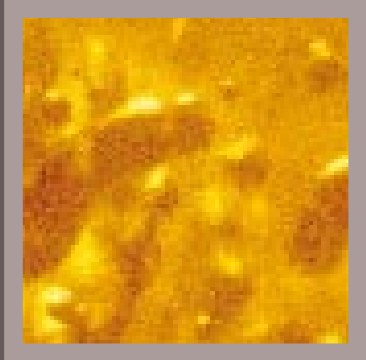
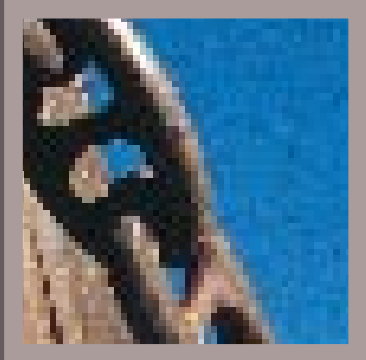
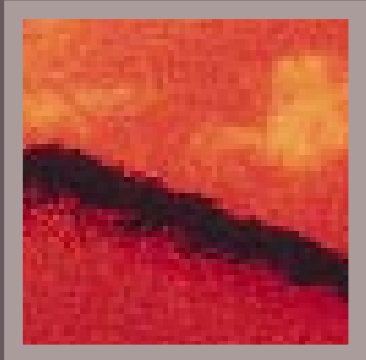


QUEENSLAND CENTRE FOR ADVANCED TECHNOLOGIES

QUEENSLAND CENTRE FOR ADVANCED TECHNOLOGIES



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QCAT occupants

QCAT occupants

The Queensland Centre for Advanced Technologies (QCAT) is a world class facility for research and development in all aspects of the mining, energy and manufacturing industries with the goal of increasing the international competitiveness and efficiency of Queensland's and Australia's resource based and related industries.

Established in 1990 by agreement between the Queensland Government and Commonwealth Scientific and Industrial Research Organisation (CSIRO).

Government Occupants:
CSIRO
Exploration and Mining
Minerals
Energy Technology
Manufacturing Science and Technology

Cooperative Research Centres for:
Black Coal Utilisation
Cast Metals Manufacturing (CASTMM)
Landscape Evolution and Mineral Exploration (LEME)
Mining Technology and Equipment (CMTE)

Australian Centre for Mining Environmental Research Limited (ACMER)

Commercial Occupants:
Cutting Edge Technology Pty Ltd
Nicolay Technology

QCAT CONTACTS

m Minerals and Energy Resources are the largest export sector of the Australian economy, worth over \$39 billion a year, or 34% of our total exports of goods and services, and continues to be one of the major strengths of the Australian economy.

The Queensland Centre for Advanced Technologies (QCAT) was established by agreement between the Commonwealth and Queensland Governments to expand and diversify the research and development activities undertaken by CSIRO in Queensland. Both Governments attach great importance to excellent science and innovative technology.

The Centre provides a unique mix of disciplines directed at research into advanced exploration technologies, coal mining, coal preparation, equipment automation, mine safety, minerals processing, hard rock mining and new foundry technologies. Its reputation and success as a world class venue for mining, energy and manufacturing research and development has provided tangible returns on the investment made by the Commonwealth and Queensland Governments into research infrastructure.

A further investment of \$24.43 million by the Queensland Government for physical infrastructure, together with increased operating funds to the value of approximately \$8 million per annum from the Commonwealth, will enable the Centre to increase its research capacity in a Stage 2 expansion. As part of the initial expansion, the Centre has established a \$3 million Advanced Coal Gasification research facility to evaluate the performance of Australian coals using modern Integrated Gasification Combined Cycle (IGCC) technologies. A joint project between CSIRO Energy Technology and the Cooperative Research Centre for Black Coal Utilisation, the gasification facility will provide black coal producers with performance data for their coals in advanced power generating systems. This project is an example of successful collaboration between industry, the Commonwealth and State Governments, universities, and the CSIRO.

The QCAT Stage 2 initiative is providing a timely boost for the growth and diversification of research and development in the mining, energy and manufacturing industries within Queensland and Australia.

I commend the science and the new developments achieved by all the staff at QCAT in 1998/99. They provide a pathway for increasing the international competitiveness and wealth of Australia's resource industry.

executive manager

In coal mining, improved understanding of the relationship between coal petrography and fracture mechanics has allowed a greater capability in prediction for outbursting, pillar stability and coal fines generation. Work at one minesite suggests that CSIRO research on minimising fragmentation and fines production, if replicated at full-scale, will yield benefits of \$7 million annually.

In minerals mining, a full-scale prototype of a revolutionary rock excavation technology, the Oscillating Disc Cutter, is currently being fabricated based on designs resulting from laboratory and mathematical modeling programs. The prototype will be used to assess the reliability and operating costs of potential mining systems using this new technology.

In iron ore processing, we have seen the construction and commissioning of the world's largest diameter Hopkinson bars for characterisation of particle breakage. Preliminary models for predicting crusher performance have been developed from Hopkinson bar and in-crusher breakage characterisation parameters.

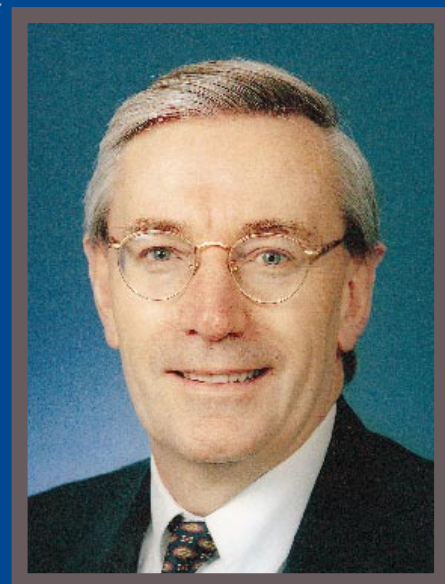
In foundry technology, the fatigue properties of a candidate magnesium alloy for a lightweight engine block have been measured at both room temperature and at elevated temperatures. Magnesium casting technologies developed at QCAT are now being applied to other metals such as lead and aluminium.

During the past twelve months we have also witnessed significant progress in the expansion of the facility. Construction of the advanced gasification research facility was completed in March 1999 and the building was officially opened in July. This facility will provide the technical information required to introduce and support Australian coals in new domestic and international markets based on high efficiency coal utilisation processes. Work on the Stage 2 expansion to provide new laboratory space, office and process bay accommodation and a technology transfer building to house associated industry companies and staff commenced in July and is expected to be completed in July 2000. The commitment made by the Commonwealth and Queensland governments and CSIRO to the Stage 2 expansion will enhance our science and provide a timely boost for the expansion and diversification of research and development in the Australian minerals industry.

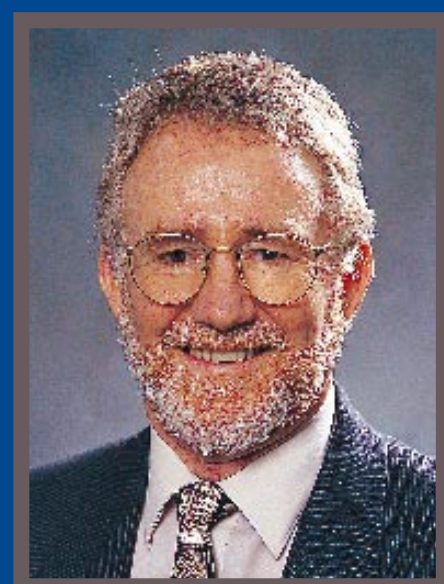
The focus of this year's annual report is Australian science and its role within the Australian minerals industry. Over the past year, staff at the Queensland Centre for Advanced Technologies (QCAT) have been working on a variety of innovative and challenging projects in collaboration with the minerals industry. Typical of these are:

In geophysics, where new instrumentation has been developed to directly measure ground deformation for mine planning, safety and productivity. In a trial project, observations of loading and deformation have been used to increase longwall recovery ratios by 5% without compromising safety margins.

