ARRC

Australian Resources Research Centre

CSIRO

The University of Western Australia

Curtin University of Technology

2005-06 Annual Report

FOREWORD

The Australian Resources Research Centre (ARRC) plays a vital role in supporting research in our mining and energy sectors and encouraging technological advancement at the State, national and international levels.

The Western Australian mining and energy sectors are powerful factors in our State's economy. Since 2000, the Western Australian economy has grown by 30 per cent, compared to a national growth rate of 17 per cent. In 2005-06 the State's minerals and energy sector set a new record, rising by 29 per cent to reach $43.2 billion of sales. This follows a decade of average annual growth of more than 10 per cent.

This record result was driven by strong overseas demand for our resources and rising commodity prices. The minerals and petroleum sector continues to remain central to the State's economy, accounting for around 30 per cent of Gross State Product, 80 per cent of its export income and around 17 per cent of employment. The latest Australian Bureau of Statistics' Survey of Business Expenditure on Resources and Development shows that the Western Australian industry is leading the nation in expenditure on mining research.

ARRC was initially home to CSIRO Exploration and Mining, CSIRO Petroleum and Curtin University of Technology's Geophysics and Petroleum departments. Opened in November 2001, ARRC is quickly becoming one of the world's leading centres of petroleum and minerals research.

The original objectives of ARRC were to enhance petroleum and mineral exploration and extraction research in Western Australia, and facilitate technology adoption by Western Australia's resource industries. Both of these objectives have been reached and the Centre is now at full capacity. In addition to its original tenants, ARRC now proudly hosts a wealth of exciting researchers. These include four Cooperative Research Centres, five major industry alliances, the National Measurement Institute, BHP Billiton's Perth Technology Centre and the Western Australian Energy Research Alliance (WAERA) Major Research Facility.

The WAERA is one of the principal hubs in Western Australia's oil and gas technology clusters. The three research institutions located within the organisation, CSIRO Petroleum, The University of Western Australia and Curtin University of Technology share knowledge, skills and facilities. The WAERA is fast developing into one of the world's leading oil and gas research institutions through its partnerships with companies and Government.

Since its establishment as a Western Australian major research facility in 2004, WAERA has attracted research contracts in excess of $30 million, validating the State Government's decision to invest in this strategically important research.

Another example of ARRC's ability to encourage collaborative networks is the Interactive Virtual Environments Centre (iVEC), the hub of advanced computing in Western Australia. iVEC's partners - Curtin, Murdoch University, Central TAFE, CSIRO and The University of Western Australia - have worked together to make iVEC one of the leading advanced computing centres in Australia. The State Government has committed $1.95 million per year over the next four years to continue funding iVEC into the next decade. This will ensure that iVEC continues to increase Western Australia's innovative capacity and economic development through the exploitation of advanced computing technology.

I am excited for the future possibilities that ARRC holds. I congratulate all the staff on their dedicated hard work which has ensured that Western Australia continues to be a leader in international mineral and petroleum research excellence.

Alan Carpenter MLA
PREMIER OF WESTERN AUSTRALIA

EXECUTIVE SUMMARY

The last 12 months has been a year of phenomenal economic growth for Western Australia, driven primarily by the resources sector. Retention of the State's competitive advantage is fundamental to this performance. That has been achieved through the application of leading edge technology in our resources industries, supported by an active R&D program. In the last few years ARRC has been at the forefront of the research effort which underpins this competitiveness.

This year ARRC celebrates its fifth birthday. The building has undergone major refurbishment to accommodate BHP Billiton's Perth Technology Centre. In addition, the National Measurement Institute, Western Australia node moved into the Centre bringing with it opportunities for researchers to benefit from technology transfer.

In addition to the inclusion of these entities, there was also the creation of an embedded researcher program. This year saw four scientists working in the Goldfields, facilitating the real time transfer of new technologies and concepts into operational practice.

While much of the work this year has extended and developed existing projects, there have been, as well, several new ventures. The drilling of massive seabed sulfides was our first real look at the potential of undersea mining. With the potential for considerable mineral wealth in Australia's unexplored economic zone, there is the opportunity to develop environmentally sound mining and recovery practices.

The phenomenal gas resource with which the State and its offshore waters are endowed is rapidly becoming the basis of a major LNG industry. Western Australia has the opportunity to capitalise on this by becoming a research hub for the international gas industry. Working with its university partners at WAERA, a growing gas research program at ARRC is a major priority going forward.

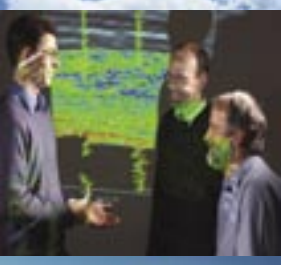
While the work performed over the last year is a credit to the Institution, it is important to recognise the contribution of many of the individuals who feature in this report. Their dedication and their success are fundamental to the intellectual competitiveness of ARRC.

It is an honour to be associated with ARRC, and it is with pleasure that I am able to inform you that 2005-06 has been an outstanding success for this Institution.

CHAIRMAN, ARRC ADVISORY COMMITTEE






LOOKING BACK

Five Years at ARRC

November 2006 marks five years since ARRC was officially opened by the then Premier of Western Australia, the Hon. Geoff Gallop, and nearly 200 research and support staff from CSIRO and Curtin University of Technology came together with the vision of creating a petroleum and minerals centre of expertise for the South-East Asian region.

When the Western Australian State Government agreed to establish ARRC they had some very clear objectives in mind for the organisations who would reside there. These were to: enhance petroleum and mining exploration and extraction R&D in Western Australia; partner and work with industry; respond to changing industry requirements; enable significant activities to be carried out with CRCs; and recruit research staff.

CSIRO's Petroleum Division relocated its head office from Victoria to ARRC in Western Australia, CSIRO's Exploration and Mining Division relocated its existing Perth office to the Centre, and Curtin University of Technology moved its departments of Petroleum Engineering and Exploration Geophysics, as well as its Centre for High Definition Geophysics, to the new ARRC facility. The Cooperative Research Centres for Landscape Environments and Mineral Exploration (CRC LEME) and Predictive Mineral Discovery (pmd*CRC), as part of CSIRO Exploration and Mining activities, also relocated to ARRC.

Five years on, ARRC is full to capacity, housing 443 (273 staff and 170 students) people from the following areas:

CSIRO
- Petroleum
- Exploration and Mining

Curtin University of Technology
- Exploration Geophysics
- Petroleum Engineering
- Centre for High Definition Geophysics
- Curtin Reservoir Geophysics Consortium

Cooperative Research Centres
- Landscape Environments and Mineral Exploration (CRC LEME)
- Predictive Mineral Discovery (pmd*CRC)
- Sustainable Resource Processing (CSRP)
- Greenhouse Gas Technologies (CO2CRC)

Alliances
- Western Australian Energy Research Alliance (WAERA)
- R2D^3 (WAERA + Woodside)
- AES:WA (WAERA + Chevron)
- Interactive Virtual Environment Centre (iVEC)
- AARNET
- Earth Science Western Australia (ESWA)

Other Entities
- BHP Billiton Perth Technology Centre
- National Measurement Institute
- Calcite Technology Pty Ltd
- Genesis Petroleum Technologies

ARRC Highlights 2001 – 2006

The following are some highlights supporting the original objectives of ARRC

Interactive Virtual Environments Centre (iVEC)
The Interactive Virtual Environments Centre (iVEC) was officially opened in May 2002 by the then Premier of Western Australia, the Hon. Geoff Gallop, as a joint venture between CSIRO, Curtin University of Technology, Central TAFE and The University of Western Australia. A member of the Australian Partnership for Advanced Computing (APAC), iVEC is a high performance computing and visualisation centre focussing on the application of advanced computing and high-end visualisation into major industries such as mining and petroleum, medical training and research, architecture and construction, multimedia, education and urban planning.

In 2004 Murdoch University joined the venture's second stage and the Western Australian Government committed funding to support iVEC2, providing $3.25 million over three years. This was matched by iVEC's core participants and APAC.

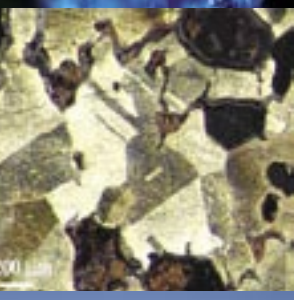
For more information about iVEC, visit **www.ivec.org** and the Major Collaborative Ventures section later in this Annual Report.

The Western Australian Energy Research Alliance (WAERA)
WAERA – an alliance between CSIRO, Curtin University of Technology and The University of Western Australia was established in 2003 to provide innovative, sustainable energy technologies and solutions to the global oil and gas industry.

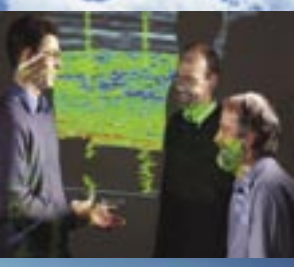
In April 2004, Woodside Energy became WAERA's first major client with the signing of a partnership called R2D^3 ("Research to Discover, Develop and Deploy" energy solutions for a sustainable future). R2D^3 was embraced by Woodside as a way to better direct more than $25 million it expected to spend over five years on oil and gas research. R2D^3's focus is on reservoir characterisation, gas utilisation and specialist training for oil and gas engineers and technicians.

In July 2004, WAERA was announced as the successful bidder for a $20 million grant under the Western Australian Government's Major Research Facilities (MRF) program. In announcing the success, the then Premier of Western Australia, the Hon. Geoff Gallop, said the initiative meant Western Australia would be home to one of the world's leading research hubs for oil, gas and clean energy technologies. He expressed it was a major decision in the context of the future of the State and would add value to the tremendous contribution the oil and gas industry makes to the economic well-being of Western Australia.

In April 2005, Chevron and WAERA entered into a research agreement called the Western Australian Alliance for Advanced Energy Solutions (AES:WA). The alliance provides for the development of multiple research projects in petroleum research, technology development and education and training, with an investment target by Chevron of up to $5 million per annum.






Fluid History Analysis (FHA)
(also reported in the Awards and Recognition section of this report)

CSIRO Petroleum's Fluid History Analysis (FHA) team based at ARRC has developed an innovative suite of techniques that reveal the stepwise fill history of petroleum reservoirs in previously unseen detail, positioning CSIRO as the world-leader in the application of fluid inclusion-based methods for reducing risk when oil companies drill exploration wells. This work was recognised with the award of a CSIRO Medal for Research Achievement – the first such medal for research led by ARRC scientists.

The techniques use samples of oil preserved within mineral grains that are retained when the reservoir fluid changes to gas or water, and are not visible at the well site. They are investigated in the laboratory using microscopy, spectroscopy and geochemistry. This work has enormous significance for the oil and gas industry because the techniques add value to the large datasets used to select drill targets by providing information about oil migration and the stepwise filling of reservoirs.

