 Inclusion Approach**

Value

\$633,870

Commencement

March 2007

Duration

3 years

Research Director

Alan Goode

The project combines three approaches: study of sulphide melt inclusions in early formed phenocrysts in mafic magmas from various tectonic setting; thermodynamic modelling of crystallisation of mafic intrusions; and a detailed study of petrology and geochemistry of a world-class intrusive/volcanic complex associated with large Ni deposits. All are aimed at understanding (1) the potential of various mafic/ultramafic magmas to form magmatic sulphide deposits and (2) which processes during magma evolution are responsible for the formation of deposits.

Sponsors

Anglo American plc; BHP Billiton Minerals Exploration; Votorantim Metais

Research Providers

Centre for Ore Deposit Research, Professor Leonid Danyushevsky; Institute of Experimental Mineralogy (Moscow); Russian Academy of Sciences; Vernadsky Institute (Moscow)

P972
**Mineral Chemistry
 Applied to the
 Characterization and
 Exploration of Ore
 Deposits**

Value

\$534,064

Commencement

January 2009

Duration

3 years

Research Director

Joe Cucuzza

The overall objective of this proposal is to compile a comprehensive database in order to develop new robust and cost effective "mineralo-chemical" tools that will not only permit a better understanding of mineralising systems but more importantly will offer explorers a new and improved method of vectoring into mineral deposits. Efforts will be concentrated on optimising drilling programs (ie. helping in vectoring towards higher-grade ore zones) and improving the geologic evaluation of prospects and targets by developing a process based independent mineralo-chemical tool. Hydrothermal ore deposits are the result of a combination of diverse physicochemical processes that imprint diagnostic geochemical signatures characteristic of this mineralisation. This study is designed to try to "read" these signatures with the final goal to use them as indicators/discriminators. The proposed mechanism to read these signatures is through the mineralogical and chemical analysis of texturally controlled resistate minerals.

Sponsors

Barrick Gold of Australia Limited; BHP Billiton Metals; Rio Tinto Exploration Pty Limited; Vale Exploration

Research Providers

Universidad de Concepcion, Dr Osvaldo M. Rabbia; Laurentian University; University of Oklahoma and CSIRO Exploration and Mining

P981 Guidelines for Improved Downhole Gamma-ray Spectral Logging

Value
\$150,000

Commencement
February 2007

Duration
2.5 years

Research Director
Joe Cucuzza



Gamma logging is used routinely in mineral exploration with particular relevance to uranium where total count logging is commonly used. Spectral (radiometric) down-hole probes are now being manufactured, which have the potential to replace total count logging since the derived spectral information can be used to distinguish contributions from Potassium (K), Uranium (U) and Thorium (Th). However, obtaining sufficient spectral resolution is difficult with the traditional NaI(Tl) crystals and processing software does not exist to take full advantage of the spectral information. This project is testing the new BrillLanCe® 380 crystal, manufactured by Saint-Gobain. It has properties which are likely to significantly improve the spectral resolution and, by adopting existing methodologies for processing airborne radiometric data should dramatically improve the estimations of radioelement concentrations. Utilising these advances may also allow accurate estimations of uranium in the presence of disequilibrium.

Sponsors

Advanced Logic Technology S.A; Areva NC Australia Pty Ltd; Cameco Corporation; Deep Yellow Ltd; Geoscience Associates; Geotron Systems; Heathgate Resources Pty Ltd; Marathon Resources Limited; Mega Redport Limited; Nova Energy Ltd; Primary Industries & Resources South Australia (PIRSA); Toro Energy Ltd; Uranium Equities Ltd

Research Providers

Dickson Research Pty Ltd, Dr Bruce Dickson



P1004**An Industry-led bid for a New Cooperative Research Centre for Deep Exploration Technologies***Value*

\$455,920

Commencement

November 2007

Duration

2 years

Research Director

Joe Cucuzza

Australia's two existing geoscience-focused Cooperative Research Centres (CRC) ceased operating in July 2008. This means not only the loss of important centres of geoscience research, but that \$30M in direct Government investment and an equal amount of institutional support will no longer be available to the minerals industry. This initiative is to prepare a bid for a new geoscience focused CRC.

Sponsors

Barrick Gold of Australia Limited; BHP Billiton Nickel West Ltd; Boart Longyear Pty Ltd; CSIRO Exploration and Mining; Curtin University of Technology; FUGRO Airborne Surveys; Newcrest Mining Limited; OZ Minerals; University of Adelaide; Vale Australia

Research Providers

Freelance Global Limited

Project completed**P1014****Review of Existing & Emerging Cross-over Technologies that could be Adapted and Deployed in Coal and Metalliferous Drilling***Value*

\$184,500

Commencement

February 2008

Duration

0.5 years

Research Director

Joe Cucuzza

The aim of this initiative was to undertake a detailed and critical review of existing and emerging technologies in different industries that could potentially be adopted by the coal and metalliferous mining sectors.