Minister for Industry, Science and Resources



Senator the Hon Nick Minchin



Dr John Read Executive Manager Queensland Centre for Advanced Technologies

Nick Minchin

John Read

foreword

mineral EXPLORATION

The Cooperative Research Centre for Landscape Evolution and Mineral Exploration (CRC LEME) operates an office from QCAT with a staff of three scientists specialising in mineral exploration, geochemistry, landscape evolution, and in the processing and interpretation of digital spatial and exploration data. These scientists are actively involved in exploration research projects in Queensland, Northern Territory and New South Wales. CRC LEME, which is an unincorporated joint venture between CSIRO Exploration and Mining, the University of Canberra, the Australian National University and the Australian Geological Survey Organization, has a national focus to develop new methodologies for the discovery of mineral deposits concealed by regolith.

QCAT based staff have been involved in the Eastern Queensland Transects Project, which includes an assessment of the regolith over the Queensland extensions of the New England Fold Belt. Researchers have also begun an industry-sponsored project to assess, map and evaluate the exploration significance of regolith and its effect on mineral exploration in Central Australia.

Other research is aimed at developing and assessing new methods for the analysis and interpretation of airborne radiometrics data using a modelling approach that involves digital elevation and Landsat data (AMIRA Project P-491).

The CSIRO Exploration and Mining Airborne Gravity Gradiometer project is progressing rapidly towards laboratory proof of concept. The system, details of which are still held as commercial in confidence to enhance its commercial viability in the industry, will be capable of providing measurements from low flying aircraft at a rate and sensitivity suitable for the detection of buried orebodies down to a scale of approximately 300 metres at burial depths of 200 metres. The measurements will be integrated into other geophysical measurements from the same or other airborne platforms to enhance exploration capabilities.

Research Achievements

- Work has begun to assess the regolith over of the Mt Morgan district, which covers the northern extensions of the New England Fold Belt into Queensland. This work is aimed at increasing the prospectivity of these areas for mineral exploration purposes. Knowledge of the landscape and regolith conditions will allow companies to choose appropriate geochemical sampling and geophysical methodologies to assist exploration over these areas.
- The final meeting of AMIRA Project P-491, which was aimed at developing and assessing new methods for the analysis and interpretation of airborne radiometrics data using digital elevation and Landsat data, was held in October 1998. There was sufficient interest from Sponsors to support a six-month extension of the Project beginning in February 1999. The results of this project are currently confidential to sponsors; however some significant conclusions have been made regarding the roles of geomorphology and geology in determining the radiometric responses as seen from an airborne detector system.



Marian Skwarnecki examining a ferruginous outcrop in the Northern Territory

- The Airborne Gravity Gradiometer project has developed measurement precision of the key sensors achieving measurements better than 10 picometers (about one tenth the diameter of an atom).

Technology Transfer

- The final project report for AMIRA Project P-491 is available in HTML format on a CD, which includes both documented case histories and a tutorial on the methodologies investigated as part of the project. Project results were presented to sponsors during the October 1998 Meeting.



The key targets of this group are to develop and demonstrate new techniques for deposit delineation, grade control and rock mass characterisation necessary for maximisation of recovery of reserves and for minimisation of dilution. Geophysical data acquisition systems will control new mining systems, monitor real time progression of the mining operation, and contribute to safety in mining by enabling increased automation, and by better monitoring of stability and ground response to mining.

The requirements for deposit delineation, rock mass characterisation and safety are shared by the metalliferous and coal mining sectors and are addressed from a common technology base. Research is undertaken by CSIRO Exploration and Mining staff and also within the Cooperative Research Centre for Mining Technology and Equipment (CMTE*). The core of the group's deposit delineation work is geophysical logging.

Research Achievements

- Five international sales of new spectrometric nuclear logging tools. These provide coal and ore quality estimates from boreholes for precise resource quality maps used in production scheduling.

- Computer based analysis procedures are being applied to 3D seismic and borehole tomographic data to provide images of geological structures and boundaries beneath the earth's surface. Through geophysical imaging, geological boundaries and rock structures can be mapped without extensive drilling. Geophysical imaging is allowing overall geological conditions to be established with far greater certainty. (*)



Mihai Borsaru examines coal ash content using the coal face ash analyser

geophysics

- Seven field studies of induced failure mechanisms using microseismics at Australian coal mines have been performed. This tool is now being used at several minesites to enhance the understanding of dynamic migration of stress failures associated with longwall mining and goaf generation in underground mining and for the study of gas emissions.
- The development of new and simplified instrumentation to directly measure ground deformation for mine planning, safety and productivity. In a trial project observations of loading and deformation have been used to increase longwall recovery ratios by 5% without compromising safety margins.

Technology Transfer

- Advanced microseismic stress monitoring systems have been delivered and currently utilised in five Australian coal mines. One system has been delivered to Shandong coal mine, China.
- CMTE's Windows based automatic geophysical log interpretation is now commercially available.
- Uptake of deformation monitoring systems into the American National Earthquake Hazard Reduction program.
- Eight international sales of ground penetrating radar control and interpretation software.



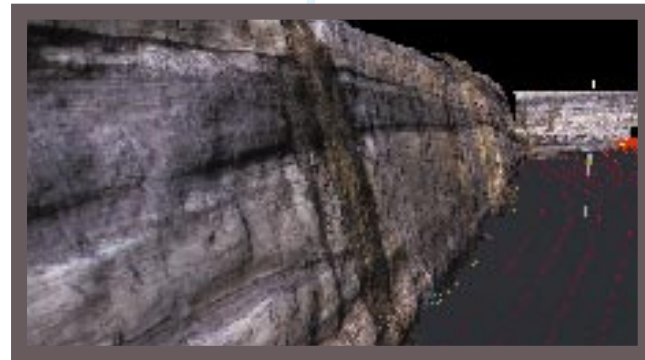
coal mining

Research and development in coal mining is focused on multidisciplinary areas, which effectively use fundamental science to feed applied approaches to the coal industry. CSIRO Exploration and Mining, CSIRO Manufacturing Science and Technology and the Cooperative Research Centre for Mining Technology and Equipment (CMTE*) are working together to deliver applied technology solutions to major industry issues such as optimising of mine design, lowering of pit costs, enhancing reserve estimation, increasing recovery and reducing geotechnical risk in mining operations. The team approach is crucial, as industry problems require the integration of disparate disciplines.

Research Achievements

- Development of predictive geological and geotechnical models have led to improvements in mine planning. The benefits realised in minimising stoppages and increased safety are estimated at \$600,000 per day for a typical underground longwall mine.
- CSIRO Exploration and Mining and Cutting Edge Technology have developed the guidance technology for the world's first guided auger-based highwall mining systems. The system features the world's first fully guided and instrumented single auger cutterhead including an inertial guidance system and real-time monitoring of gas concentration at the face. A twin auger has been operating successfully for a year, establishing world records for penetration depth and production.
- Several Australian mines are now taking advantage of improved Longwall Geomechanics characterisation tools that have been developed by CSIRO.
- CMTE's Tight Radius Drilling (TRD) project sponsored by BHP Coal Pty Ltd has demonstrated TRD as a viable means of extracting methane gas from underground seams. Two patent applications have now been lodged. (*)
- Successful drilling, simulation and modelling work on gas in coal has been carried out. This research is contributing to safety goals and minimising lost production from shutdown due to gas problems. Better techniques of assessment for gas control and ventilation have also resulted from new capabilities in 3D computational fluid dynamics.