CSIRO's Fluid History Analysis techniques have been widely adopted by the petroleum exploration industry in offshore regions of Australia and South-East Asia, and are now routinely used in evaluation of petroleum exploration wells. Here is what some industry representatives have said:

"Nearly all the world's major companies exploring for oil in the region now use the fluid history analysis technique, developed by CSIRO, in exploration and field appraisal and development."
- Mr Peter Baillie, Chief Geologist Asia Pacific, TGS-NOPEC Geophysical Company in Perth and formerly Manager, Petroleum Exploration and Production, Western Australian Department of Minerals and Energy.

"CSIRO's fluid history analysis, and particularly the measurement of Grains containing Oil Inclusions (GOI) in sandstone samples from petroleum exploration wells, has provided a vital contribution to understanding fluid flow, reservoir diagenesis and hydrocarbon entrapment history, leading to a significantly better understanding of hydrocarbon prospectivity of a sedimentary basin."
- Mr Grant Ellis, Senior Geologist, ENI Australia Limited.

"Santos are using GOI technology in investigations of the Mutineer and Exeter oil fields, to determine detailed time aspects in the fill history of the reservoirs and to understand fluid continuity as part of production planning for the fields."
- Mr Glenn Scotford, Senior Staff Geologist, Santos Limited.

AusGas and the Australian Gas Centre
Early in 2004, CSIRO Petroleum produced a discussion paper called *AusGas – the energy choice for a low emissions economy*. The paper suggested the formation of a national partnership between industry, government and research institutions to identify and prioritise a common approach to increase the role of gas in achieving the energy objectives of the nation. After highly successful consultation with gas industry participants to outline key R&D objectives, the concept of the 'Australian Gas Centre' was born.

To be based at ARRC, the Australian Gas Centre aims to be the international leader in development and deployment of new high-value technologies through the gas value chain. As a world-leading gas technology hub, it is envisaged the Centre will attract up to 250 additional scientists and industry practitioners with open access to new state-of-the-art facilities including laboratories, pilot-scale equipment and testing facilities. Already strong interest has been received from Australian and international energy companies with one major player expressing interest in becoming a foundation investor.

Government and industry investment will help create the new infrastructure required to make the Australian Gas Centre a reality – the outputs of which will secure many economic, environmental and social benefits for Western Australia. The R&D carried out at the Centre and the technologies produced will not only help Western Australia draw value from its enormous gas reserves, but also enable the generation of safe, secure, clean and cost-competitive energy.

Earth Science Western Australia (ESWA)

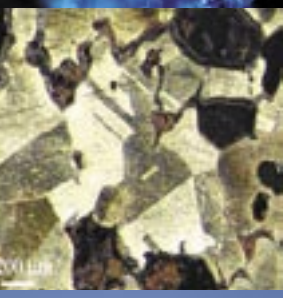
Earth Science Western Australia (ESWA), a consortium representing The University of Western Australia, Curtin University of Technology, CSIRO, the Geological Survey of Western Australia and the Western Australia Museum, was created in May 2005 to:

- raise the profile of geoscience in the State's secondary schools to a level matching the strategic needs of Western Australia, and to increase awareness of the wide range of career opportunities it provides
- facilitate collaborative tertiary geoscience teaching and research
- market Perth and Western Australia as an international centre of excellence in tertiary geoscience teaching, research and training.

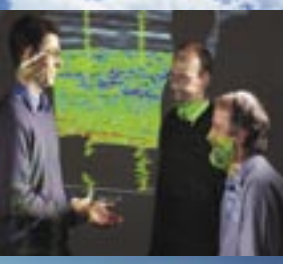
ESWA is based at ARRC and is receiving funding of $220,000 as well as in-kind support from CSIRO over its first three years.

As the world's leading mining and exploration province, the interest and awareness of geology in Western Australian high schools has been at an alarming low in recent years. ESWA has been addressing this downturn by providing support for a new Earth and Environmental Science Course to be implemented in schools in 2007. ESWA enjoys enthusiastic support from the resources industry, professional organisations, the Chamber of Minerals and Energy of Western Australia and the Science Teacher's Association of Western Australia.

ESWA has been providing the support necessary to reinvigorate science teachers to provide engaging lessons in Earth Science. Teachers can access a CD of sequenced learning activities written specifically for the new Earth and Environmental Science Course, and ESWA has also organised subject-specific seminars for teachers and assisted with student field trips. With these and many other activities planned, ESWA hopes to play an important role in creating the next generation of geoscientists to discover and manage Western Australia's mineral and petroleum wealth.





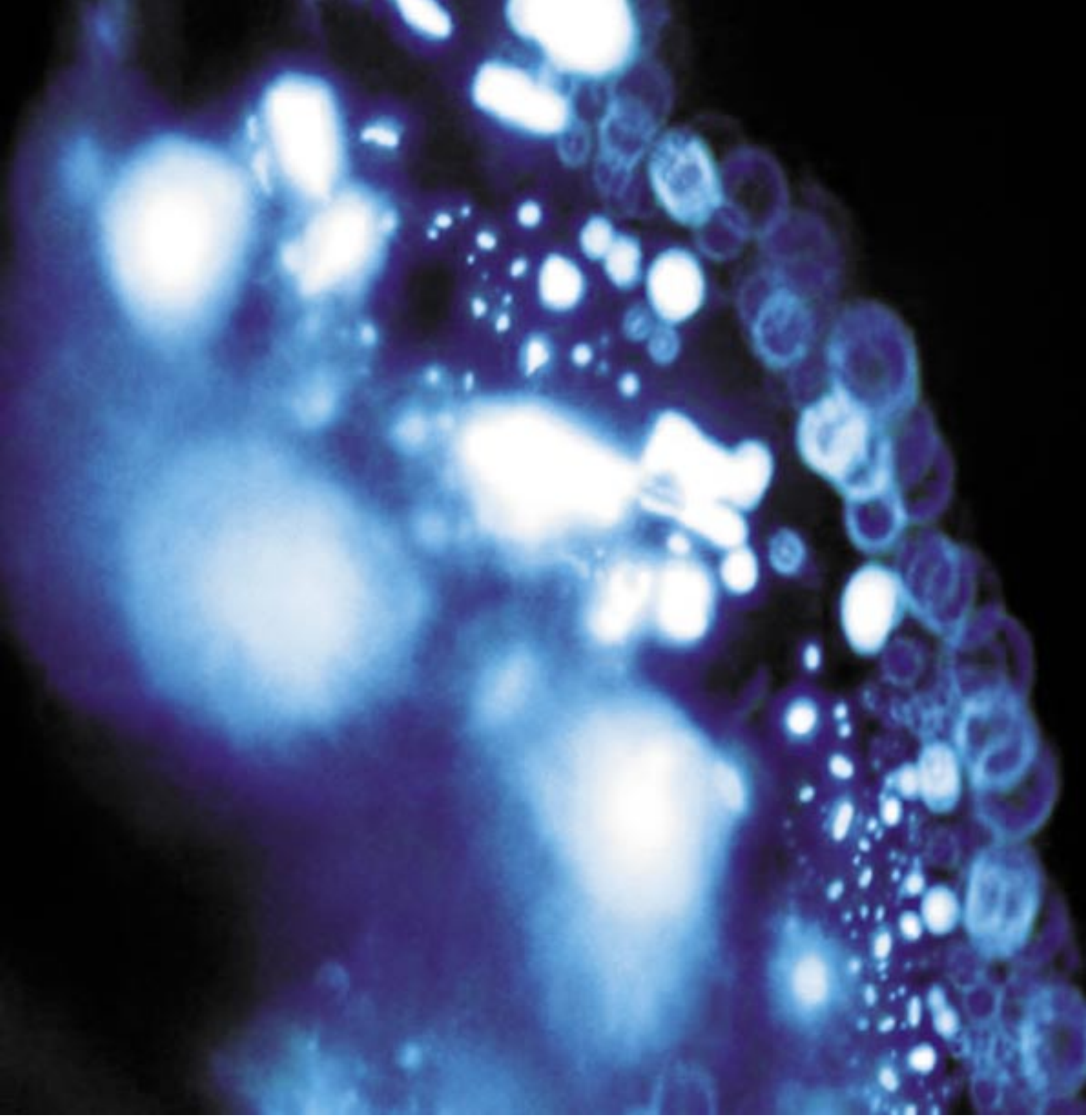

The Creasy Gold Collection

In June 2006 a stunning research collection of gold crystals, nuggets and specimens – showing the many forms gold takes – was unveiled at ARRC. This collection is studied by CSIRO Exploration and Mining researchers to help answer how, where and why gold occurs in different parts of the Australian landscape and in different ore systems.

The Black Smoker Display

The black smoker, or Bikpela (meaning "big fellow" in pidgin), was collected in April 2000 from the PACMANUS hydrothermal field during a CSIRO expedition with the research vessel "Franklin" to the eastern Bismarck Sea, between New Britain and New Ireland, Papua New Guinea. In June 2006 this unique sulfide chimney was mounted for display purposes at ARRC.

CSIRO's work on seafloor sulfides began in 1986, soon after the initial discovery of black smokers in the East Pacific in 1979. In contrast to the East Pacific Rise, where the initial discoveries were made, CSIRO concentrated its investigations on settings that are analogous to ancient ore forming environments. The initial aim of the research was to understand how sulfide deposits form today on the ocean floor, and transfer this knowledge to exploration strategies for finding equivalent ore bodies in ancient geological provinces, such as the 2.7 to 3.0 billion year old Yilgarn Craton of Western Australia.



RESEARCH HIGHLIGHTS

MINERALS AND PETROLEUM EXPLORATION

Computational Geoscience for Predictive Discovery

Increasing impact of numerical modelling to mineral exploration across Australia
2005-06 saw increased engagement with industry and hence further movement towards knowledge and process-driven prediction of ore location. CSIRO Exploration and Mining is developing a quantitative, geological process understanding of ore formation, based on the fundamental physics and chemistry of earth processes. The aim is to provide industry with a tool-kit of predictive concepts and technologies.

Engagement with industry was primarily through the Predictive Mineral Discovery Cooperative Research Centre (pmd*CRC) sponsoring organisations. In addition to the CRC core programs, numerical modellers increased the number of mining companies they worked with from five in 2004-05 to 13, plus two geological surveys. Target commodities expanded from a strong focus on gold to include zinc, lead and uranium.