Sponsors

Barrick Gold of Australia Limited; Technological Resources Pty Ltd (Rio Tinto Limited); VALE Inco

Research Providers

AMC Consultants Pty Ltd, Mr Doug Buerger

mine engineering

P884 **Planning & Rapid Integrated Mine Optimisation (PRIMO)**

Value

\$3,351,303

Commencement

December 2006

Duration

3 years

Research Director

Matthew Dalziel

The design and scheduling of open cut mines can be optimised using commercially available software. However in underground mines no such optimisation tools are currently available. There is a recognised need for improved software tools to support the planning, design and operation of underground mines. This project will combine the expertise of researchers in optimisation of stope definition, scheduling, cutoff grade selection and design of underground networks to determine stope, infrastructure designs and production schedules that maximise profitability over the life time of a mine. Integration of the following five research optimisation software modules is proposed:

- > Strategy Selection (inclusive of Cutoff Grade and Mining Method selection)
- > Geomechanics Risk Minimisation
- > Stope Outline Optimiser
- > Access and Haulage Network Optimiser
- > Automated Mine Development Scheduling and Stope Sequence Optimiser.

Sponsors

Barrick Gold Corporation; BHP Billiton Limited; Vale INCO Limited; Datamine Software Limited; GijimaAst; Maptek Pty Ltd; Newmont Mining Corporation; OZ Minerals; Rio Tinto Technical Services Limited; Xstrata Nickel Limited

Research Providers

MIRARCO Mining Innovation, Dr Martin Smith; Alford Mining Systems; AMC Consultants Pty Ltd; University of Melbourne; University of South Australia; University of Waterloo

Project completed**P992**
Load Capacity of
Early-Age Fibre
Reinforced Shotcrete**Value**

\$252,000

Commencement

April 2008

Duration

0.5 years

Research Director

Matthew Dalziel

The early-age properties of Fibre Reinforced Shotcrete (FRS) are critical to estimation of the time to safe re-entry under freshly sprayed FRS linings. Tests in the field have indicated that shear failures dominate early-age load resistance and thereby govern the performance of a lining over the first few hours after spraying. This investigation examined the shear properties of FRS in detail and identified the most important variables affecting shear capacity. The relation between shear capacity, thickness, and load characteristics associated with loose rocks and lining self-weight were then assessed to develop a rational engineered design method for estimation of lining capacity and safe re-entry time at early ages. The result is an improvement in the confidence geotechnical engineers and mine designers can have in the time to safe re-entry after spraying, thereby reducing the risk of injury, death, and liability.

Sponsors

BHP Billiton; Boliden Minerals AB; Vale INCO Limited; Gold Fields International Services Ltd; LKAB; Newcrest Mining Limited; OZ Minerals

Research Providers

Technologies in Structural Engineering P/L, Dr Stefan Bernard



mineral processing

PoogO Optimisation of Mineral Processing Through Modelling and Simulation 2008 - 2011

Value
\$13,690,831

Commencement
January 2008

Duration
4 years

Research Director
Richard Beck



The vision of the P90 project is to improve comminution, classification and flotation performance on sponsor sites through modelling, simulation and characterisation of particles and their process environments, and through training and transfer of skills and technology to the industry. Based on the past achievements of P9N, P9O and associated projects will develop an integrated multi-component simulator structure of the entire comminution, classification and flotation process chain, and multi-component models of the unit operations. The project will also deliver new measurement and characterisation (and other) tools, which will considerably enhance the ability to predict and improve plant performance.

Sponsors

Alcoa World Alumina Australia; Anglo Platinum (Rustenburg Platinum Mines Ltd); AngloGold Ashanti Limited; Ausenco Limited; Barrick Gold Corporation; Bateman Minerals & Metals (Pty) Ltd; BHP Billiton Limited; Cayeli Bakir Isletmeleri-INMET; Vale; COREM; FLSmidth Minerals; Freeport-McMoRan Mining Company; Hatch Africa; Impala Platinum Ltd; Intellection Pty Ltd; LKAB; Lonmin Platinum; Magotteaux Pty Ltd; Metso Minerals Process Technology; Newcrest Mining Limited; Newmont USA Limited; Outotec; Outotec Minerals OY; OZ Minerals; Polysius AG; Rio Tinto Limited; Russell Mineral Equipment; Senmin South Africa (Pty) Ltd; Servicios Industriales Penoles SA de CV; Technological Resources Pty Ltd (Rio Tinto Limited); Teck Resources Metals Ltd; Xstrata Copper Limited

Research Providers

Julius Kruttschnitt Mineral Research Centre, Professor Emmy Manlapig; Centre for Sustainable Resource Processing CRC; Hacettepe University (Benzer); Hacettepe University (Ekmekci); McGill University; Universidade Federal do Rio de Janeiro; University of Cape Town; University of Newcastle

P260E**Improving Sulphide Mineral Flotation****Value**

\$4,836,960

Commencement

December 2005

Duration

4 years

Research Director

Paul Greenhill

The overall aims of the P260E project are to:

- > Increase fine and coarse value mineral recovery in Sponsor flotation plants
- > Improve selectivity in Sponsor flotation plants by improving rejection of gangue minerals
- > Test and validate the WARK Flotation Model on different mineral systems to achieve the aims above.

Generic models will be applied, at laboratory scale, to specific sulphide mineral systems of interest to each of the sponsors which have an operating sulphide mineral flotation plant.

A case study sponsor may also have specific plant work focussed on these project issues, as part of individual case studies within the project. The project is structured with three programs: Sulphide Mineral Flotation, The Flotation Process and Characterisation Tools and Methods. Benefits to sponsors include: process improvements, characterisation tools, technology transfer and enhanced research infrastructure.