- A new tool to enable wireless communication in underground mines during normal and emergency situations has been successfully trialed.
- An improved skill base in 3D digital photogrammetry and 3D visualisation will assist further development of mine mapping, control technologies and 3D interactive mine models. The coal geology and 4D visualisation team has succeeded in creating an enhanced 4D system to merge time-dependent and seismic data with the geological, geophysical, mining, surveying, and design data to produce information displayed in interactive accurate 4D mine models.
- Improved understanding of the relationship between coal petrography and fracture mechanics allows a greater capability in prediction for outbursting, pillar stability and coal fines generation. Work at one minesite suggests that CSIRO/CMTE research on minimising fragmentation and fines production, if replicated at full-scale, will yield benefits of \$7 million annually. (*)



Virtual mine model showing integration of disparate data sets including highwall images, coal thickness contours and drillholes

- A CMTE-CSIRO ACARP project has successfully demonstrated the use of ground probing radar on a longwall shearer to measure remnant floor coal thickness. This method of coal interface detection will be employed in future development work on longwall horizon control.

Technology Transfer

- A CMTE radiometric/radar geo-steering tool for in-seam drill guidance is being commercialised through Sibra Pty Ltd.
- Expertise in predicting longwall geomechanics is being taken up directly by mines and through consultants Strata Control Technology.
- CMTE-CSIRO guidance technology is used extensively by highwall mining operators in both Australia and the USA. Roche Highwall Mining Pty Ltd is commercialising the guidance system used in continuous miner-based highwall mining operations.
- Improved geotechnical assessment tools are being implemented via one on one contracts with specific Australian coal mines.



The ability to remain competitive in international markets while maintaining the highest standards in safety, health and environmental performance is crucial to the long-term viability and acceptability of the mining industry. The Mine Safety Health and Environment Group is currently working to assist the industry in improving its safety and environmental performance through its research in mine gas control, heavy vehicle collision avoidance and greenhouse gas mitigation. The group works closely with other groups within CSIRO Exploration and Mining and CSIRO Energy Technology, and with commercial partners, Advanced Mining Technology.

Research Achievements

- A prototype collision avoidance system incorporating cutting edge digital RF technology, and high resolution video has been developed, built and tested in conjunction with Advanced Mining Technology and supported by ACARP. This has eliminated the need for reversing alarms on large mining equipment and is greatly improving safety.
- Studies at Dartbrook Mine have developed goaf gas flow models using FLUENT Computational Fluid Dynamic code which have been verified by tracer gas testing. This is the first work of its type in Australia and is a cooperative venture with the Japan Coal Energy Centre, Dartbrook Mine and ACARP.



Working to improve the health and safety of miners and the community.

minesafety

Technology Transfer

- The group has played a major role in assisting the Coal industry to set its research priorities for greenhouse gas mitigation, in conjunction with CSIRO Energy Technology.
- Goaf gas modelling and implementation of the results at Dartbrook has increased the efficiency of goaf gas drainage by 40% and allowed the mine to reach ventilation specifications required by regulators and control heatings in the goaf.
- As a result of the collision avoidance system project taking place at Bengalla Mine, they have adopted the use of high resolution colour cameras on their haul trucks; the camera systems alone have provided a tremendous safety and operational improvement. They are trialing the full system.



coal processing & UTILISATION

CSIRO Energy Technology has a major component of its Coal Preparation Group based at QCAT. This group is strongly focused on addressing the issues associated with preparing Australian coals for sale on the international market.

The Coal Preparation Group at QCAT is developing methods and techniques for improving the quality of Australian product coals, and a number of projects have been developed which address key components in the research priority areas of fine coal sizing and cleaning.

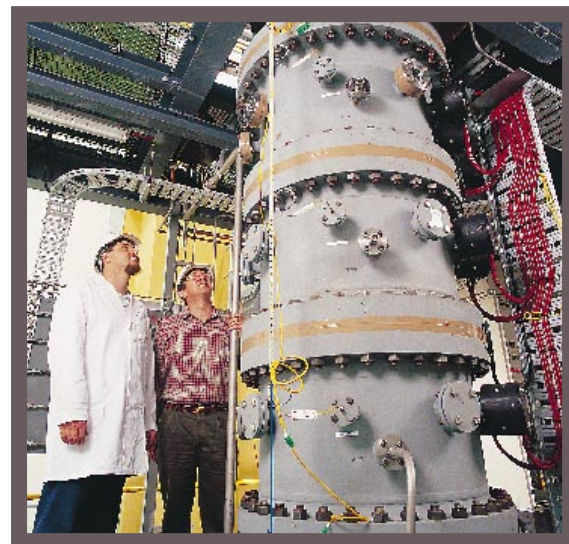
During 1999, CSIRO Energy Technology moved part of its Energy Conversion Group to QCAT. An advanced gasification research facility has been established to evaluate the performance of Australian coals in emerging power generation technologies. The initial focus of the work will be on Integrated Gasification Combined Cycle (IGCC) power generation technologies.

The research in the new facility is aimed at supporting future export markets of Australian coal into these new technologies. The facility will also be used to provide technical data necessary to assess and adapt these technologies for use in the Australian power generation industry. This work is being performed through the Cooperative Research Centre for Black Coal Utilisation.

Research Achievements

- The coal preparation team working through the CMTE completed successful field trials with a large diameter classifying cyclone at the Stratford mine in NSW. This type of unit has the potential to markedly simplify fine coal circuits. It now appears that this type of unit actually performs better than would be expected and a number of new design initiatives are now possible. (*)
- The pilot scale Turboflotation system has been shown to produce acceptable metallurgical performance with four different coals feeds with a capacity rating twenty times that of normal flotation. A 30cm diameter development system has been constructed and detailed investigations carried out at South Blackwater and Catherine Hill Bay coal preparation plants. Ludowici Mineral Processing Equipment Pty Ltd and CSIRO are combining efforts to construct and investigate a full commercial scale (1m diameter) system at Coppabella. Numerous other applications of this new technology have been identified.

- The high pressure entrained flow gasification facility has been constructed and commissioned under contract by DMT, a leading German technology company. Collaborative research links are being developed between the CRC for Black Coal Utilisation and several international energy research laboratories to enhance the application of the work done at QCAT and to help position the group prominently in the international gasification research community.
- ACARP have provided funding to the CRC for Black Coal Utilisation to perform an initial assessment of a wide range of Australian coals using the gasification facility. This work will be followed by more detailed examinations of promising coals in order to define appropriate coal test procedures and to determine optimum operating conditions for different coal types.



David Harris and Daniel Henderson with the Advanced Gasification Research Facility

Technology Transfer

- Presentations on the outcomes of the large diameter cyclone project were given at the ACARP Symposiums in Singleton and Emerald. Presentations were also given at the XIIIth International Coal Preparation Congress held in Brisbane, October 1998 on Turboflotation, Size Classification and the Dewatering of Coarse Coal.
- Coal gasification research is being conducted with close involvement of the participants of the CRC for Black Coal Utilisation. These include Australia's leading export coal companies and several major black coal based power generators. The Queensland Department of Mines and Energy is also a strong participant in the Centre.



Oscillating Disc Cutter test rig (Image courtesy of CMTE)

minerals mining

Staff from CSIRO Exploration and Mining and CSIRO Manufacturing Science and Technology are working with the Cooperative Research Centre for Mining Technology and Equipment (CMTE*) in the areas of drill guidance and logging, geophysical imaging and alternative excavation methods. The prime objective is to increase safety and productivity in the Australian metalliferous mining industry.