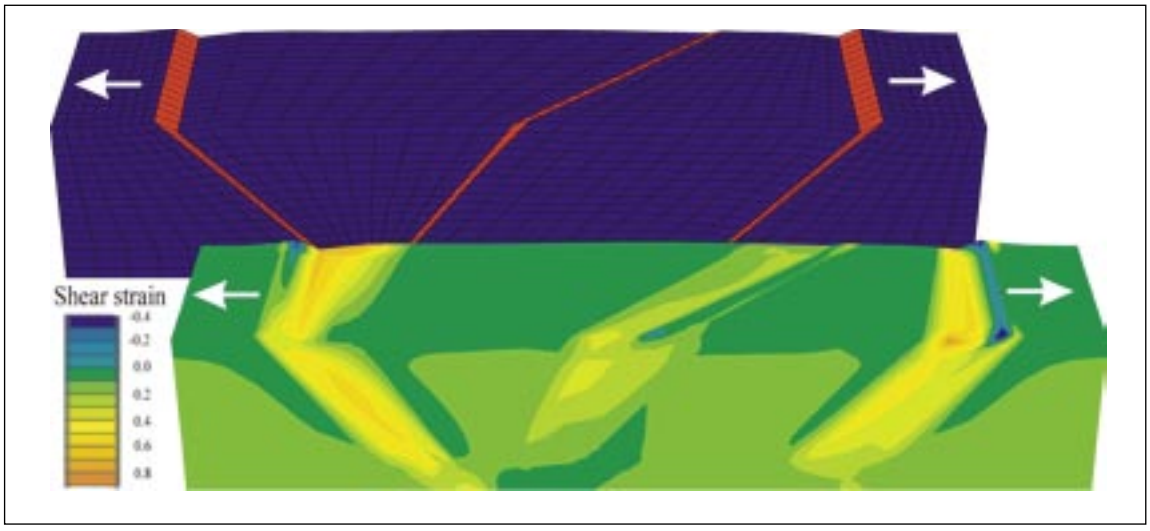
Increasingly sophisticated computational technologies for numerical simulation were central to this project work. Capabilities in interoperability and grid computing resulted in:

1. the Desktop Modelling Toolkit, which now fully supports generation of fluid/thermal simulations

2. the GeoSciML project, which is in the process of developing what will be the global XML standard for geoscience information

3. support for the Water Resources Observation Network (WRON) project (part of CSIRO's Water for a Healthy Country Flagship).

This science is generating great results for CSIRO and directly impacts on Western Australia's mining and exploration industry.



Numerical model of shear strain development in a fault graben.

Premier's Fellow, Klaus Regenauer-Lieb, drives new science agenda in Western Australia

In April 2006 Dr Regenauer-Lieb began a four year fellowship (jointly appointed with The University of Western Australia). His extensive experience as a mathematical geophysicist in geodynamic modelling is being utilised to plan for a more productive and secure future for Western Australia. The aim of the work is to be able to create a comprehensive understanding of the earth's crust across several science and research disciplines. The novel unified approach is essentially based on a computational solution to basic thermodynamics and has been shown to be useful for understanding geodynamics, but its potential goes far beyond this.

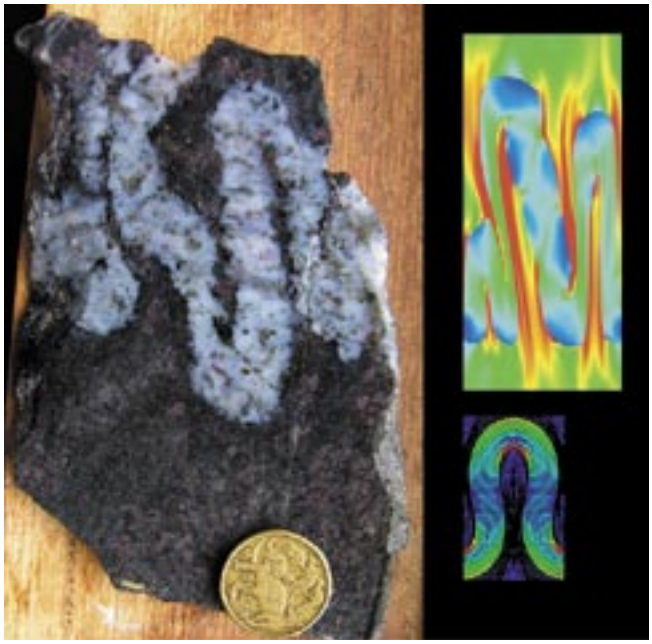
While the immediate focus of research is on mineralisation and resource formation, cross-scale fluid flow and deformation studies could produce profound results in the future. For example, studies could reveal possible solutions to salinity and water production, and the associated environmental and agricultural impact. Dr Regenauer-Lieb has already initiated preliminary discussions with the Western Australian Government to investigate how geodynamic modelling could be used in the development of a geothermal desalination plant.

Other applications could include production and extraction of geothermal energy; CO_2 geosequestration; response of the earth's crust to engineering activity; and the possibility of predicting large-scale catastrophes including earthquakes and tsunamis.

This can be achieved by tying together the three main levels of geological studies: on a microscopic level, the underlying mechanical and chemical interactions within and between the host rock and its fluids; at a medium level, small change in crystalline water content that can impact on large scale geological behaviours such as plate tectonics; and at a very large scale, phenomena such as mantle overturn events that can critically affect smaller scale behaviours such as the location and timing of major metal deposits.

In bringing together all research disciplines to better understand both the opportunities and threats presented by Western Australia's unique geology, it's believed science will provide the bridge between our natural world and positive outcomes for the community.

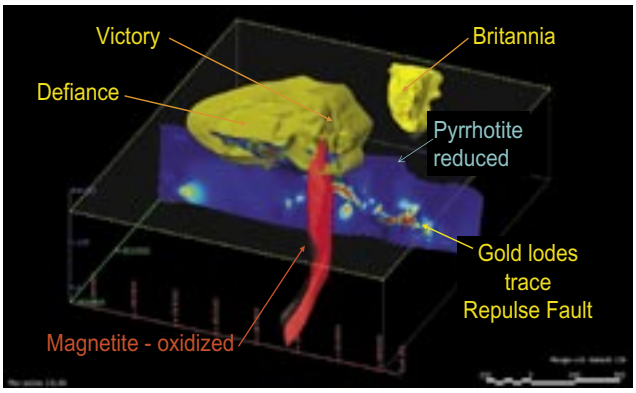
The fellowship held by Dr Regenauer-Lieb will help drive this process and guide its practical application across the State.



The image shows a photo of a deformed natural rock sample. The central light coloured layer was more or less straight before deformation and has been shortened to form a fold. The classical folding theory (right panel bottom) reproduces the general shape of the fold, however, fails to produce thickness variations and irregularities in the fold structure. The right panel shows on the top the first results of the new global "thermodynamic approach" applied to small scales, thus giving a promising new way for understanding and quantifying the emergence of patterns in nature.

Integrated research activities in St Ives Gold Field
Research at St Ives and elsewhere in the Eastern Goldfields of Western Australia (led by Dr John Walshe from CSIRO and Dr Peter Neumayr from The University of Western Australia's Centre for Exploration Targeting), is developing targeting models by integrating architectural, geodynamic and geochemical data from deposit to district scale. 3D models of the architecture and alteration patterns aid identification of pathways (both structural and lithological) for contrasting fluid types, aquitards (structural and lithological), sites of enhanced fluid flow and coincident sites of strong chemical gradients that are favourable for gold deposition. The project which is supported by MERIWA, pmd*CRC, St Ives Gold Mine and Barrick Gold Corporation brings together researchers from CSIRO, The University of Western Australia and Geoscience Australia. The project supports the Embedded Researcher (ER) Initiative (see page 26) that is providing a novel and practical strategy for disseminating new technologies and enhancing skills in the exploration and mining industry.

In 2005-06 Dr Tony Roache, ER at St Ives, has focussed on acquisition of hyper-spectral data using the CSIRO Hychipper with support from CSIRO's Mineral Mapping group. This work is identifying the silicate minerals that aid the mapping of oxidised and reduced fluid flow paths that were active at the time of gold mineralisation. Intersections of such structures are highly favourable exploration targets. The end goal is to provide datasets that will help provide robust exploration targets both near mine and at camp-scale.



St Ives Report

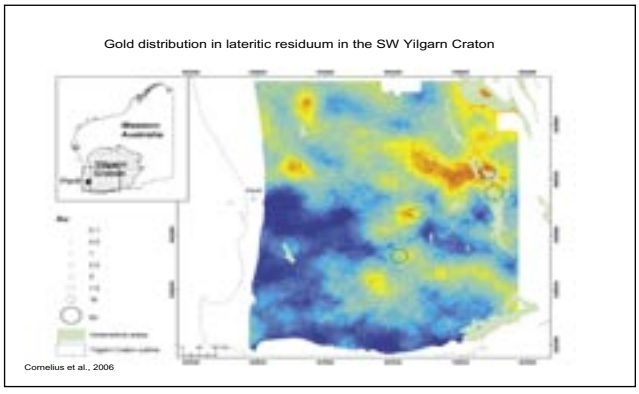
Exploration Through Cover

Laterite Geochemistry Atlas for South-West Yilgarn
The first part of the database from the Cooperative Research Centre for Landscape Environments and Mineral Exploration (CRC LEME) was released in March and offers a host of new data that can be used for mineral exploration and land use management.

The project aims to establish a geochemical atlas for the Western Yilgarn Craton, by multi-element analysis of lateritic residuum, lag derived from lateritic residuum and lateritic detritus found in colluvium. This will provide baseline data which can be used to identify major geochemical trends and provinces, both in residual and depositional terranes that could assist mineral exploration and lead to the discovery of new mineral deposits. To date, approximately 3300 samples have been analysed and results for approximately 2000 samples from the south-west quadrant have been published (Cornelius et al. 2006).

In September 2005 an oral presentation was made at the 22nd International Geochemical Exploration Symposium (IGES) in Perth and several presentations have been made at CRC LEME Mineral Exploration Seminars. An article has also been published in *Mining News*.

The atlas provides a regional geochemical framework at a spacing close enough to recognise regional geochemical trends, major rock types and dispersion halos around significant mineralisation. Data suggests the Western Yilgarn has the potential to host further gold and base metal mineralisation. As a result there has been increased exploration activity in the South-West Yilgarn Craton.



The four-year project which began in 2003 is supported by CSIRO, CRC LEME, GSWA and MERIWA.

Initiation of AMIRA P778 on biochemistry
Australian Mineral Industry Research Association

A core objective within biogeochemical research is to develop new methods for detecting geochemical signatures of undiscovered mineral deposits buried beneath transported cover.

Early indications are that deep-rooted trees in some inland arid environments act as hydraulic pumps of dissolved metals drawn from mineralised regolith and groundwater. This work has raised awareness of a biological process that can create geochemical anomalies in the plant's biomass near the surface, which could become a valuable indicator for mineral explorers.

The new major AMIRA/CSIRO/CRC LEME project commenced in May 2006 and will run for three years. The project team is using innovative approaches to systematically study the potential role of various biological and chemical mechanisms that cause geochemical anomalies in areas of transported overburden in a variety of Australian and Chilean environments. The project represents a new science thrust, involving skills in biogeochemistry, plant physiology, geomicrobiology, geochemistry and regolith geology.