Sponsors

Anglo Platinum (Rustenburg Platinum Mines Ltd); BHP Billiton Limited (Olympic Dam Corporation, Nickel West); Boliden Limited; COREM; Freeport-McMoRan Mining Company; Intellection; Lundin Mining Corp; Magotteaux Australia Pty Ltd; Ok Tedi Mining Limited; Outotec; OZ Minerals; Rio Tinto Kennecott ; Rio Tinto Limited; Teck Resources Ltd; Vale; Xstrata Copper Limited; Xstrata Technology

Research Providers

University of South Australia, Assoc. Professor Stephen Grano; Levay & Co Environmental Services, Mr George Levay



Researchers past and present from the Ian Wark Research Institute.

L to R: Michael Pietrobon, Grant Small, Daniel Fornasiero, Bill Skinner, John Ralston, George Levay, Stephen Grano, Roger Smart.

P266F Improving Thickener Technology

Value

\$4,095,000

Commencement

January 2009

Duration

3 years

Research Director

Gray Bailey



The use of thickeners in mineral processing and hydrometallurgy is widespread with operational objectives varying from low solids in the overflow from clarifiers to the production of high yield stress paste underflows. Across all applications there is a need for enhanced performance to meet demanding operational and environmental expectations. P266F involves a core “pre-competitive” work program on three integrated topics plus confidential studies for individual sponsors can be arranged:

Topic 1: Experimental studies (laboratory, pilot-scale and site-based) required for insight and to provide the basis for model development and validation. Alternative thickening concepts that may have the potential to produce step changes in performance will also be assessed and, where appropriate, examined in detail.

Topic 2: Modelling studies to establish the physics and completing the numerics required for full thickener CFD modelling. Existing and to-be-developed modelling capabilities and general understanding will be applied to develop new design concepts and thickener technologies.

Topic 3: Technology Transfer by multiple mechanisms to ensure the learnings, knowledge, tools and techniques arising from P266F activities are effectively transferred to P266F sponsors.

Sponsors

Alcoa World Alumina Australia; ALUNORTE - Alumina do Norte do Brasil S/A; Anglo Research; Aughinish Alumina Ltd; Bateman Engineered Technologies Ltd; BHP Billiton; BHP Billiton Nickel West Ltd; BHP Billiton/Worsley Alumina Pty Ltd; Ciba Specialty Chemicals Australia; Cytec Industries Inc; Exxaro Resources Limited ; FL Smidth Minerals Inc; Freeport-McMoRan Mining Company; Hatch Associates Pty Ltd; Metso Minerals Process Technology Asia-Pacific ; Nalco Australia Pty Ltd; Norilsk Process Technology; Outotec; Shell Canada Limited; Rio Tinto Limited; Teck Resources Ltd; Total E&P Canada; WesTech Engineering Inc

Research Providers

Parker CRC for Hydrometallurgy (CSIRO Minerals), Dr John Farrow; University of Melbourne, Professor Peter Scales

Project completed**P498B**
Polymers at Mineral Interfaces*Value*

\$760,000

Commencement

May 2005

Duration

3 years

Research Director

Bruce Fraser

The P498 series has been successful in bringing together polymer manufacturers and mineral companies as sponsors of research, with mutual benefits. The underlying goal of the project series has been to enable Sponsors to select the right polymer for the right application, based on knowledge of polymer-mineral surface interaction. This is a significant improvement over existing trial-and-error based tests of polymeric reagents. The project extended our existing methodology by: expanding our knowledge base of polymer-mineral interactions, providing a maturing in our polymer selection decision tree; and advancing our performance testing procedure to allow accurate predictions of the performance of polymeric depressants, dispersants, and flocculants based on simple, measurable parameters of the adsorbed polymer.

Sponsors

Anglo Platinum (Rustenburg Platinum Mines Ltd); CP Kelco Oy; Cytec Industries Inc; Penford Australia Limited; Rio Tinto Limited; Xstrata Plc

Research Providers

University of South Australia, Dr David Beattie

P498C
Enhanced Selectivity in Flotation using Polymers*Value*

\$678,500

Commencement

October 2008

Duration

3 years

Research Director

Paul Greenhill

The AMIRA P498 series of projects (P498, P498A and P498B) have been successful in bringing together polymer manufacturers and mineral companies as sponsors of research, with mutual benefits. The underlying goal of the project series has been to provide sponsors with the ability to select the right polymer for the right application based on knowledge of how the polymer interacts with the mineral surfaces. This approach represents a significant improvement over existing trial-and-error based testing of polymeric reagents.

The aim of this proposal is to extend our existing methodology in two ways:

To expand our knowledge base of polymer-mineral interactions, thus enabling a maturation of our polymer decision tree

To advance our performance testing procedure to allow accurate prediction of the performance of polymeric depressants, dispersants, and flocculants, based on simple, measurable parameters of the adsorbed polymer.