Research Achievements

- A radiometric sensor is being developed for use in the guidance of in-seam drills. CMTE's research has enhanced the information obtained from drilling by providing improved geophysical tools to evaluate geological conditions within and between drill holes. (*)
- A revolutionary rock excavation technology has been developed by the CMTE (the Oscillating Disc Cutter) and is allowing hard rock to be mechanically cut on a continuous basis. This is in contrast to conventional drilling and blasting which is inherently dangerous, non-selective, environmentally hazardous and cyclic in nature. The new technology has been demonstrated in the laboratory by successfully cutting rocks at high advance rates with strengths of up to 279 MPa (UCS). A full-scale, prototype cutting machine is currently being fabricated based on designs resulting from the laboratory and mathematical

modeling programs. This prototype will be used to assess the reliability and operating costs of potential mining systems using this new technology. (*)

Technology Transfer

- CMTE'S ImageWin software for the analysis of crosshole radio imaging and seismic tomographic data is currently being commercialised. Coal mine data sets from Newlands and Dartbrook mines have been successfully analysed, as has data from Canada.
- ACARP support has been attracted for the development of in-situ techniques for geotechnical assessment. Work is underway using data sets from a number of Australian coal mines. CMTE's computer program LogTrans for the automated interpretation of geophysical logs continues to be refined. Commercialisation of this software is also underway.

- The commercialisation of CMTE's Oscillating Disc Cutter is currently being negotiated with manufacturers and end users. The next stage of the project is an AMIRA sponsored field test of the technology funded by Australian and international mining companies. This represents the next step towards producing a commercial mining system.

The mining automation team at QCAT comprises staff from CSIRO Manufacturing Science and Technology and CSIRO Exploration and Mining. It carries out applications-oriented work in robotics, machine vision, image analysis and systems control. The work is currently focused on research towards the automation of existing mining systems and the development of new automated mining techniques. Some of this work is carried out within the CMTE. (*)

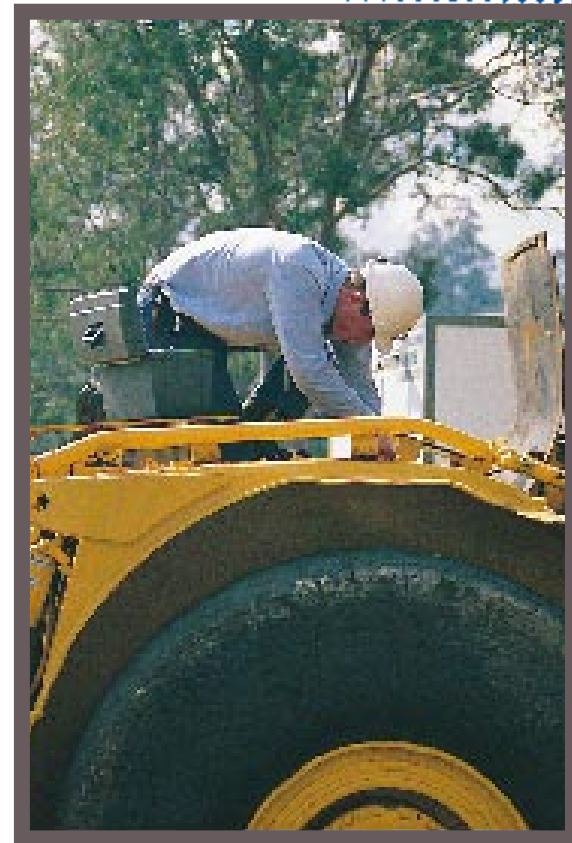
The prime objectives of the group are to improve safety by removing people from hazardous areas and to improve productivity. To this end, significant resources for automated vehicle research have been established at QCAT including an artificial mine test site, control room and a number of automated vehicles.

Research Achievements

- Field trials for the autonomous vehicle project were conducted at the Northparkes mine where the prototype system was successfully demonstrated. The automation system carried out its functions successfully and operated with no additional infrastructure beyond the normal basic mine communication and teleoperation systems. A novel reactive navigation technique was used that does not require complex area surveys and can operate the vehicle in an "unrehearsed" area. (*)
- The dragline automation group has demonstrated control of all major elements of a dragline automated swing cycle. The potential productivity increase for a typical mine is equivalent to \$3 million per year or an industry-wide potential of \$280 million per year. Field trials were successfully demonstrated on a BE 1370 production dragline at Tarong in late 1998. (*)
- Automatic location of underground blast holes has been achieved. This work demonstrated that it was possible to use 3-D range image processing techniques to determine the location of pre-drilled blast holes.
- Automatic estimation of the volume of material in a shovel dipper (bucket) has been achieved using 3-D range image processing techniques.

Technology Transfer

- In the LHD project, a new company has been formed by one of the industrial sponsors with the intent of commercializing the technology.
- In the dragline project, negotiations are currently underway to develop a commercial prototype.
- The work on automatic location of blast holes has been transferred to Orica Explosives. This work forms a critical enabling technology for automated blast-hole charging.

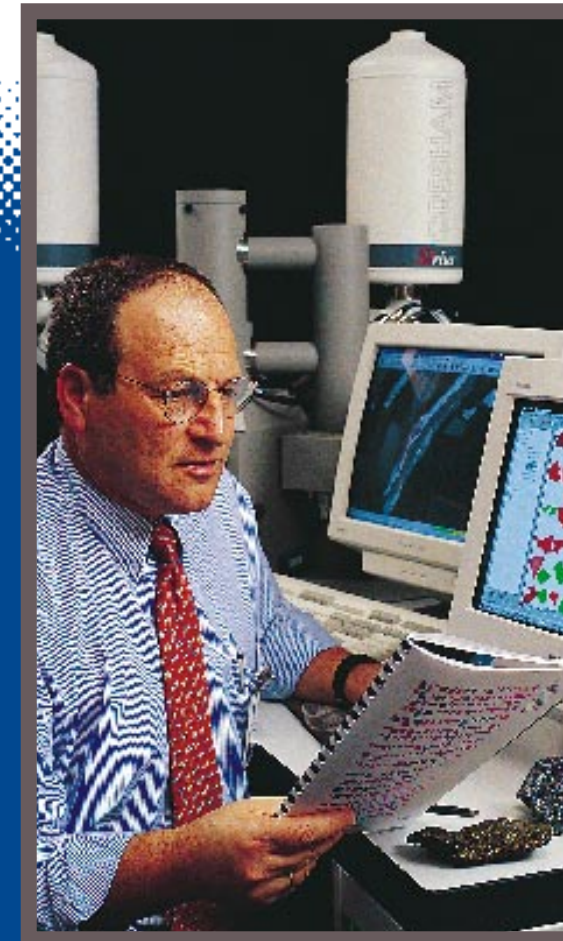


Andrew Castleden working on the autonomous vehicle project

- The work on shovel dipper volume estimation has been transferred to Rio Tinto Coal (NSW) Ltd. This work is a precursor to the design of shovel dippers that can fill haul truck trays with an integral number of loads.



Non-ferrous mineral processing research at QCAT is focused on developing new and improved methods for ore characterisation, comminution, liberation analysis, process optimisation and process modelling to meet the current and future needs of the mining industry. CSIRO Minerals research staff are at the cutting edge in mineral processing research with a strong appreciation of the key technological issues facing industry.



Paul Gottlieb and the QEM*SEM system (QemSCAN)

non-ferrous mineral processing

coupled with processing expertise to deliver a multidisciplinary research package. This will enhance the research efforts and will provide better solutions for industrial clients in plant problem solving and optimisation.

Research Achievements

- Development of new acoustic emission techniques for monitoring and ultimately improving the performance of Autogenous Grinding (AG) and Semi Autogenous Grinding (SAG) mills.
- Further development of new ways of using high pressure grinding rolls in mineral processing.
- Commissioning of a new QemSCAN machine at QCAT with variable pressure capabilities enabling characterisation of wet samples.
- Application of QemSCAN technology to the characterisation of drill cuttings to assist in stratigraphic sequencing in petroleum and gas reservoirs.
- Application of QemSCAN technology to the location, identification and classification of indicator minerals as an aid to mineral exploration.

Technology Transfer

- Collaborative projects and strong linkages with mining companies, equipment manufacturers and service suppliers to demonstrate the application of new and improved mineral processing technologies in company operations.
- QemSCAN measurement service to industry for supply of mineralogical data. Approximately 2000 samples were measured during the year for Australian mining companies. This work helps to ensure that QemSCAN technology is appropriate to present and future industry needs.