Researchers from Chile will also participate in this project. Its importance is emphasised through sponsorship by most of the major mineral exploration companies in Australia and Chile (Barrick Gold Corporation; BHP Billiton Minerals Exploration; Inco Resources (Australia) Pty Ltd; Independence Group NL; Newmont Australia Limited; SGS Minerals; Teck Cominco Ltd; Cameco Corporation, Rio Tinto Limited; CVRD and Codelco).

It is a significant plank in CSIRO's strategic engagement with the mineral exploration industry through its key role in CRC LEME and is the largest AMIRA co-funded greenfields exploration R&D project since the mid 1990's. This project will significantly ramp up our engagement with industry and AMIRA.

Release of Northern Territory Atlas of Regolith Materials
Cooperative Research Centre for Landscape Environments and Mineral Exploration (CRC LEME)

Understanding the regolith is central to effective mineral and diamond exploration. It also improves our comprehension of landscape evolution, extractive and placer mineral occurrences, groundwater potential, rangeland management and environmental geoscience.

Fieldwork began in 2003 and the Atlas was completed in February 2006. Specimens of regolith, including weathered rocks, sands and soils and their secondary cemented products (silcrete, ferricrete, calcrete) were collected along some 20, 000 km of traversing. These have been merged with specimens collected by CRC LEME in 1998-99 from the Amadeus Basin in the southern part of the Northern Territory.

The regolith materials have been grouped and described according to large-scale regolith terrains and have been split according to their regolith classification. Most of the specimens have been chemically and mineralogically analysed to contrast their compositions, including some important 'stable' elements such as zirconium and titanium.

Soils and sands have been subdivided into coarse outcrop-proximal deposits, alluvium, sandplain deposits, aeolian deposits, calcareous sands and black soils.

The excellent regional and detailed regolith datasets, and the detailed regolith investigation of new sites of this project extends our understanding of the regional regolith-landform framework of the Northern Territory.

The Northern Territory Atlas is now available to exploration companies to assist Australia as a whole to maximise its mineral resources. The accompanying regolith map by Mr M.A. Craig of Geoscience Australia in Canberra, is also being used as a reference guide for similar terrains. Many of the techniques used in creating the map are also being used in other projects.

Hydrogeochemistry for nickel exploration in the Northern Yilgarn Craton project

This project was established in early 2005 to develop reliable regional and smaller-scale hydrogeochemical vectors to nickel sulfide mineralisation in the North-Eastern Yilgarn Craton, particularly the region between Leonora and Wiluna.

It specifically seeks to understand four main hydrogeochemical issues:

- the groundwater expression of nickel sulfide mineralisation
- to evaluate larger scale variation in element concentrations or isotope ratios
- to test different collection, sample treatment and analytical protocols to develop cost-effective recommendations for hydrogeochemical exploration
- to understand groundwater-induced dispersion processes in this environment.

Testing in 2005-06 resulted in 265 groundwater samples being analysed, along a strike length of 300 km for the externally funded project on nickel hydrogeochemistry in the Northern Yilgarn. Another 48 groundwaters were sampled for the Cu:Zn deposit at Jaguar, and five for the nickel sulfide deposit Miitel in the Southern Yilgarn.

Results have more than matched project expectations. So far, a model for the evolution and variation in groundwater chemistry with depth, for sulfide enriched rock and regolith has been formed. In addition, a variety of indices have been developed from the analytical data which are able to distinguish lithological changes, barren and mineralised sulfides. If, as intended, these advances remove the effect of false positives due to barren sulfides and account for varying sampling depth, this will make hydrogeochemistry more effective for regional exploration.

Results from this research may be applicable in similar areas, including areas of Western Australia further to the north, northern South Australia, Northern Territory, north-west New South Wales and south-west Queensland. Further research would be required to develop analogous methods for the acid/saline areas of southern Western Australia and South Australia.

Discovery Technologies

Society of Economic Geologists (SEG) Nickel Volume

A special volume on the nickel deposits of the Yilgarn Craton, edited by Dr Steve Barnes, is currently in press with the Society of Economic Geologists and will appear by the end of 2006 as SEG Special Publication number 13. The volume was originally conceived as the third in the "CSIRO Explores" series, but was subsequently offered as a nearly-complete collection of papers to the SEG, who agreed to publish it. The final version includes two chapters written by Dr Barnes on komatiites and nickel sulfide deposits, as well as chapters written by industry experts on exploration history, the Mt Keith deposit, exploration geochemistry (by CSIRO authors Charles Butt and Ernie Nickel), geophysical signatures and nickel laterite deposits. BHP Billiton have kindly agreed to sponsor the volume to allow inclusion of a number of colour maps and plates.

Nickel AMIRA project and Nick Arndt linkage, including industry workshop

This project, "Controls on platinum group element variation in mafic and ultramafic magmatic systems", has just entered its second year, following a successful sponsor's meeting to review the first year's progress. The principal investigators are Dr Steve Barnes from CSIRO and Dr Marco Fiorentini from The University of Western Australia's Centre for Exploration Targeting.

The main objective of the project is to further understand the magmatic behaviour of the platinum group elements (PGEs) in order to apply PGE lithogeochemistry to exploration for magmatic sulfide deposits.

The main achievements of the first year were:

- compilation of a comprehensive literature database on PGE geochemistry
- engaging two PhD students
- securing a third sponsor IGNL (Independence Group), MERIWA funding and an Australian Research Council Linkage grant to fund collaborative experimental studies by Dr John Mavrogenes at the Australian National University
- collection of new PGE and other geochemical data from two main study areas in the East Yilgarn; Wildara and Mt. Clifford
- topping-up of existing database with new samples from Perseverance and Black Swan.

The new results are placing limits on the applicability of proposed lithogeochemical indicators, and have also indicated strong signals of so far undiscovered sulfide mineralisation at Mt Clifford.

First exploratory drilling for seafloor massive sulfides

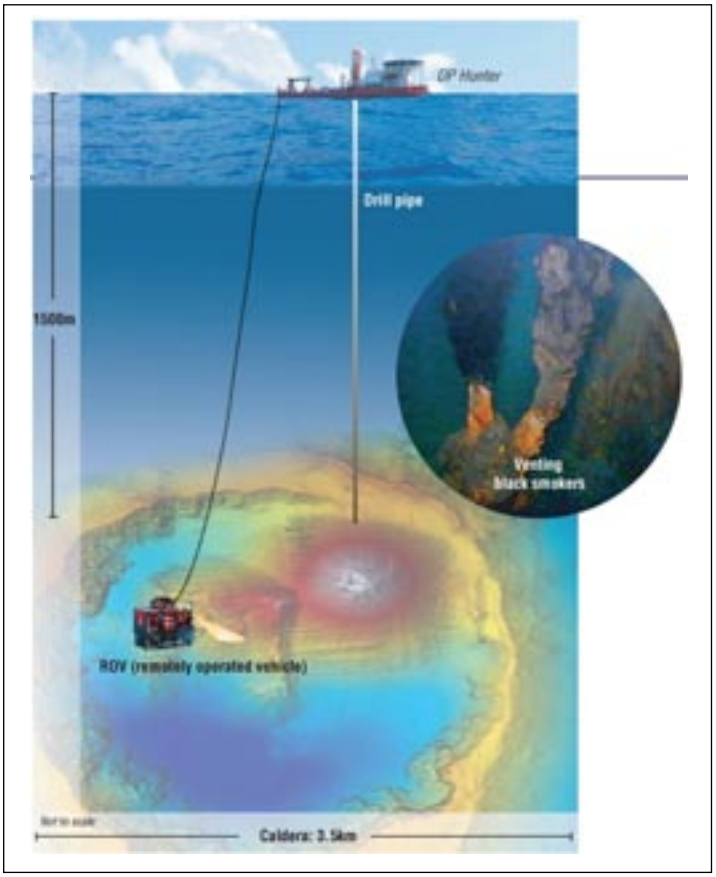
In December 2005, CSIRO Exploration and Mining's Seabed Ore Systems team was contracted to manage the science aspects of the first ever commercial drilling to test seafloor hydrothermal systems for the presence of massive sulfides. The work was undertaken in the Kermadec volcanic arc, within New Zealand's Exclusive Economic Zone and in the exploration licence operated by Neptune Resources (Kermadec) Limited.

The work was inspired by the discovery of "black smoker" sulfide chimneys in the late 1970s. In the 27 years since then, research-led exploration has discovered further sites in virtually all the world's oceans, with CSIRO scientists playing a major role in a number of discoveries in the south west Pacific.

Not surprisingly, black smokers and their associated massive sulfide deposits have attracted commercial attention from the minerals industry due to their high concentrations of base and precious metals. However, 2005 became a watershed year for commercial activity thanks to a number of factors including the technological advances in deep water exploration in the oil and gas industry. Although this inaugural commercial drilling program did not define commercial quantities of sulfide mineralisation, it did confirm that:

1. drilling and core recovery is possible in water depths of 1210 to 1680 m on slopes exceeding 15°
2. high resolution deep tow swathe bathymetry is an effective tool in the direct detection of sulfide chimney fields
3. technologies developed for deep water oil and gas and cable laying industries are suited to seafloor sulfide exploration.

A major technological highlight of the expedition was the effectiveness of Remotely Operated Vehicles acting as the eyes of geologists on the seabed. Post expedition work comprised compilation of a geological map, petrological, petrophysical and metallurgical studies, chemical analysis of drill core and spectral reflectance studies of drill core using CSIRO HyLogger™.



KO5 Survey

Development of a direct dating method for gold
The aim of the project is to develop the first capability to directly date gold using only milligrams of sample.

The mining industry will use this technology in an exploration context. Secondary gold deposits occur in the thick layer of weathered rock covering much of Western Australia. Uplift and erosion has dissolved some of the original "parent" gold and redistributed it into secondary accumulations of "supergene gold". Knowing the age of formation of supergene gold may provide information that will enable explorationists to trace the gold back to its original source region.

During 2005-06 the team successfully tested helium extraction protocols for (U-Th)/He analysis of gold nuggets from the Creasy Collection. They also successfully tested the gold dissolution procedures for uranium and thorium analysis.

The team has determined that helium is not contained in fluid inclusions hosted within the gold, but is likely located in the lattice. They have only detected radiogenic helium (4He) in the nuggets, implying that there is no evidence of a 3He signature indicative of deep mantle degassing.

While a number of samples have been analysed, work is continuing to refine techniques for He, U and Th determination. Early results suggest that gold thermochronology is feasible, but reproducibility of data for a single sample is required before the ages obtained can be interpreted in a geological context.

Petroleum Geochemistry

Hydrocarbon sensors
Start-up project on developing new sensing technology

In 2005-06 a multi-institution project was initiated to investigate new sensor technology for sensing hydrocarbons in the marine environment.

Those involved include CSIRO Petroleum, CSIRO Industrial Physics, the Wealth from Oceans National Research Flagship and Curtin University of Technology.

The research objectives include:

- Developing new enabling technology in the form of small, inexpensive, robust nano-chemical sensors capable of detecting, fingerprinting and measuring large numbers of specific hydrocarbon compounds and ionic species, in real-time, in the marine environment.