Sponsors

Anglo Platinum (Rustenburg Platinum Mines Ltd); CP Kelco Oy; Newcrest Resources Inc; Penford Australia Limited

Research Providers

University of South Australia, Dr David Beattie; Levay & Co Environmental Services, Mr George Levay

P667B SAG Mill Monitoring

Value
\$996,000

Commencement
April 2008

Duration
3 years

Research Director
Richard Beck

The previous extension of this project developed a ruggedised piece of equipment to measure surface vibrations on mills, which has been extensively tested at NorthParkes Mine. The signals from the unit have been processed in a number of ways to show relationships to key mill operating parameter: toe and shoulder position, mill loading, particle size, ore hardness and liner wear. This project is validating these relationships to develop predictive models. This will include an on-line advisory alarm system to warn operators of substantial departures from normal operating conditions. A unit has been installed on a mill at Mogalakwena Mine and a further installation is under consideration for another platinum mine. The data from these units will be used in the validation and modelling work.

Sponsors

Anglo Platinum (Rustenburg Platinum Mines Ltd); Freeport-McMoRan Mining Company; Rio Tinto Limited; Xstrata Zinc

Research Providers

CSIRO Division of Minerals, Dr Ralph J Holmes; CSIRO Mathematical & Information Sciences

P780A Flotation Cell Hydrodynamics

Value
\$418,000

Commencement
June 2005

Duration
2 years

Research Director
Matthew Dalziel

This project builds on the successful results of the computational fluid dynamics and experimental work carried out by CSIRO in collaboration with the P9M Mineral Processing project, to understand the hydrodynamics of the Metso and Outokumpu flotation cells. The new models being developed dramatically increase the understanding of flotation cell hydrodynamics, potentially allowing Sponsors to achieve large savings in operating and capital costs.

Sponsors

Anglo Platinum (Rustenburg Platinum Mines Ltd); BHP Billiton Nickel West Ltd; Outotec; Rio Tinto Limited

Research Providers

CSIRO Division of Minerals, Dr Phil Schwarz

Project completed**P868 B**
Development of
JKSim Float V6.4**Value**

\$625,000

Commencement

February 2007

Duration

1 year

Research Director

Richard Beck

This project has further developed the JKSimFloat V6 package which is software designed to aid users to analyse and understand flotation circuits. The development has been staged through AMIRA projects P868 and P868A and is now known as JKSimFloat V6.4, this stage P868B included model fitting and provision of data templates; namely gas hold-up, superficial gas velocity, residence time distribution and froth recovery. Deliverables to sponsors were in the form of one corporate licence for the software product, JKSimFloat V6.4.

Sponsors

Anglo Platinum (Rustenburg Platinum Mines Ltd); Barrick Gold Corporation; BHP Billiton Base Metals; BHP Billiton Limited; BHP Billiton Nickel West Ltd; Freeport-McMoRan Mining Company; Impala Platinum Ltd; Lonmin Platinum; Newmont Mining Corporation; OZ Minerals; Rio Tinto Limited; Teck Resources Ltd

Research Providers

Julius Kruttschnitt Mineral Research Centre, Dr Rob Morrison, Professor Emmy Manlapig, Professor Jean-Paul Franzidis; University of Cape Town



P879A Microwave Comminution & Liberation of Minerals

Value

\$3,378,000

Commencement

September 2006

Duration

3 years

Research Director

Richard Beck

This project aims to develop the knowledge to design and construct equipment to treat different ores at pilot scale (20-100 tph) at economical microwave energy inputs. The objective of this phase (2006-2009) of the programme is to undertake a systematic and staged investigation to develop the technology to the point where pilot scale equipment can be confidently designed along with clear understanding of the influence of treatment on the downstream processing of ores. This will be done both in terms of existing flow sheets and novel conceptual designs that optimally exploit micro-fracturing e.g. liberation at an enhanced size or enhanced leachability. Key objectives are:

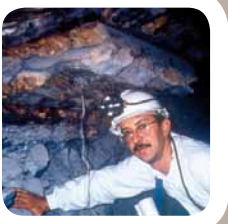
- > Developing a complete understanding of the failure mechanisms in different ores under different microwave exposures (power levels, pulse width and repetition rate)
- > Specification of electromagnetic cavity design and materials handling. Microwave applicators will be designed to achieve the optimal processing conditions (selective heating, selective breakage and enhanced liberation) at scale for individual ore types, textures and mineralogies
- > Design and development of millisecond pulse capability to optimise energy efficiency and processing throughput, as this has been shown to be vital for future development and expansion of this work
- > An initial investigation as to how well current magnetron cathode technology is suited to the RF requirements for mineral ore processing.

Sponsors

Anglo American Corporation of South Africa Ltd; BHP Billiton Limited; Outotec; Outotec Minerals OY; Rio Tinto Limited

Research Providers

University of Nottingham, Dr Sam Kingman; e2v technologies; University of Stellenbosch



P968 Flotation of Copper in Saline Waters

Value
\$594,000

Commencement
April 2009

Duration
3 years

Research Director
Juan Daniel Silva

This project will establish the practicality of using saline waters in the industrial processes of a copper concentrator, by investigating the mechanisms by which saline solutions influence metals recovery. To that end the topics listed for study are:

- > Survey of the State of the Art of Mineral Processing in Saline Waters
- > Rougher flotation of copper and molybdenum minerals in saline waters
- > Influence of salt concentration on the flotation and depression of the important copper ore minerals including chalcocite, chalcopyrite, molybdenite and pyrite
- > Frother behaviour in the saline waters used in studies above
- > Effect of salinity on the flocculation and sedimentation and the rheology of copper tailings.