The industry drivers continue to be improved ore characterisation methods and more efficient techniques for processing fine grained ores, particularly improved feed preparation and grinding optimisation. Leo Electron Microscopy Ltd is now actively marketing the CSIRO QEM*SEM technology as QemSCAN. Over the last year sales have been made in Canada (two machines) and in South Africa, with further prospects in Finland, Canada, South Africa, Chile and Iran. Mineralogical skills are currently being

- Presentation of a suite of papers at the AJM Crushing and Grinding Conference in Kalgoorlie in April 1999 to familiarise mining companies and equipment suppliers with the latest mineralogical and process testing technologies available for plant design and optimisation.
- QemSCAN Users meeting in Johannesburg to share experience in the application of QemSCAN to mineral processing.
- Training of undergraduate and postgraduate students from overseas Universities in mineral processing.

mining Automation



iron ore processing



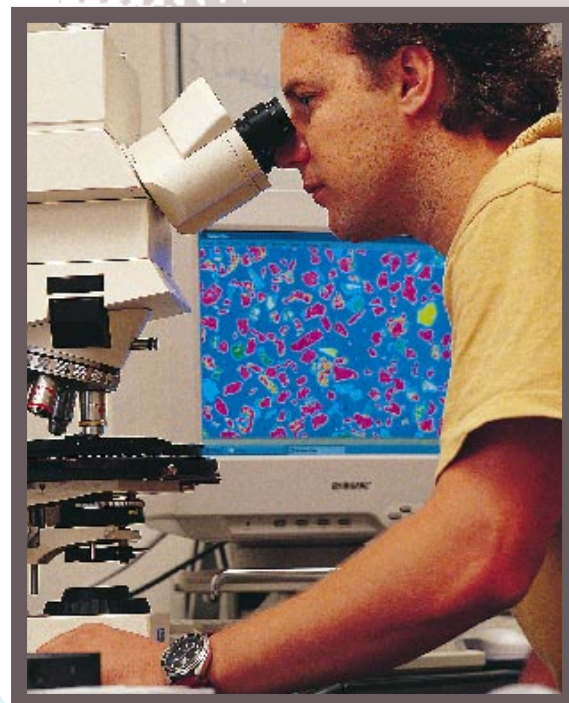
Australia's iron ore industry is entering a challenging period with the development of new orebodies and further downstream processing. The continuing price reductions for iron ore exports have also intensified the focus on reducing capital and operating costs. In response to these drivers, the iron ore processing research at QCAT is focused on new and improved methods for ore characterisation, comminution, beneficiation, sintering, quality control and international sampling standards. The research staff are world leaders in these areas, with an excellent appreciation of the key issues facing the industry and strong links with complementary research at QCAT in non-ferrous mineral processing and coal preparation.

A key aspect of current research is the characterisation of iron ores and prediction of downstream processing performance using optical microscopy and computer-based image analysis techniques, backed up by a wide range of complementary techniques such as electron microscopy and microprobe analysis. The breakage properties of large rocks up to about 100 mm diameter are also being determined using a Hopkinson bar or in-situ in a laboratory crusher to optimise comminution performance. In addition, new capabilities in wet and dry beneficiation have been developed and are being applied to the treatment of lower grade ore deposits and production of high grade concentrates for direct reduction processes, including the removal of deleterious elements such as phosphorus. Better sampling methods and standards are also being developed to improve quality control procedures, both to meet contract specifications and optimise resource life.

Research Achievements

- Development of optical image analysis methods for liberation characterisation and assessment of beneficiation options.
- Construction and commissioning of the world's largest diameter Hopkinson bar for characterising particle breakage.
- Development of preliminary models for predicting crusher performance from Hopkinson bar and in-crusher breakage characterisation parameters.

- Completion of construction of a modular pilot plant for wet beneficiation of iron ores, which can be transported to company operations for on-site trials. The plant circuit is flexible with separate modules including a ball mill, size classification and a Wet High Intensity Magnetic Separator.
- Development of a pilot scale hydrocyclone test facility for improved hydrocyclone design and validation of holistic CFD models.
- Development of techniques for characterising the motion of dry particle separation devices to improve separations based on size, density or shape.
- Development of a novel vibration-based dry fine-particle density separator.
- Development of improved methods for removal of phosphorus from iron ores.
- Completion of revision of ISO 3082 (Iron ores – Sampling procedures) and publication by the International Standards Organisation.



Jason Young with the VP32 "MINERAL" image analyser

Technology Transfer

- Collaborative projects and strong linkages with mining companies, equipment manufacturers and service suppliers to demonstrate the application of new and improved iron ore processing technologies.
- In-house training of company mine geologists and metallurgists in iron ore classification schemes.
- Training of undergraduate and postgraduate students from Queensland and overseas Universities.



One of the important areas of research of the ACMER is identifying indicators of ecosystem rehabilitation success

The Australian Centre for Mining Environmental Research Limited (ACMER) is an incorporated research institution comprising five of the major groups in Australia carrying out environmental research for the mining industry:

- CSIRO
- The University of Queensland (Centre for Mined Land Rehabilitation)
- Australian Nuclear Science and Technology Organisation (Environment Division)
- Curtin University of Technology (Mulga Research Centre and the Mine Rehabilitation Group)
- University of Western Australia (Centre for Land Rehabilitation)

and six of Australia's major mining companies:

- BHP, North Limited, Placer Dome Asia Pacific Limited, Rio Tinto, Shell Coal Pty Ltd, WMC Resources Ltd

The ACMER vision is to be an internationally recognised centre of excellence supporting continual improvement in environmental performance in the minerals industry for community benefit.

Major research programs of the Centre include waste rock dump stability, final void water quality, acid mine drainage, tailings disposal and remediation, and ecosystem reconstruction processes and strategies.

Research Achievements

- National review of practices on mine sites to manage sulfidic wastes and associated production of manuals for the minerals industry on (1) management of these wastes and acid drainage and (2) the use of risk assessment as a tool in sulfidic waste management.
- Completion of a three year study on Spinifex Re-establishment on Mine Sites which has identified the climatic, soil and plant factors limiting re-establishment and the treatments necessary to enhance recolonisation of the species which inhabits 25% of Australia's land surface.
- Identification of the factors affecting the seed dormancy of key native plant species used in revegetation programs across Australia.
- Completion of a review, for Environment Australia, on revegetation in the wet-dry tropics of Australia to assist government assessment of rehabilitation performance of mines in the Northern Territory.

Technology Transfer

Short courses (SC) and workshops (W), which were attended by approximately 355 mining industry, government, research and consulting personnel, and community representatives, including –

- Principles and Practice of Mine Rehabilitation (SC) (Perth);
- Tailings Management and Rehabilitation Practice (W) (Perth);
- Indicators of Ecosystem Rehabilitation Success (W) (Melbourne);
- Environmental Management and Rehabilitation of Quarries (SC) (Launceston);
- Mine site Environmental Management in the Tropics (SC) (Darwin);
- Water Analysis and Monitoring (SC) (Brisbane);
- Water Management on Mine sites (W) (Brisbane);
- Native Seed Biology for Revegetation (W) (Perth);
- ANSTO Workshop on Managing Mine Wastes (Brisbane).

In addition, the Centre conducted a 2-week Train-the-Trainer Course in Best Practice Environmental Management in Mining in Bandung, Indonesia, for 45 representatives of the Indonesian mining industry, Bapedal (the Environment Protection Agency) and the Indonesian Department of Mines and Energy.

mine-site REHABILITATION



foundry technology

CSIRO Manufacturing Science and Technology scientists undertake research in casting technology and in alloy design in three main areas:

Process technology – developing existing casting processes in order to improve both quality and productivity; investigating new processes for making high integrity castings and adapting existing processes for use with new alloys.