- Developing integrated chemical sensor, communications and data recording units with capacity to work autonomously or be a 'plug and play' component of an integrated multi-component agent networked system. This combined technology will be able to be commercialised, with numerous applications within the hydrocarbon and other industries.

- Developing a multi-component system capable of detecting hydrocarbon seepage using a combination of current sensing technologies and technology developed during the course of this project.

In the past year, the project has grown substantially with the recruitment of three new post doctorates and refurbishment of a laboratory at ARRC. The preliminary results from the project to date have been very encouraging with the test sensor platforms performing better than anticipated in laboratory tests.

Quantitative Grain Fluorescence
During 2005-06 the Quantitative Grain Fluorescence (QGF) and QGF on extracts (QGF-E) techniques have been commercialised in China through the licensing to China University of Petroleum. The techniques have been applied in a number of oil fields operated by PetroChina and China National Offshore Oil Corporation (CNOOC) to address various charge history issues.

A Memorandum of Understanding for transferring the technique to China PetroChemical Company (SINOPEC) has been signed.

QGF and QGF-E are patented technologies of the fluid history analysis group at CSIRO and specifically focus on detecting current and palaeo residual oils in reservoirs, which is critical information for petroleum exploration and development.

The techniques are already used extensively by industry in conjunction with a range of other methods in Australia and South-East Asia, helping identify where hydrocarbons originate from and where they might be located. This has proven to save time and money in oil exploration.

QGF and QGF-E techniques provide a rapid turn around time, are cost effective and provide both current day and palaeo oil saturation information during a single analytical procedure. Other fluid history analysis techniques may only detect palaeo oil saturation.

SINOPEC will use QGF and QGF-E extensively in petroleum exploration in Eastern and Southern China, particularly in exploring Palaeozoic carbonate reservoirs and shallow burial, young clastic reservoirs, where fluid inclusions are often poorly developed.

The uptake of the QGF technology by SINOPEC and the adoption of the technology by PetroChina and CNOOC through the China University of Petroleum marks a significant recognition of CSIRO technology by major national companies and is expected to draw the attention of other major international companies.

PETROLEUM RESERVOIR DEFINITION AND PERFORMANCE

Reservoir Characterisation

ARRC Petrophysics Laboratory
The ARRC Petrophysics Laboratory has continued to provide high quality rock characterisation services in support of numerous research projects in the CSIRO Petroleum portfolio, and has also been instrumental to the success of small and large consultancy projects to a range of clients:

- X-ray Computed Tomography scanning, dielectric spectroscopy and Nuclear Magnetic Resonance (NMR) measurements of shales for the Integrated Predictive Evaluation of Traps and Seals (IPETS) project. This work has been commended by sponsors and won a Best Paper Award at the Society of Petrophysics and Well Log Analysts symposium in Veracruz, Mexico, June 2006.
- NMR studies of reservoir quality in hydrocarbon fields for local and overseas clients. These studies have helped to define pay intervals and identify the value of assets and type of recovery system to be employed.
- Porosity and permeability measurements of outcrop samples from the Perth Basin for The Western Australian Department of Industry and Resources.
- X-ray imaging of fault rocks from the Turbidite Research Initiative (TURI) study area in New Zealand for the Digital Core Project.
- Determination of electrical, dielectric, NMR and poroperm properties of synthetic rock samples for the Digital Core Project.
- X-ray imaging for numerous rock mechanics projects, both for research and consulting to major companies such as Woodside and Chevron. These studies have impacted on major investment decisions on the North West Shelf assets, e.g. optimised drilling trajectory and completion method.
- Downhole log analysis for the multiclient IPETS project, and in support of rock physics projects for Woodside.

Oil and gas fields workflow
This year there has been a significant contribution to the suite of techniques used for probabilistic reservoir characterisation using seismic data.

CSIRO has already had success with existing tools such as Delivery which is an open-source, trace-based Bayesian seismic inversion code for use in oil reservoir characterisation at the early development and appraisal stage. Wavelet extractor is a welltie and wavelet extraction program bundled with Delivery.

This year the DeliveryMassager code was added. It is a tool for moving the stochastic inversion results coming out of Delivery over to the cornerpoint grids (Eclipse-style) typically used in geomodelling packages. The code can integrate inter-layer and inter-property correlation structures induced by the seismic data with transverse correlation requirements coming from geological knowledge and hard well data from logs.

It is being used by BHP Billiton for a number of fields off Western Australia. This tool integrates the whole range of seismic information into the reservoir modelling and risking process - in particular the uncertainty information and resolution considerations that could not be taken into account using traditional methods now explicitly inform the risking process. More accurate knowledge of the range of possible outcomes from imperfect knowledge or limited resolution measurements improve decision making, investment strategy, and ultimate profitability.

Geophysics

Rock physics
This research project continues to contribute at an international level through theoretical developments in predicting seismic attenuation and dispersion in complex reservoir rocks. It provides insights into seismic characteristics in poroelastic structures, effects of micro-heterogeneity on effective stress coefficients and hence the dynamic properties of the rock.

This fundamental research provided the basis for numerous journal papers published this year and is fuelled by talented doctoral and post doctoral researchers in a team developed by Professor Boris Gurevich, joint professorial appointee of CSIRO and Curtin University of Technology. The experimental aspects of this research, led by Dr David Dewhurst, have continued through the evaluation of the elastic response of shales and sandstones in a number of research contracts commissioned by international research groups from Chevron, BP and ConocoPhillips.

A project commissioned through WAERA with Woodside developed a methodology for simultaneous prediction of porosity and shale content from acoustic impedance data volumes for known and unknown fluid saturations. The methodology has been incorporated into a rock physics software and established proof of concept with excellent results. A further pilot study has been initiated and then a deployment pathway to asset workflows will be established.

Chevron, through AES:WA and WAERA, has assessed CSIRO's rock physics expertise as world-leading and a range of projects have been developed for advanced evaluation of anisotropy in various rock types, elastic fracture evaluation and participation in development of dielectric measurements. These and several other projects form the basis of a close collaboration which is evolving into the future. As testament to this relationship, Dr Don Sherlock was seconded to work within the quantitative seismic group at the Energy Technology Company of Chevron in San Ramon, California, for one year.

Electromagnetic technology
The electromagnetic expertise of both CSIRO and Curtin University of Technology has continued to develop an understanding of the rapidly developing petroleum technology of marine Controlled Source Electromagnetics (CSEM). A focussed research project was completed on the evaluation and quality control of CSEM data from West Africa for Hardman Resources. Additionally a one day industry workshop was organised with 50 industry delegates through the Australian Society of Exploration Geophysicists (ASEG). The proceedings have been made available through a CD recording.

DRILLING AND WELL PERFORMANCE

Platform Free Fields

Now in its second year, CSIRO's Platform Free Fields (PF^2) project is continuing to grow. PF^2 works on the development of technologies to extract remote offshore gas economically, without the use of traditional production platforms.

These new sea-bed based technologies, such as subsea separation, flow assurance processes and monitoring systems, will deliver transformational benefits to Australia's oil and gas industry. If the processing of hydrocarbons and other associated fluids could be made totally subsea and down-hole, then platforms and surface facilities could become structures of the past. The cost of the platforms currently absorbs about a third of production costs over the life of a field, and the availability of this sea-bed technology would bring up to a 75 per cent reduction in capital investment for the development of an offshore gas field.

During 2005-06 a major collaboration with Institut Francaise du Petrole (IFP) was formed for the study of hydrates transportability in gas dominated flows in subsea pipelines. There has also been a substantial achievement in the initial conceptual design of a very compact water-gas separation system for high gas flow rates (200-300 MMscf/day) and relatively low water fractions (up to 8 per cent).

Integrated wellbore instability software

CSIRO continued to develop state-of-the-art software that can be used for the evaluation of wellbore instability and drilling fluid design by integrating a range of independently-developed, stand-alone software packages.

This new integrated software is aimed at providing drilling engineers, who may have limited specialist knowledge in the areas of geomechanics and drilling fluid design, with a tool to address potentially costly wellbore instability problems encountered while drilling oil and gas wells.

The Driller's Wellbore Stability Tool (DWST) has been applied to solve a number of wellbore instability problems, of high angle and extended reach wells, in both local and overseas fields. It has also provided input data for modelling wellbore instability during production.

During the 2005-06 year alone, the tool was used to assist major international companies in solving wellbore instability problems in Australia and other South-East Asian countries.

Several successful commercial studies, including lab tests, Driller's Wellbore Stability Tool (DWST) simulations and expert analysis were performed for a range of clients for different application scenarios. These included wellbore stability while drilling, sand production, stability of hydrates-bearing sediments, effect of CO_2 concentration in the stability of reservoir rocks and diffusivity of CO_2 through shales.

Near wellbore characterisation tool
The optimisation of a well's performance during its life cycle demands improved understanding of processes occurring in the reservoir, near-wellbore and inside the well and flow lines. With this purpose, the industry has been conducting, for several years, initiatives towards reservoir-wellbore coupled simulations.

CSIRO has developed a system to couple the near-wellbore reservoir and the wellbore hydraulics models, which contributes to the optimisation of well completion design (before and while drilling the well) and the maximisation of the well inflow performance during production phases, with support of real-time and historical data. The ultimate goal is the development of an adaptive (self-learning) system capable of integrated, real-time analysis, decision support and control of the wells to maximise productivity and recovery factors at reservoir/field level.

At the current stage, the system simulates the inflow performance based on an iterative algorithm that links a reservoir simulator to a hydraulics simulator that describes the flow inside the wellbore. The link between both simulators is based on equalisation of flow rates and pressures so that a hydraulic balance solution of well inflow is obtained.

This approach allows for full simulation of the reservoir, taking into consideration the petrophysical and reservoir properties, which is then matched with the full pressure profile along the wellbore.

In 2005-06 the tool and process were successfully applied in the design optimisation of a horizontal well for an Australian field in terms of placement of inflow control devices (ICVs). There was approximately $1 million worth of savings in completions equipment because of reduction of the number of ICVs required in the optimised design. It also maximised oil production and improved recovery factors (estimated increase of 2 per cent in the recovered volume).

ENVIRONMENT AND GAS

MERIWA environmental monitoring project
The development of a hyperspectral environmental measurement tool for monitoring mining related infrastructure and rehabilitation.

The MERIWA M375 collaborative research project between CSIRO Exploration and Mining, BHP Billiton Iron Ore (BHPBIO), Ravensthorpe Nickel, Worsley Alumina, Alcoa and the Western Australian Department of Environment and Conservation (DoEC) began in April 2006 and will operate for 18 months. It aims to develop and validate measurements of critical environmental parameters from airborne hyperspectral imagery and demonstrate their value for "best practice" environmental monitoring in the minerals industry of Western Australia. The research is focussed on a variety of mineral commodity types and environmental conditions important to Western Australia, including iron ore in the Pilbara, alumina in the south west jarrah forests and lateritic nickel on the southern coastline.