Sponsors

Anglo American Chile Ltda; Antofagasta Minerals S.A.; BHP Billiton Base Metals

Research Providers

Universidad de Concepcion, Professor Fernando Concha

P970 Selective Flotation Separation of Arsenic Minerals

Value
\$352,000

Commencement
June 2009

Duration
2 years

Research Director
Gray Bailey

Early selective rejection of components containing arsenic and other penalty elements (such as selenium, tellurium, mercury, antimony and bismuth) offers the opportunity to capitalise on the resultant products; a minor co-product stream with the contaminant mineral components and the major 'clean' value concentrate stream.

Sponsors

Anglo American Chile Ltda; Rio Tinto Limited

Research Providers

CSIRO Minerals Down Under Flagship, Dr Sharif Jahanshahi; Centre for Sustainable Resource Processing

P996 Advanced Instrumentation and Control Strategies for Optimising Thickeners

Value

\$1,003,000

Commencement

April 2009

Duration

3 years

Research Director

Juan Daniel Silva

The project aims to develop new instruments and control strategies to optimise the thickening operation in the mineral industry with direct impact on water consumption. This project will develop tools to facilitate the automatic control of thickeners. The objectives are:

- > Establish instruments and protocols for measuring or inferring the key thickening parameters
- > Standardise the methodology of parameter determination and test the phenomenological model for robustness
- > Develop knowledge of the dynamics of thickener responses to process variations
- > Develop model based control schemes and incorporate them into a thickener simulation package
- > Design and implement a mobile instrumented pilot plant that can be transported to the sponsors' sites for on-site demonstration.

Sponsors

Antofagasta Minerals S.A.; Codelco

Research Providers

Universidad de Concepcion, Professor Fernando Concha



extractive metallurgy

Project completed

P420C **Gold Processing Technology**

Value

\$1,912,246

Commencement

March 2005

Duration

3 years

Research Director

David Nairn

Gold producing companies face continuing challenges to reduce costs and increase recovery. It has been recognised that improving overall efficiency not only requires generation of new knowledge, but additionally, that complementary technology transfer systems need to be created to allow implementation and retention of the knowledge. There is also continuing community pressure concerning the use of sodium cyanide and its environmental impact. The industry needs to continually demonstrate that cyanide is being used in a sustainable manner, while alternatives to cyanide continue to be investigated and developed. The complexity of gold ores being treated continues to increase, requiring novel approaches.

The project has provided both short and long term areas of research in gold processing, addressing process and environment issues of current operations while evaluating process options in thiosulfate leaching and the treatment of complex refractory ores.

Sponsors

AngloGold Ashanti Australia Limited; Barrick Gold Corporation; Bateman Engineering Pty Ltd; Gekko Systems Pty Ltd; Gold Fields Australia Pty Ltd; Intec Ltd; Kemix (Pty) Ltd; Knelson Gold Concentrators Inc; Newmont Mining Corporation; Oceana Gold; Orica Australia Pty Ltd; Placer Dome Asia Pacific; Placer Dome Technical Services Limited; Rio Tinto Limited; Wesfarmers CSBP Limited

Research Providers

Parker CRC for Hydrometallurgy, Mr Bill Staunton; Cape Peninsula University of Technology; Murdoch University



P507C
**Thermodynamic
 Characterisation of
 Organics in Bayer
 Liquor**

Value

\$934,400

Commencement

June 2007

Duration

4 years

Research Director

Gray Bailey

This latest stage investigates the thermodynamic properties of Bayer process liquors containing various organic impurities. This will involve the study of redox reactions in highly alkaline solutions containing humic substances, the outcome of which will provide knowledge of the identity and abundance of organic species in Bayer Liquors. A fundamental basis for flow sheet optimisation will also be delivered to assist in improving impurity control, product recovery and process monitoring.

Sponsors

Alcoa World Alumina Australia; Aughinish Alumina Limited; BHP Billiton/Worsley Alumina Pty Ltd; Hydro Aluminium Metal Products; Rio Tinto Limited; Rio Tinto Alcan Limited

Research Providers

Parker Centre (Murdoch University), Professors Peter May and Glenn Hefter

P521C
**Mathematically
 Modelling the Effect
 of Solid Phase Oxalate
 on Gibbsite Secondary
 Nucleation**

Value

\$540,000

Commencement

October 2007

Duration

2 years

Research Director

Gray Bailey

Sodium oxalate is one of the most significant impurities in the Bayer Process. Due to a low solubility in aluminate liquors, oxalate can co-precipitate with gibbsite in precipitation circuits forming a solid phase oxalate (SPO). The presence of the SPO in precipitation circuits has commonly been associated with increased levels of fines in gibbsite product. This project will focus on the mechanism and magnitude of the oxalate effect and develop a mathematical model for gibbsite secondary nucleation to quantify the oxalate effect under different operating conditions.

Sponsors

Alcoa World Alumina Australia; Aughinish Alumina Limited; BHP Billiton/Worsley Alumina Pty Ltd; Hydro Aluminium Metal Products; Rio Tinto Alcan Limited

Research Providers

Parker CRC for Hydrometallurgy; CSIRO Minerals, Dr Iztok Livk

P575B Influence of Thermal Transformation on Alumina Strength

Value
\$368,000

Commencement
April 2008

Duration
2 years

Research Director
Gray Bailey

This project focuses on the interactions between thermal transformation and particle structural features on the strength of smelting grade alumina. This entails addressing two important aspects of hydrate calcination: - the significance of phase composition and other physical properties in the initial stages of calcination on the strength of final alumina, and the effect of the main calcination variables, such as calcination temperature, heating rate and preheating on the final alumina strength.