Tooling and prototyping – improving the design of dies so as to reduce their capital cost and to understand the factors that lead to die failure so as to increase the operating life of dies.

Alloy performance – developing and optimising both aluminium and magnesium alloys to produce improved strength and fatigue resistance.

The total effort in the Division in these areas is some 55 full-time technical and research staff and we are, in addition, collaborating with several external agencies, including the Cooperative Research Centre for Cast Metals Manufacturing. At QCAT we have 9 full-time staff working in the areas of Process Technology and Alloy Performance. The research team at QCAT has developed leading edge technology for the casting of magnesium and for the production of magnesium alloys. Capability in numerical modelling of casting is of world standard with work being done for Australian foundries as well as supporting internal projects.

Research Achievements

- The magnesium project team has 6 patent applications in various stages of progress.
- The magnesium Horizontal Direct Chill continuous casting machine has been developed to the point where continuous lengths of magnesium product have been produced. The machine has now been relocated to the Australian Magnesium Corporation (AMC) Demonstration Plant in Gladstone and further trials are being conducted there.
- Thixobillet for semisolid casting has been prepared by a novel and inexpensive process and operating conditions for satisfactory casting have been determined.

- The tensile and fatigue strengths of aluminium alloy castings are affected to different degrees by alloy content, heat-treatment condition and casting quality (i.e., level of defects). Relationships that can be used to optimise the choice of foundry alloy and foundry processes have been found for these variables.
- The fatigue properties of a candidate magnesium alloy for a lightweight engine block have been measured at both room temperature and at elevated temperature. This work is part of a larger project being carried out at other CSIRO sites and which includes measurements of creep and tensile properties as well as research into alloy design methods for improved performance.



Simon Cashion and Nigel Ricketts discussing the surface finish of ingots cast under different protective gases (image courtesy of CASTMM)

Technology Transfer

- Magnesium casting technology developed at QCAT is now being applied to other metals such as lead and aluminium.
- Two magnesium casting machines developed at QCAT over the last 6 years have been taken to the AMC demonstration plant in Gladstone and will undergo further development during 1999/2000.
- The strategies developed at QCAT for magnesium oxidation protection will be tested on a larger scale during the AMC Demonstration Plant operations. Much of this work is aimed at the reduction of greenhouse gas emissions.
- Researchers are currently assisting a Gladstone-based company to develop continuous casting processes to produce specialty forging and thixotropic feedstock in aluminium and magnesium.

nicolay technology

Nicolay Technology commenced operation in November 1997. Nicolay Technology provides a unique blend of mechanical and electronic product design, together with experience in project management and focuses on the commercialisation of technology.

For the year 1998/99 the emphasis was on the development of an experimental Alpha Stirling Engine. The project is funded by ACARP and the CSIRO.

Engine test cycles are to be finished by the end of 1999. Apart from the design of the engine, Nicolay Technology contributes combustion technology and equipment to the Stirling project. Combustion technology and a heat source will be the energy source for the Stirling Engine. It is planned in a later stage to exchange the combustion unit with a non-combustion energy source. Prior to the development of the Alpha Stirling Engine a concept Beta version was developed.



Concept Beta version of the Alpha Stirling Engine

Nicolay Technology's ability to address advanced design needs as required in R&D has produced a reputation for being highly creative, adaptable, and able to add scope, opportunity and value to projects. State-of-the-art techniques and current quality management philosophies are an integral part of our business practice. The goal of Nicolay Technology is to become a leading partner in the development and commercialisation of technology in Australia.



CUTTING EDGE technology PTY LTD

Building on the successful launch of the Super Twin Auger last year, Cutting Edge Technology Pty Ltd (CET) has completed the design, manufacture and commissioning of a Steep Dip Highwall Auger System known as the Super Single Auger. This project is a joint program with the BryDet Development Corporation and is partly funded by the Federal Government START Program.

The ongoing strong links between CSIRO Exploration and Mining and CET have underpinned the advances made by CET. CSIRO Exploration and Mining is a key participant in the development of the guidance technology employed in both the Super Single and Super Twin Auger systems.

The collaboration has also produced the only augers in the world that are capable of detecting gas levels at the face and interpreting their explosive potential continuously during mining operations. CET and CSIRO Exploration and Mining continued to collaborate to provide geotechnical engineering support to highwall mining operations at Moura Mine for BHP Coal Pty Ltd and more recently for Brambles Industrial Services.

Contract surface auger mining operations have continued to grow in South Africa where CET provides geotechnical support to Auger Mining South Africa's operations.

The year 1998/99 has seen CET continue to develop and expand. For 1999 there are a number of projects in prospect both in Australia and overseas.

View of the Super Single Auger



researchsupport

In 1998/99 the Queensland Centre for Advanced Technologies (QCAT) carried out 55 research projects each with annual budgets over \$100K. The total value of research expenditure during this period amounted to \$23.24 million of which 51% was funded from CSIRO and 49% from Government, CRC grants and industry funding.

Research activities are conducted in close collaboration and consultation with industry, academic and Government groups to ensure that the quality of research and development undertaken at QCAT is of only the highest standards.

The Centre's 225 staff are employed by CSIRO, the University of Queensland and a small number of private companies. CSIRO Exploration and Mining, through the QCAT Site Management Committee, has responsibility for managing the Centre and for providing a safe and environmentally friendly state-of-the-art research environment for all staff.

The workforce at QCAT is diverse and staff are recruited from Australia and overseas. At present there are staff from Africa, China, Malaysia, the Philippines, India, Latin America, North America, South Africa, Eastern and Western Europe, the UK, New Zealand and Australia. We employ research scientists, engineers, programmers, and technical and research support staff. Consistent with its mission to create a competitive advantage for Australia's mining and manufacturing industries, QCAT's staffing profile reflects a concentration on research and development.

Through the QCAT Library, CSIRO divisions, CRCs and tenant companies gain access to an extensive range of information services. In keeping with QCAT's commitment to world class research, the Library makes sophisticated electronic information delivery options available to its clients, and actively assists them to optimise their research potential. The Library's interactive web site www.cat.csiro.au/qcat/services/library/about.htm is a gateway to powerful search tools that are at the forefront of information technology.

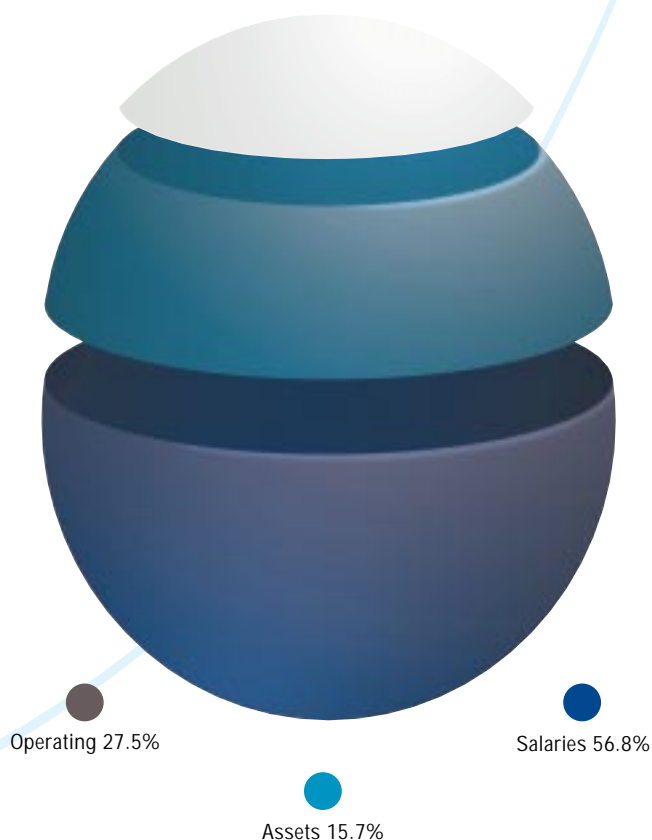
The high quality research activities performed at QCAT require a state-of-the-art IT infrastructure and effective user support. To ensure this, the Computer Support Group manages a complex TCP/IP network and offers expert computing advice to research staff.