Specific objectives include:
- extend dust monitoring methods developed in Port Hedland, which successfully demonstrate the capabilities of hyperspectral technologies to fulfill this role, to include bauxite and lateritic nickel-derived dust
- complete the development of an operational iron-derived dust monitoring system, building on previous research in Port Hedland
- investigate the ability to derive parameters related to rehabilitation progress using hyperspectral remotely sensed imagery in a range of Western Australian mining environments
- develop/test methods for multi-temporal visualisation, monitoring, modelling and prediction of these hyperspectral environmental products
- development of a series of case histories of mine site operations for monitoring of iron ore, bauxite and lateritic nickel
- establishment of hyperspectral environmental product standards for potential legislative requirements

- drafting, promotion and initiation of guidelines for the use of hyperspectral technology as "best practice" procedures, together with legislative bodies such as DoEC (Department of Environment and Conservation), Environmental Protection Authority and Department of Industry and Resources.

Ideally, this project will help establish the basis for using hyperspectral sensing as a standard quantitative mapping and monitoring tool by the resource industry and regulators for performance monitoring, the appraisal of environmental impact and assessing the obtainment of closure criteria targets.

It is intended to use the results of this work for technology transfer and embedded scientists at BHPBIO and DoEC will conduct more analysis as more data becomes available.

Vegetable dielectric fluid
During the previous reporting period (2004-05), a CSIRO-led research team finalised the development of a vegetable oil based fluid for use in power and electricity distribution transformers. In 2005-06 a bulk oil processing facility was established at an industry partner's location and pilot scale processing has been carried out successfully. Field tests are scheduled to begin in the near future. A full patent has now been filed for the new dielectric fluid, which could replace the estimated 40 billion litres of toxic mineral oil which is currently used in transformers across the world. Using it would improve the safety of power and distribution transformers, the occupational health and safety of power workers and protect habitats around electricity facilities.

CO_2 sequestration
Significant progress has been made this year in developing the monitoring and verification contributions to the Otway Basin Pilot Project initiated by the CO2CRC. The program now incorporates atmospheric measurement techniques provided by CSIRO Marine and Atmospheric Research, geochemical tracers for migration mapping and hydrodynamic monitoring from research at ARRC, and geophysical characterisation through the combined resources of Curtin University of Technology and CSIRO Petroleum. Central to this is the design and fabrication of a downhole system that provides the means to acquire seismic monitoring and geochemical sampling simultaneously throughout the injection process. Development of the program has been accompanied by collaborative participation in the Frio Brine project in Texas, and project development with Lawrence Berkeley Laboratories from San Francisco California. The program has also been seen as world leading through presentation in a number of Carbon and Greenhouse Gas Technology conferences in Saudi Arabia, Norway and the US. Kevin Dodds has been charged with coordinating the third International Energy Agency (IEA) Monitoring and Verification Network meeting in Melbourne in November 2006, which will attract 50 international delegates and will be run with an integrated regulators meeting from Australian Federal and State Governments.

Gas Processing

New catalytic gas turbine
The CSIRO developed Catalytic Gas Turbine for the partial oxidation of natural gas to syngas (synthetic gas – a mixture of CO and H_2) is currently being patented and awaits field trials. The new system involves placing the catalyst on the blades of a turbine. This new gas turbine uses the energy from the reaction, as well as simultaneously processing the gas. This novel system improves the economic performance of gas processing, through the concurrent generation of electricity. Being able to condense plant equipment, by using new syngas production techniques, will enable exploitation of what are now considered to be non-commercial gas fields.

Methane pyrolysis
The gas processing team has designed and commissioned a high-temperature methane pyrolysis test-rig to investigate direct conversion of natural gas to larger hydrocarbons. These products will be suitable for direct use as transport fuels, further processing to gasoline or use as fuel additives. Preliminary work has shown very high throughput, and high temperature conditions are capable of yielding the desired products. Optimisation of the process is currently underway with the aim to minimise carbon formation at the same time as maximising the yield of larger hydrocarbons. The test-rig and analytical equipment, located at Clayton, have met all safety and operability requirements.

This method of natural gas conversion is likely to give smaller plant footprints, consequently lowering plant costs and allowing the commercialisation of stranded Australian gas reserves, most of which are located in north-west Western Australia. The methane pyrolysis project is being funded jointly through the WAERA partnership and CSIRO.

Milestones:

- design, construction and commissioning of pyrolysis test-rig
- use of novel induction heating to drive pyrolysis reaction giving promising preliminary results.

Acetylene processing

Conversion of the products of methane pyrolysis to gasoline and fuel additives is also being investigated by the gas processing team. This is the follow-on step from methane pyrolysis and is necessary for the Gas to Liquids (GTL) transformation producing gasoline and octane improvers. It is anticipated that the methane pyrolysis/acetylene processing GTL route will enable substantial quantities of gasoline to be produced from natural gas, giving an alternative to the crude oil production route.

Milestone:

- Identification of a catalyst that gives good yields of gasoline and diesel range products in methanol/acetylene systems. The catalyst also shows no loss in performance over 100 hours testing.

Work on both of these steps will concentrate on defining process conditions for optimal product yields. An understanding of what happens on the molecular scale is also important as it will assist in achieving the aim of maximising product yields.

MAJOR COLLABORATIVE VENTURES

John de Laeter Centre for Mass Spectrometry (JdLCMS)
In May 2005, the Western Australian State Government announced its intention to support stage two of the John de Laeter Centre for Mass Spectrometry (JdLCMS) by providing $2.06 million over five years from the West Australian Centre of Excellence scheme.

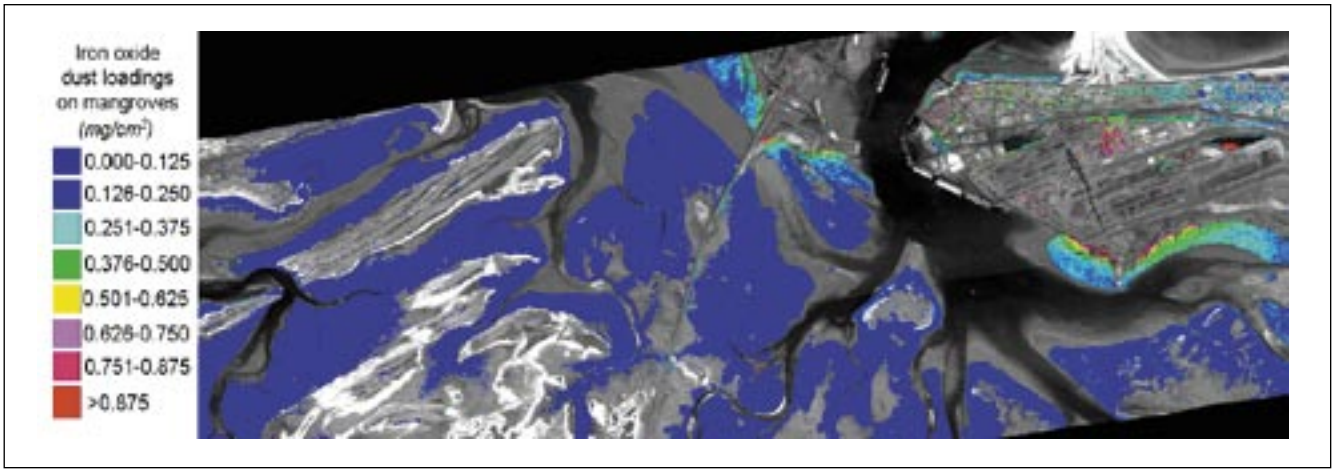
The funds will be used to support the acquisition of state-of-the-art technology, techniques and methods useful for the geochemical characterisation of rocks, fluids and minerals. The JdLCMS, established in 1999, is a joint venture between Curtin University of Technology, The University of Western Australia, CSIRO and the Geological Survey of Western Australia (GSWA). The JdLCMS applies high precision and high spatial resolution capabilities in radiogenic isotope, stable isotope and elemental abundance mass spectrometry, to wide ranging research. It is particularly useful in the areas of mineral and energy resources, the environment and fundamental science.

The Centre consists of seven geochemistry research nodes:

1. SIMS/SHRIMP Lab primarily used for U-Th-Pb geochronology
2. Argon Noble Gas Lab primarily used for K-Ar and Ar-Ar geochronology
3. Helium Noble Gas Lab primarily used for U-Th-He thermochronology
4. TIMS/Advanced Ultraclean Lab primarily used for studying metals in the environment
5. LA-ICP-MS Lab primarily used for mineral trace element analysis and forensics research
6. Organic Geochemistry Lab primarily used for biomarker research
7. Stable Isotope MS Lab primarily used for inorganic geochemistry studies

The JdLCMS is actively engaged with the international geoscience community and has close collaboration with industry. In August 2005, Woodside Executives Peter Moore (Exploration Manager) and Andrew Murray (Chief Geochemist) toured the JdLCMS and discussed opportunities for petroleum research. In October 2005 Dr Djadjang Sukarna, the Director of the Geological Survey of Indonesia, visited the JdLCMS to investigate opportunities for collaboration. It lead to an agreement to purchase a CSIRO Alphachron™ U-Th-He thermochronology instrument.

In June 2006 the JdLCMS announced the appointment of Stanford Professor Michael McWilliams as its new Director after an intensive international search. With a leadership style that has been described as motivating and inclusive, Professor McWilliams has the capacity to build an integrated research capability across the nodes of the Centre. He will join the Centre full-time in October 2006. Full details of the JdLCMS can be found at **www.curtin.edu.au/curtin/centre/cems/introduction.html**



A remote sensing image reveals the health of mangroves in Port Hedland

The Western Australian Energy Research Alliance

In 2005-06 the Western Australian Energy Research Alliance (WAERA) forward-committed $9.5 million of the Western Australian Government's major research facility grant funding to enhance research capability via recruitments into CSIRO, Curtin University of Technology and The University of Western Australia. Recruitment is proceeding slowly in a very competitive market, but by the end of June 2006 substantial progress had been made, with over half of the successful appointments being filled by researchers recruited internationally.

In June 2006, WAERA's Board appointed Dr Ian Finnie to the role of Chief Executive, and Professor Mark Trebble as the Gas Technologies Research Program Leader.

R&D initiatives conducted under the umbrellas of WAERA's two strategic industry partnerships – the AES: WA alliance with Chevron and the R2D^3 alliance with Woodside – continued to evolve to meet the specific needs of both companies. In 2006 a particular highlight of WAERA's stimulation of cross-company collaboration resulted in joint Chevron-Woodside agreements to fund two new professorships – in Corrosion Science at Curtin University of Technology and in Geoscience at The University of Western Australia.

iVEC

The hub of advanced computing in Western Australia

iVEC is a joint venture between Central TAFE, CSIRO, Curtin University of Technology, Murdoch University and The University of Western Australia. It facilitates the use of high performance computing and visualisation in Western Australian research.