Sponsors

ALUNORTE - Alumina do Norte do Brasil S/A; BHP Billiton/Worsley Alumina Pty Ltd; Hydro Aluminium Metal Products; Rio Tinto Alcan Ltd

Research Providers

Parker Centre (CSIRO Minerals), Dr Iztok Livk

P705A Improved Anode & Cathode Processes in the Electrowinning of Base Metals

Value
\$1,693,000

Commencement
August 2006

Duration
3 years

Research Director
Terry Braden

Innovation in base metals electrowinning can lead to increased throughput in tankhouses, reduced operating costs and improved product quality. This project is aimed at helping industry to achieve these outcomes. The project comprises a modular structure with three concurrent modules to be undertaken within the overall work program:

Module 1: Advancing Electrode Processes and Cathode Quality

Module 2: Maximising Energy Utilization: Enhancing Uniformity of Current Distribution

Module 3: Improving Electrolytic Cell Technology: Optimising Electrolyte Flow.

This project will focus on developing a core of fundamental knowledge on electrowinning and develop a base for innovative discovery applicable to base metal electrowinning. The base knowledge will be transferred to operations through site visits and training classes offered near or on plant sites.

Sponsors

Anglo Research; Bateman Engineering Pty Ltd; BHP Billiton Limited; Freeport-McMoRan Mining Company; Hatch Associates Pty Ltd; Nyrstar; OZ Minerals; RSR Technologies Inc; Teck Resources Ltd

Research Providers

Parker CRC for Hydrometallurgy, Professor Mike Nicol; CSIRO Division of Minerals; University of Melbourne

P986 Improving Crushed Ore Agglomeration

Value

\$1,845,516

Commencement

April 2009

Duration

3 years

Research Director

Terry Braden

Heap leaching of low grade copper and gold ores has been successfully employed over the past two to three decades. It has been realised that percolation is highly dependent on the size distribution of the crushed ore with fines playing a significant role. To minimise the percentage of fines and improve overall percolation, agglomeration of crushed ore has been implemented in gold and copper heap leach operations. While agglomeration has become common practice to improve heap leach recovery, the fundamental understanding of the agglomeration process for crushed ores is still lacking.

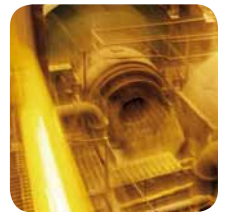
This project will investigate the factors effecting crushed ore agglomeration and percolation in a heap leach environment in the laboratory. Deliverables will include an operator's toolkit to improve operator's control over agglomeration and modelling of the heap leach.

Sponsors

BHP Billiton Minerals; Freeport-McMoRan Mining Company; Gold Fields Group Services (Pty) Ltd; Vale Exploration

Research Providers

University of Utah, Assoc. Professor Michael S Moats



sustainability

P791A Potroom Dust: Character & Causes

Value
\$878,400

Commencement
August 2007

Duration
3 years

Research Director
Gray Bailey

The aims of this study are to (1) determine the origins of potroom dust; (2) identify the important generation mechanisms; (3) evaluate the influence of cell technology, practices and alumina and crushed bath material properties on dust generation and composition; (4) determine how broadly dust generation mechanisms and origins can be generalised across the industry, or whether they are specific to a given smelter or potroom.

Sponsors

Alcoa World Alumina Australia; Hydro Aluminium Metal Products; Rio Tinto Limited

Research Provider

University of Auckland, Assoc. Professor Margaret Hyland

P933 Evaluation of ARD Passivation Treatments

Value
\$542,000

Commencement
January 2006

Duration
3 years

Research Director
Gray Bailey

This project will extend our existing methodology through:

- > Evaluating the reaction mechanisms and products of selected treatment technologies and approaches using an extensive literature review and experimental work (including surface chemistry, mineralogy and kinetic experiments), and providing a better understanding of how the treatments work and the long-term implications
- > Carrying out sensitivity analysis by varying conditions (such as pH, Eh and flushing rates) in laboratory based tests to provide a better understanding of passivating product stability
- > Incorporating and evaluating data from field trials of treatments from sponsor sites and companion research programs
- > Outlining the implications for management and considering the application of selected technologies.

Sponsors

OZ Minerals Limited; PT Freeport Indonesia; Rio Tinto Technical Services Limited; Teck Resources Ltd

Research Providers

ACeSSS University of South Australia, Professor Roger Smart, Dr Jun Li; Levay & Co Environmental Services, Dr Russell Schumann; Environmental Geochemistry International P/L, Dr Stuart Miller

multi-disciplinary

P599B High Concentration Suspension Pumping

Value
\$300,000

Commencement
September 2008

Duration
3 years

Research Director
Matthew Dalziel

Detailed understanding of the flow regimes obtained in P599 and P599A has provided an opportunity to exploit various aspects of high concentration flows to improve existing processes and possible pumping applications. There are five areas in which extension work should be undertaken:-

- > Technology transfer
- > Flow fundamentals
- > Vertical conveying
- > Separation techniques
- > PipeTools development.