The Group also maintains 350 PCs, printers, workstations and servers attached to the network and operates an extensive communications network.

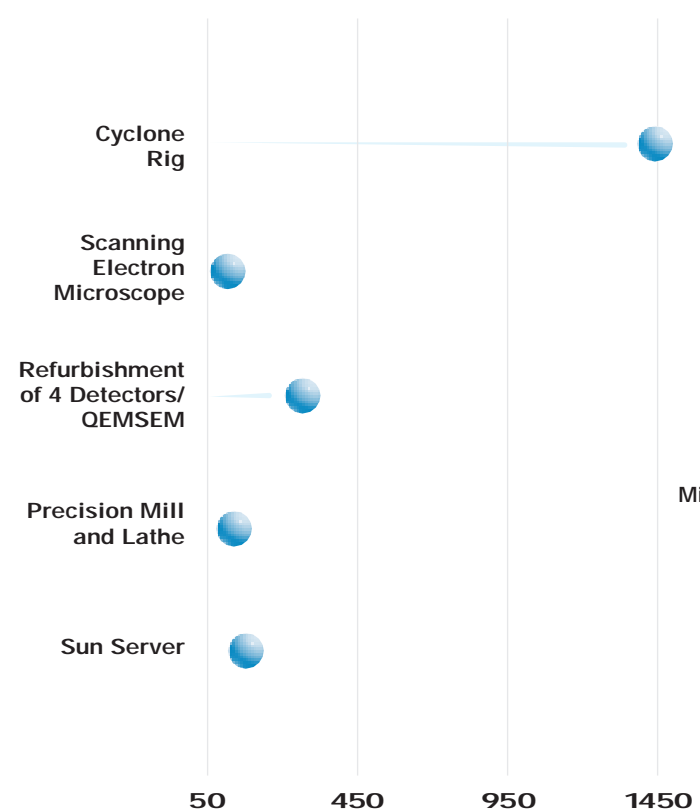
Within records management, professional staff assist in the development, coordination and implementation of records management procedures for participating CSIRO Divisions located at QCAT. All commercial, scientific and corporate records are captured and maintained in accordance with CSIRO policies and best practice guidelines.

The engineering workshop at QCAT supports research projects requiring the construction of specialised prototypes for mining and processing applications. The workshop operates on a contract user pay system and is maintained by a workshop supervisor and an apprentice. Examples of work undertaken throughout the year include hydro cyclone pilot plant used to mathematically model cyclones used in fine coal circuits, two microprojectile DNA guns, and the installation of instrumentation and high pressure and temperature equipment for the new advanced gasification research facility.

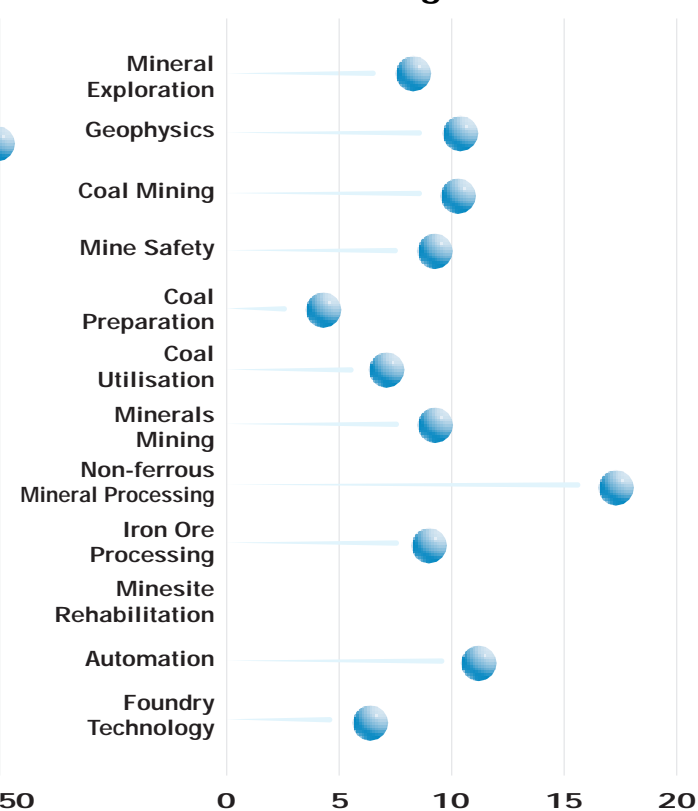
During the year new computer numerical control (CNC) facilities have been established at QCAT which further enhance the Centre's mechanical engineering capabilities.



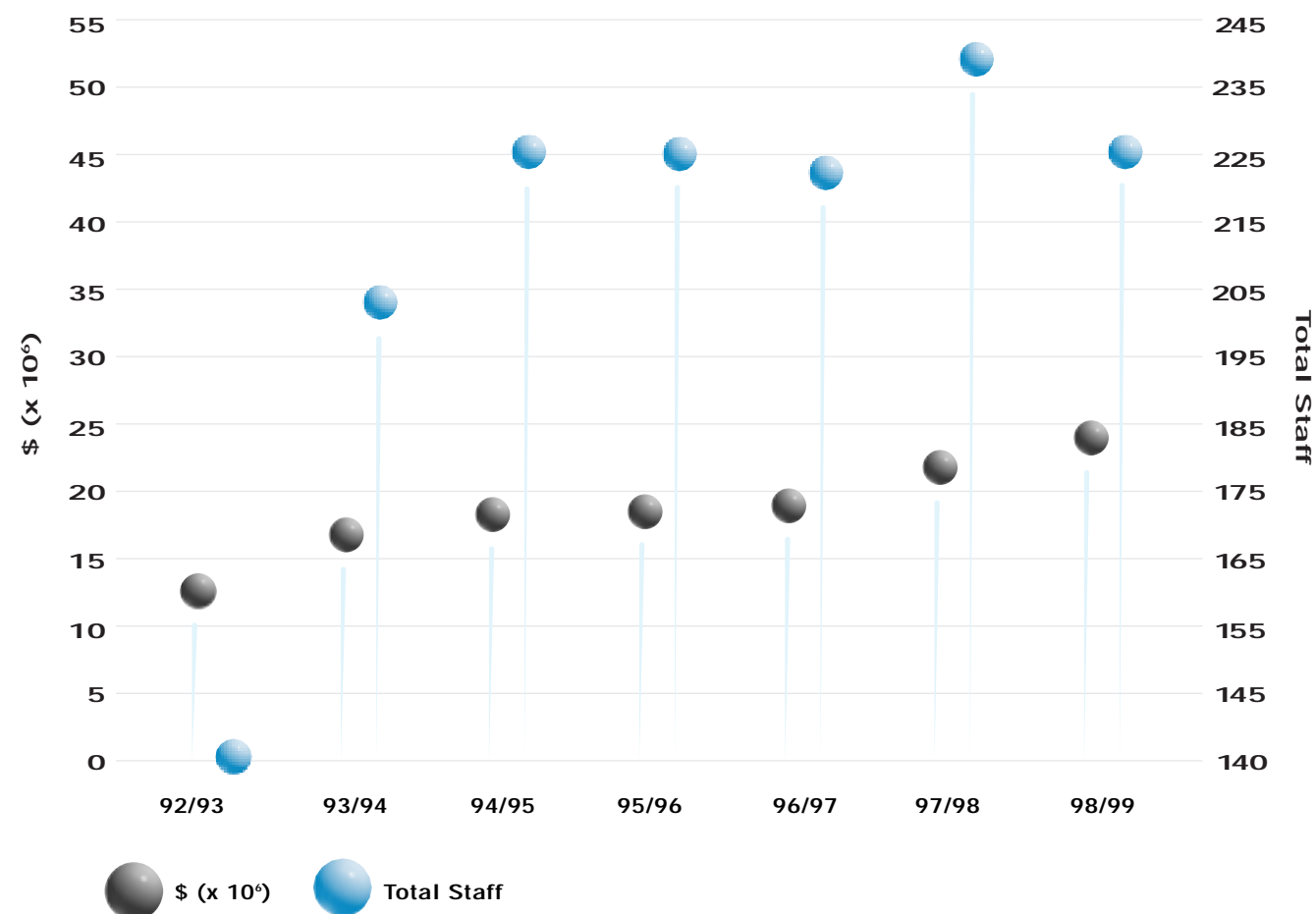
Major Scientific Equipment (>\$50k) Purchased During 1998/99