Both the iVEC facilities and the expertise provided by iVEC staff are being used in nanotechnology, radioastronomy, high energy physics, medical and mining training, medical research, mining and petroleum, architecture and construction, multimedia and urban planning.

In 2005-06, there has been a strong focus on bringing the new high performance computing resources online and integrating them with the APAC (Australian Partnership for Advanced Computing) National Grid, which allows seamless access to supercomputers around Australia.

At the ARRC node, the 160 processor SGI Altix has been available to users since late October 2005. It has been running at around 90 per cent usage since May 2006 but will be utilised at almost full capacity over the next year.

The WASP node has been relocated to the Physics building at The University of Western Australia. This has involved the extensive remodelling and refurbishing of the ground floor to house the 164 processor Cray XT3 system and its associated 32 TB of high speed disk storage, as well as a dedicated Access Grid room and a state-of-the-art visualisation laboratory. The XT3 was installed in its new home in late June 2006 and will be fully operational by December 2006.

The Industry Uptake Program completed its first year of operation and has engaged with industry on several levels. Almost 50 seminars, receptions, demonstrations and talks have been held to promote iVEC's facilities and capabilities to Government agencies and industry.

Three projects were awarded iVEC Industry Uptake Grants totalling $100,000 in June 2006. This brought the tally of projects with industry over the last year to 13.

Finally, in May 2006, the Treasurer Eric Ripper announced that the State Government had set aside $1.95 million per year over the next four years to continue funding iVEC into the next decade. This large investment will ensure that iVEC remains one of the leading advanced computing centres in the nation, increasing Western Australia's innovative capacity and economic development through the exploitation of advanced computing technology.

Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC)
The CO2CRC researches the logistical, technical, financial and environmental issues of storing industrial carbon dioxide emissions in deep geological formations. The CRC also researches the capture and separation of carbon dioxide from industrial systems.

Developed from the original Australian Petroleum CRC (APCRC), the CO2CRC is directly contributing to the Government's objective of decreasing greenhouse gas emissions and maintaining Australia's economic growth.

Areas of research expertise include petroleum geology and geophysics, organic geochemistry and petrography, isotope and chemical stratigraphy, basin analysis, reservoir characterisation and simulation, numerical modelling, reservoir physics, rock mechanics, drilling and wellbore engineering, evaluation and simulation of low-permeability reservoirs.

Cooperative Research Centre for Predictive Mineral Discovery (pmd*CRC)
The aim of the pmd*CRC is to generate a fundamental shift in exploration practice and cost-effectiveness by developing a vastly improved understanding of mineralising processes and a four-dimensional understanding of the evolution of the geology of mineralised terrains.

The extremely buoyant climate in the industry over the past year has meant a steady increase of one-on-one projects with individual industry clients from both the sponsor group and external companies. These projects have covered a spectrum from data acquisition in the case of a new seismic transect in Victoria, 3D mapping and model building in New South Wales and a range of numerical modelling and simulation projects throughout Australia.

Major terrain projects are on track with the research effort during the past year focussed on consolidation and research integration. Also technology development for mineral system process simulation has made excellent progress and has placed the CRC in a strong position to pursue opportunities for commercialisation of technology based IP.

The CRC has continued to put substantial effort into a range of delivery mechanisms to ensure that a wide variety of opportunities are provided for uptake of the new science and also the technology developments.

Cooperative Research Centre for Landscape Environments and Mineral Exploration (CRC LEME)
CRC LEME is the Cooperative Research Centre for regolith geoscience, a joint venture between eight government, university and industry participants including CSIRO's Exploration and Mining and Land and Water Divisions and Curtin University of Technology.

The Centre has more than 130 contributing researchers from around Australia who generate and apply regolith knowledge for mineral exploration and environmental management. CEO, Dr Steve Rogers, is based at the Head Office located at ARRC.

During the year, the Centre made significant breakthroughs in its research programs. Highlights include an acidic drainage study that discovered uranium anomalies in the Western Australian Wheatbelt which led to a new research partnership with mineral exploration company Mindax Ltd to further investigate the anomalies' origin.

Spinifex sampling over the Coyote Gold Deposit in the Tanami Desert of Western Australia has shown the plant has potential to become a new geochemical sampling medium following the detection of anomalous gold in its leaves.

Through Curtin University's Geophysics Department, CRC LEME will soon embark on a major geophysical work program over 1,000 km^2 of land north of Perth during the next three years for the Water Corporation of Western Australia, following a successful Ground Penetrating Radar Trial over the Gnangara Water Mound.

Turbidite Research Initiative (TURI)
Turbidite reservoirs have become increasingly important to both the global and Australian oil industry with technological advances opening up deep-water environments to exploration and production.

TURI is a three year multi-disciplinary research program to investigate and characterise the controls on hydraulic connectivity and conductivity in faulted deep-water turbidites. The study is based on the analysis and in-situ testing of a world-class turbidite reservoir analogue exposed on the west coast of New Zealand's North Island. The results of the TURI project will be used to help devise strategies to optimise the recovery of hydrocarbons from complex reservoirs of this kind.

The first year of the project has already provided a wealth of new data, with the completion of several key milestones including sedimentary and structural outcrop studies, and behind outcrop Ground Penetrating Radar and 2D seismic surveys. The project is part of CSIRO's Wealth from Oceans Flagship and enjoys the support of four major oil and gas companies (BHP Billiton, Petrobras, Petronas and Woodside).

Via TURI, CSIRO – along with collaborators GNS (New Zealand) and Curtin University of Technology – is positioning itself as a technological leader in the characterisation of turbidite reservoirs.

Integrated Predictive Evaluation of Traps and Seals (the IPETS Consortium)
IPETS is a research consortium involving CSIRO, The University of Adelaide, The University of South Australia and Petroleum GeoServices (PGS). It aims to develop predictive relationships between intact and breached hydrocarbon column distributions, leakage indicators, structural geometry evolution, fault geometries and rock properties through integrating regional and field/prospect scale seismic datasets, modelling and laboratory investigations. The IPETS Consortium started in 2005 and will run for four years. It is sponsored by Woodside, Chevron, Department of Primary Industries and Resources of South Australia, Schlumberger, Kerr-McGee, Origin Energy and Santos.

The SEE Grid initiative
AusIndustry supplied further funding in 2005-06 for a Solid Earth and Environmental Sciences (SEE Grid) Roadshow to roll out Web Feature Services (WFS) to each of the state and territory Geological Surveys. This was based on the success of the AusIndustry/MCA funded SEE Grid Information Services Roadmap project the previous year. The installation of these systems was accompanied by intensive local training with technical seminars and an executive briefing provided to the public. Much of this was aimed at the mining and geological communities, but reached a broader audience, including the heritage and environmental communities. As a direct result of the Sydney briefing, the submission of the Australian Geoscience Council to a Prime Ministerial working group included the following:

"….social sciences for analysis of confidential data on topics such as health, ageing, indigenous culture, taxation status, mobile phone services and even climate change. We therefore recommend that the social sciences are encouraged to participate in the development and implementation of SEE Grid."

With endorsements such as these, and the successful installation of the new services around the country, the Roadshow was deemed highly successful. AusIndustry was complimentary of the positive outcomes and management within budget. The team included staff from CSIRO, Geoscience Australia and Social Change Online.

The SEE Grid community exists to foster the development and adoption of open standards for web-based information and computation services in the earth and environmental sciences. There are now more than 300 members, including state and federal agencies, all committed to open standards and exchange.

SEE Grid is also part of the national Australian Partnership for Advanced Computing Grid program which is building a national grid infrastructure to give Australian researchers seamless access to computational and data resources.

PETRONAS Research and Scientific Services
CSIRO and PETRONAS Research and Scientific Services (PRSS) (an R&D unit of PETRONAS – Malaysia's national petroleum corporation) continued their collaborative research arrangements in 2005-06, working together in the areas of petroleum exploration and production, alternative "clean" energy and advanced materials technologies. As a fully-fledged business-driven R&D centre, PRSS serve the needs of the PETRONAS Group and other petroleum-related companies, both domestic and international. During 2005-06 CSIRO and PRSS have carried out projects in thermal maturity and PRSS has become an important partner in both the TURI (Turbidite Research Initiative) and Hydrates joint industry projects. CSIRO has long been the technological partner of PRSS in petroleum geomechanics, particularly in the areas of wellbore stability and sand production.

MAJOR COLLABORATIVE VENTURES

Hydrodynamics project with TNO Netherlands
CSIRO continues to work with the Netherlands national research agency TNO, the Dutch Bureau of Economics and two major energy companies to use the PressureQC™ quality control methodology — a technology developed by CSIRO Petroleum.

The technology works to reduce exploration and production risks and to evaluate the viability of developing newly discovered oil and gas fields. This method is currently used by the Australian petroleum industry in the North West Shelf. The collaborative venture is an extension of last year's successful completion of developing what will be the first integrated quality-controlled pressure and hydrodynamics database for the North Sea by collating data, collected over the past 40 years, from about 500 wells in the Southern North Sea Basin. This will enable the exploration industry to interpret the petroleum system to better predict the location and size of new resources.

Embedded Researcher Initiative
2005-06 saw the consolidation of the Embedded Researcher Initiative with progress towards the real goal – getting new knowledge/technologies used in ore discovery.

The first researcher was embedded at St Ives in 2003 with an initial agreement for a trial 3-6 month period of work. The concept involved the researcher being on-site and full-time with the company and responsible for liaising with all personnel in the exploration cycle, including core loggers, geologists and target generation specialists.

In 2005-06 four embedded researchers have worked in the Eastern Goldfields, at St Ives Gold Mining Company, Placer Dome (now Barrick Gold Corporation) and at the Western Australian Geological Survey's Core Library in Kalgoorlie. The on-site researchers are supported by CSIRO and The University of Western Australia personnel working through the Mineral and Energy Research Institute of Western Australia (MERIWA) and the Predictive Mineral Discovery Cooperative Research Centre (pmd*CRC). For their efforts the Embedded Researcher team was awarded the Exploration and Mining Innovation Award 2005 for success in transferring technology into the gold mining industry of Western Australia. A "Dinner in the Desert" ensured the award was shared and celebrated with clients and partners.

The emerging vision beyond 2005-06 is to have a network of embedded researchers in all the major mining districts across the country, employed both by CSIRO and its R&D partners. This would facilitate the real-time transfer of new concepts/technologies, breaking down the barriers that impede progress and keeping the R&D relevant.