As in P599 and P599B, all outputs of the P599B research will be captured in new releases of the PipeTools software.

Sponsors

Shell Canada Limited

Research Providers

CSIRO Materials Science and Engineering; CSIRO Division of Minerals, Dr Jie Wu; Dr Lionel Pullum

P754 Metal Accounting & Reconciliation

Value
\$1,630,248

Commencement
April 2003

Duration
3 years

Research Director
Richard Beck

Corporate governance is increasingly focused on transparency between the technicalities of sampling, assays and reconciliation with financial performance. This project had two objectives; to develop a code and guidelines that meets these objectives and to carry out supporting research. The research has been completed with the awarding seven higher degrees. The Code has been well accepted by Industry. Global promotion is on going through presentations and workshops. AMIRA has been appointed to manage the future of the Code to ensure transparency and global acceptance. An International Steering Committee has also been established. A text book to support the practical understanding and use of the code was published in June 2009 under JKMRC Monographs. Copies are available from the JKMRC and the SAIMM.

Sponsors

Anglo American Corporation of South Africa Ltd; Anglo Platinum (Rustenburg Platinum Mines Ltd); BHP Billiton Limited; Namakwa Sands Ltd; Rio Tinto Limited; Zincor (A division of Exxaro Resources)

Research Providers

Julius Kruttschnitt Mineral Research Centre, Dr Rob Morrison; Mike Wortley Consulting; Neville Randolph Consulting; University of Cape Town, Dr Dave Deglon; University of Stellenbosch, Mr Chris Cutler

P813A Copper Technology Roadmap: Implementation

Value
\$229,597

Commencement
May 2004

Duration
3 years

Research Director
Joe Cucuzza

The objective of this project was to develop a Copper Technology Roadmap. This involved defining and prioritising the long-term technology-related goals and needs for the copper industry within a context of social, economic and market imperatives. The Roadmap was based on a consensus of expert opinion obtained in a collaborative workshop setting. The Roadmap provides a framework and timeline outlining how these challenges and issues should be addressed. The responsibility for implementing the Roadmap recommendations falls on the Copper Technology Working Group, a committee of senior company personnel involved in preparing the Roadmap. AMIRA International is the secretariat to this group.

Sponsors

Anglo American Chile Ltda; Antofagasta Minerals S.A.; BHP Billiton Limited; BHP Billiton Nickel West Ltd; Codelco; Freeport-McMoRan Mining Company; Rio Tinto Limited; Teck Resources Ltd; Vale Australia; Xstrata Copper Chile SA

P843 Geometallurgical Mapping and Mine Modelling

Value
\$6,168,586

Commencement
January 2005

Duration
4.5 years

Research Director
Alan Goode

The GeMill project aims to develop new fundamental approaches to the quantification and integration of geological characterisation with mineral processing performance and mine optimisation. The project was developed in response to industry needs with research designed to support initiatives currently underway within many companies to develop geometallurgical integration. A feature of the project will be site-based research carried out at six mining operations provided by Sponsors. Project modules are:

Module 1: a more effective approach to on-site core and chip logging based on automated multi-sensor logging instruments. Routine software based interpretation of data to define domains either through direct correlation with small-scale testing or use of indirect proxies for both mining (geotechnical) and processing attributes.

Module 2: an integrated microanalytical 'mineral mapping' approach to quantified ore characterisation that will expand current SEM-based techniques (eg MLA and QemSCAN).

Module 3: application of new techniques for 2D–3D textural classification relevant to mineral processing based on statistical simulation of quantified data derived from Modules 1 and 2.

Module 4: development of a methodology to correlate mineralogical and textural simulation with the results of empirical small-scale geotechnical and mineral processing

testing, leading to a fundamental modelling approach that creates new mining and processing attributes.

Module 5: provision of methods to spatially model the distribution of new ore processing attributes into orebody models and integrate this modelling with mine planning optimisation and ore valuation.

Module 6: delivery of formalised geometallurgical awareness, education and training that will help break down existing divides and promote the next generation of multi-skilled mining professionals.

The emphasis is on research that can potentially generate new methodologies, tools and protocols that can be embedded in existing software-based interpretation, visualisation and mine planning packages wherever possible.

Sponsors

Anglo Platinum (Rustenburg Platinum Mines Ltd); AngloGold Ashanti Australia Limited; Barrick Gold of Australia Limited; BHP Billiton Limited; BHP Billiton Nickel West Ltd; Codelco; Vale;

Vale Inco Technical Services Limited; Datamine Australia; Ernest Henry Mining Pty Ltd; Geotek Ltd; Golder Associates Pty Ltd; ioGlobal; Metso Minerals Process Technology; Newcrest Mining Limited; Newmont Exploration Pty Ltd; OZ Minerals; Rio Tinto Limited; Servicios Industriales Penoles SA de CV; Teck Resources Ltd



Research Providers

Centre for Ore Deposit Research, Professor Steve Walters; CSIRO Exploration and Mining; Julius Kruttschnitt Mineral Research Centre; W H Bryan Mining Geology Research Centre

P843A Geometallurgical Mapping and Mine Modelling

Value
\$2,791,590

Commencement
June 2009

Duration
4 years

Research Director
Alan Goode

The initial P843 project made major advances in developing practical methodologies and tools to deliver predictive measures of processing performance. These can be embedded in resource models and exploited in mine planning and optimisation. It delivered a wide range of hardware and software tools with demonstrated potential for routine application. These include lower-cost physical testing devices for comminution, automated core loggers and a range of imaging and microscopy platforms. These are linked to enabling software for specialist textural analysis, multivariate modelling and data integration. The P843A extension project seeks to continue this development with an increasing emphasis on large-scale site-based comparative benchmarking and validation. The research will also extend to new deposit types and processing attributes (early environmental characteristics, blasting and predictive leaching) not covered in the original project (flotation recovery and comminution). A further aim of P843A is to provide technology transfer mechanisms to support sponsors in the implementation of these tools and methods.