*Dr Mark Pirlo, ER at Barrick Gold Corporation's Granny Smith operations, underground at the Wallaby Deposit, Laverton with Dr Klaus Petersen, pmd*CRC/CET at UWA*

INDUSTRY CLIENTS

Adelaide Resources
ADNOC (Abu Dhabi National Oil Company)
Alkane Resources
Anglo American Exploration (Aust)
Australian Scientific Instruments
Baker Hughes
Barrick Gold Corporation
BHP Billiton
Cameco Corporation
Chevron
Codelco
Corelab (Indonesia and UK)
CVRD
De Beers
Deutsche Forschungsgemeinschaft
ENI Australia
Falconbridge
Fugro Robertson (UK)
GeoInformatics
Geoscience Australia
GoldFields
GSWA
GNS New Zealand
Halcyon Resources
Hamersley Iron (now Pilbara Iron)
Helix Resources
Heron Resources
Independence Group
Icon Technologies
Institut Francaise du Petrole (IFP)
Inco Technical Services
INPEX
InterMet Resources
InterOil
Jabiru Metals (formerly Pilbara Mines)
Johnson Matthey
JVPC (Japan Vietnam Petroleum Company)
Japan Oil, Gas and Metals National Corporation (JOGMEC)
Kerr-McGee
Leviathan Resources
LionOre Australia
Magellan Metals
MERIWA
Minara Resources
Mincor
Minotaur Exploration
Multiplex
Murphy Oil
Nautilus Minerals
Neptune Resources
Newmont Australia
Northparkes
NSW Department of Mineral Resources
Oil Search
Oolithica (UK)
Origin
Patterson Instruments
PIRSA
Placer Dome
PETROBRAS
PETRONAS
PRSS (Petronas Research and Scientific Services)
PT Caltex
Placer Dome
Regis Resources
Research Institute of Petroleum Iran
Rio Tinto
ROC Oil
Santos
Schlumberger
SGS Minerals
Shell
Southern Gold
Stellar Resources
Sumitomo Metal Mining
Teck Cominco
Tethyan Copper
TOTAL
WA Department of Industry and Resources
WMC Resources
Woodside Energy
Xstrata
Zinifex

AWARDS AND RECOGNITION

The greatest recognition of the work performed at ARRC is the fact that the vast majority of the R&D produced is being actively used in the resources industry. This is not only confined to Western Australia's booming mining, exploration and petroleum industries, but much of the work is also being used by the national and international community.

Formal awards and recognition in 2005-06 include:

CSIRO Medal 2005
CSIRO Petroleum's Fluid History Analysis (FHA) team won this medal for the development of an innovative suite of techniques that reveal the stepwise fill history of petroleum reservoirs in previously unseen detail, positioning CSIRO as the world-leader in the application of fluid inclusion-based methods for reducing risk when oil companies drill exploration wells.

The techniques use samples of oil preserved within mineral grains that are retained when the reservoir fluid changes to gas or water, and are not visible at the well site. They are investigated in the laboratory using microscopy, spectroscopy and geochemistry. The work has enormous significance to the oil and gas industry because the techniques add value to the large data sets used to select drill targets by providing information about oil migration and the stepwise filling of reservoirs.

The winning FHA team

Prestigious Invitation
Dr Brent McInnes of CSIRO Exploration and Mining division was invited by the Geological Society of London to give a keynote lecture at the 2006 Fermor Conference in London. The Fermor meeting is the Geological Society of London's Flagship conference and attracts high quality international keynote lecturers to encourage significant cross-fertilisation of ideas between magmatism, tectonics, geochemistry and mineral deposits research community.

Exclusive Award
Dr Simon Cox of CSIRO Exploration and Mining was given the Kenneth D. Gardels Award from the Open Geospatial Consortium (OGC). OGC is a multimillion dollar international consortium and only gives one award every year.

"This award affirms your personal commitment and extraordinary history of Technical Committee participation, the special quality of leadership you have brought to consortium activities, and the unique esteem in which you are held throughout the OGC community.

"You are an influential scientist and architect whose technical judgement and wisdom have often been sought to resolve the most complex issues of standards technology and policy. Your contributions to the development of Geography Markup Language (GML), Sensor Web Enablement (SWE) and Web Feature Service (WFS) have been of unique value to the development of 'next generation' geoprocessing, and your work with the International Organization for Standardization (ISO) has assured that OGC standards are accorded formal standing in the global community.

"Most significantly, you have been both directly and indirectly instrumental in creating conditions for the practical use of OGC standards in worldwide application markets and the growing infrastructure requirement for interoperable geoprocessing."
- OGC Committee

Horst Zwingmann: recognition

The work of CSIRO Petroleum's Dr Horst Zwingmann has gained considerable recognition in the past 12 months in local and international research circles.

His current work involves the application of potassium-argon (K-Ar) and argon-argon (Ar-Ar) dating techniques to calculate the age of clay minerals by measuring the level of decay caused by radioactive potassium. In understanding the history of mineral formation, a more accurate read can be gained of how oil and gas reservoirs form.

Based at the John de Laeter Centre for Mass Spectrometry, Dr Zwingmann has been in demand around the world, receiving various awards, research grants and invitations to chair sessions at international conferences.

The Australian Academy of Sciences awarded him a grant for the 2005-06 year via the 'Scientific Visits to Europe' program, to investigate fault-related clay authigenesis for hydrocarbon exploration in Australia's North West Shelf.

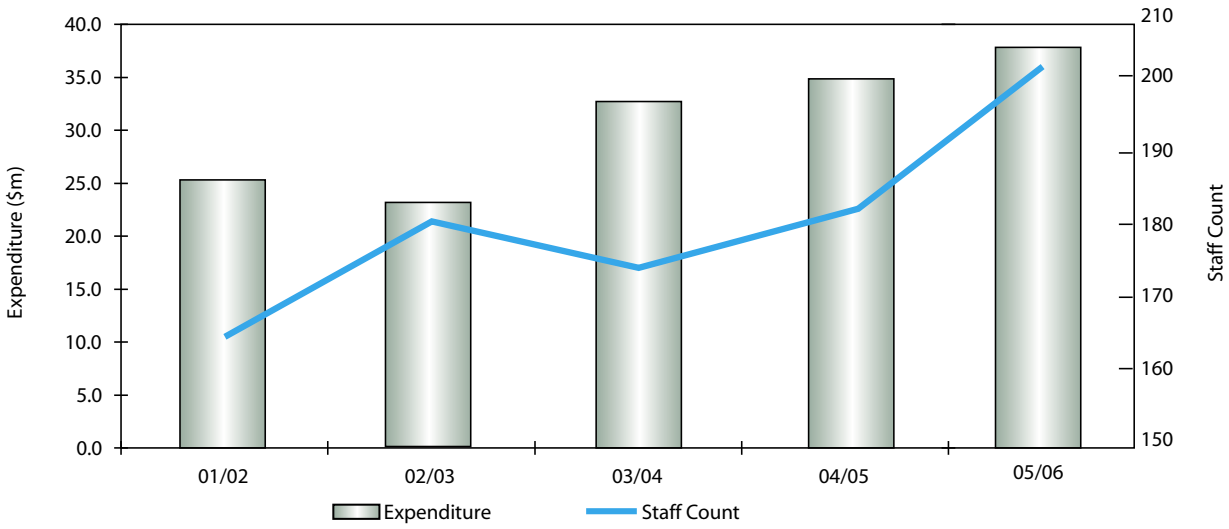
Also in recent years Dr Zwingmann has been awarded a CSIRO Petroleum and Curtin University of Technology Discovery/Linkage grant (2003), a Swiss National Fund grant (2004) and a University of New South Wales Faculty Research grant (2005-06).

His list of recent achievements also includes the publishing of more than 20 papers in reviewed journals in the past five years, including two papers listed in ScienceDirect's "hot science" in 2004. The ScienceDirect TOP25 Hottest Articles is a quarterly update of the 25 most frequently downloaded journal articles from more than 2,000 titles covering 24 subjects.

Dr Zwingmann's work received considerable attention in the middle of 2006 when he and co-researchers from the University of Sydney and the Australian Museum released a study showing that the Jenolan Caves in Central New South Wales are 340 million years old. This makes them the world's oldest discovered open caves.

FINANCIAL REPORT

Time Series Plot
Expenditure and Staff Numbers
(Combined CSIRO and Curtin figures)

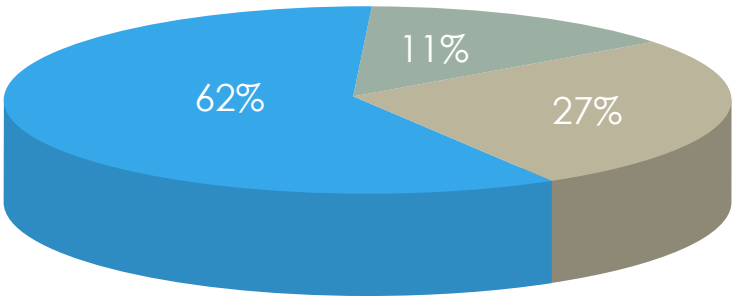


Expenditure Category	Staff ($'000)	Operations and Support ($'000)	TOTAL
CSIRO	15,144	17,046	32,190
Curtin University	2,707	2,235	4,942
Total	17,851	19,281	37,132

Funding	Institutional* ($'000)	External ($'000)	TOTAL
CSIRO	16,087	13,528	29,615
Curtin University	2,317	2,626	4,943
Total	18,404	16,154	34,558

* Direct Government funding to CSIRO and Curtin University

Non-Appropriation Funding Sources for CSIRO Exploration and Mining and CSIRO Petroleum at ARRC



State Government Departments and Universities
Cooperative Research Centre (CRC) Program and other Federal funding
Private Sector and other non-government sources

ARRC ADVISORY COMMITTEE

The role of the ARRC Advisory Committee is to provide focus and direction for ARRC's activities, thus ensuring maximum benefit to Western Australian industry, research organisations and the community. Additionally it oversees the research plans for the Centre and reviews the activities of the Centre against objectives annually. The ARRC Advisory Committee meets twice a year and comprises representatives from research institutions, government agencies and industry.

Member	Name and Position	Contact Details
	Adj. Professor David Agostini (Chair)	agostini@iinet.net.au
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	Mr Rob Male* Leader Facilities Engineering Woodside Energy Limited	

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	Professor Doug McEachern Deputy Vice-Chancellor Research and Innovation The University of Western Australia	Tel: 6488 2460 Fax: 6488 1013 pvcri@admin.uwa.edu.au
	Professor Barney Glover Former Pro Vice-Chancellor Research and Development Curtin University of Technology (member until February 2006)	
	Professor Linda Kristjanson Pro Vice-Chancellor Research and Development Curtin University of Technology (member since February 2006, replacing Professor Barney Glover)	Tel: 9266 3045 Fax: 9266 3048 L.Kristjanson@curtin.edu.au
	Mr Mike Krzus* Upstream Development Capability Manager Woodside Energy Limited	Tel: 9348 6430 Fax: 9348 4660 mike.krzus@woodside.com.au

* The ARRC Advisory Committee welcomes Mr Mike Krzus of Woodside Energy Limited as a new member for 2006-07. Mr Krzus replaces Rob Male, also of Woodside Energy Limited. The Advisory Committee would like to sincerely thank Mr Male for his dedication and valuable contribution during his five years as a Committee member.