Sponsors

AngloGold Ashanti Australia Limited; Barrick Gold Corporation; BHP Billiton Innovation Pty Ltd; Codelco; Metso Minerals (Australia) Limited; Newcrest Mining Limited; OZ Minerals; Technological Resources Pty Ltd (Rio Tinto Limited); Teck Resources Ltd; VALE INCO

Research Providers

Centre for Ore Deposit Research, Professor Steve Walters; Julius Kruttschnitt Mineral Research Centre; Parker CRC for Hydrometallurgy; W H Bryan Mining Geology Research Centre; Centre for Mined Land Rehabilitation

P903A Drilling Technology Roadmap - Implementation

Value
\$81,658

Commencement
March 2008

Duration
3 years

Research Director
Joe Cucuzza

The objective of this project is to implement the recommendations of the Drilling Technology Roadmap. The Roadmap defined the short medium and long-term technology-related needs of the mining companies. The responsibility for the implementation of the Roadmap recommendations falls on the Drilling Technology & Innovation Working Group (DTIWG), a committee of technical personnel involved in the preparation of the Roadmap. The DTIWG will also regularly review the Roadmap and monitor the progress of the project development focussed on the Roadmap priorities. AMIRA international will be the secretariat to this group.

Sponsors

Anglo American plc; Barrick Gold of Australia Limited; BHP Billiton; Codelco; Vale; CSIRO Exploration and Mining; Newmont Mining Corporation; Rio Tinto Limited

P924 Australian Mineral Science Research Institute

Value
\$8,531,600

Commencement
December 2005

Duration
5 years

Research Director
Paul Greenhill

The Australian Mineral Science Research Institute comprises four existing world-class mineral research centres, together with a global network of associates and collaborators. AMSRI will have the capacity to attack the major technical challenges in mineral and coal processing faced by the global mining industry in the next 25 years, and to reverse the declining trend in the production of technical specialists for the industry. Concurrent programs include: Energy Efficient Liberation, Frugal Water Use and Efficient Waste Management, Innovative Processing, Material and Interface Science, Advanced In (and Ex) Situ Analysis and Mathematics in Mineral Processing. Its science will deliver vital sustainability outcomes to mineral producers, and will be a major force for mineral innovation and education.

Sponsors

Anglo Platinum Management Services (Pty) Ltd; Areva; BHP Billiton Limited; Freeport-McMoRan Mining Company; Orica Australia Pty Ltd; Rio Tinto Limited; Xstrata Copper Limited

Research Providers

University of South Australia, Professor John Ralston; Julius Kruttschnitt Mineral Research Centre, Professor Emmy Manlapig; University of Melbourne, Professor Thomas W Healy; University of Newcastle, Professor Graeme J Jameson

Project completed

P931 Reduced Erosion in Multiphase Flow

Value
\$540,000

Commencement
July 2006

Duration
2 years

Research Director
Gray Bailey

A major part of the operating and maintenance cost of modern hydrometallurgy and mineral processing plant is attributed to erosion of equipment from slurry and gas particulate flows. Examples of such erosion occur on mill screens, pumps, pipe elbows, tees, manifolds, valves, fittings, orifice plates, tank walls, tank agitators, high pressure acid leach (HPAL) autoclaves, feed pumps, filter internals, heat exchanger ducts, internals and other multiphase flow equipment. This project provided specific guidelines and generic research information through progress reports on material selection, materials testing, laboratory erosion modelling and fluid flow modelling (both physical and CFD) to reduce equipment erosion and to achieve large maintenance cost savings.

Sponsors

Alcoa World Alumina Australia; BHP Billiton/Worsley Alumina Pty Ltd; Rio Tinto Alcan Ltd; Rio Tinto Limited; Tyco Flow Control Pacific Pty Ltd

Research Providers

CSIRO Minerals (Fluid Engineering) Dr Jie Wu

P961
**Global R&D Capacity
 & Activity Database**

Value
 \$90,000

Commencement
 December 2006

Duration
 5 years

Research Director
 Joe Cucuzza

The aim of the project is to develop a web based database that will enable users to access information on research institutions, academics and R&D activity of interest. The database will be populated with publicly available information on:

- > Research institutions around the globe
- > Academics, research speciality and current research activity
- > Collaborative links with other institutions
- > Public-domain R&D activity
- > Post-graduate activity and projects.

Initially the database will cover research capacity and activity in exploration, mining, mineral processing of interest to the copper industry but will later be expanded to encompass other commodities.

Sponsors

Anglo American Chile Ltda; BHP Billiton Base Metals; Codelco; Vale; Freeport-McMoRan Mining Company; Rio Tinto Limited

Research Providers

AMIRA International Limited, Mr Joe Cucuzza