Expenditure by Research Area as a % of Total QCAT Budget



CSIRO QCAT Research Summary

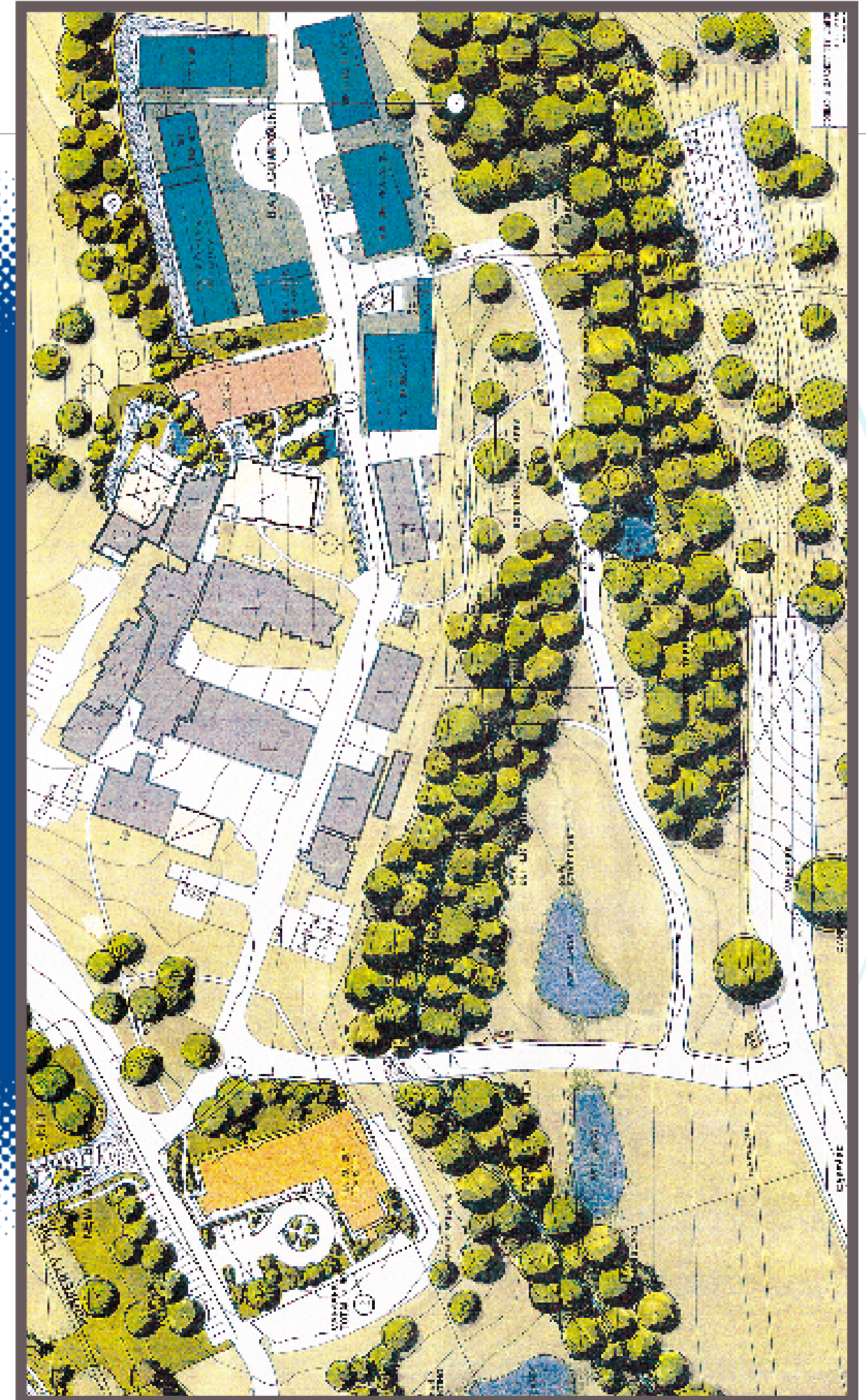
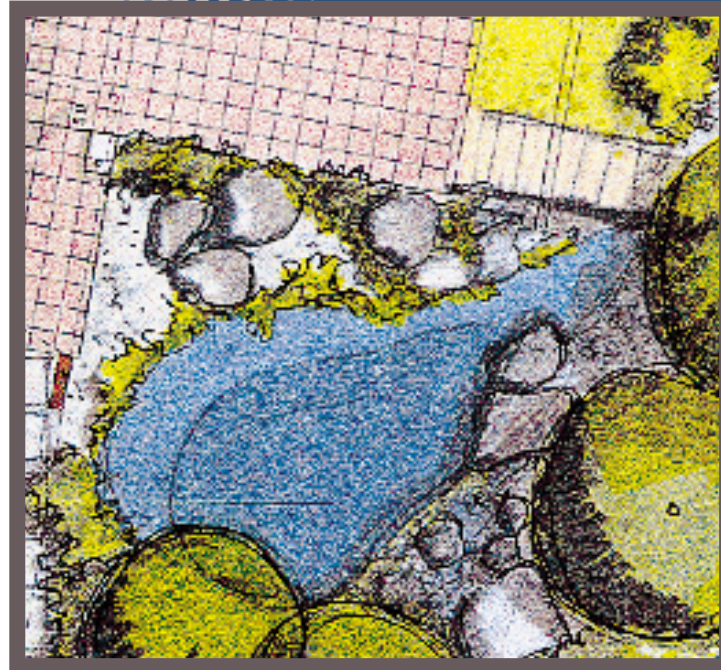


QCAT stage 2

In September 1998, Abigroup commenced construction of the advanced gasification research facility. It was completed in March 1999 and was formally opened by the Minister for Mines and Energy, the Hon Anthony McGrady, in July 1999. This Facility, established by CSIRO Energy Technology and the Cooperative Research Centre for Black Coal Utilisation, will evaluate the performance of Australian coals at the high temperature, high pressure conditions associated with advanced power generation processes.

Formal approval for the Stage 2 expansion of QCAT was received in February 1999. Primary components of the expansion are a new research laboratory, a technology transfer building, technical and process bays and expanded research support facilities. The Queensland Government funded the refurbishment of N Wing to alleviate a chronic accommodation shortage which had been compromising research results.

Following a tender process approved by the Queensland Government, Walter Construction Group began work on the second stage in the development in July 1999. With a 42 week construction period, it is hoped that the expansion will be completed in time for occupancy by early July 2000. The new facilities will enable QCAT to fulfil industry expectations for increased research into new initiatives, which increase the value added to their enterprises.



QCAT values its staff highly and recognises they constitute its most valuable asset. QCAT's workforce is highly skilled and talented as evidenced by the awards and recognition they receive.

Dr Shenggen Hu and Dr Bruce Firth of CSIRO Energy Technology were awarded the John A Brodie medal from the Institute of Engineers Australia for their paper "Factors Causing Biased Slurry Feed Subdivision and a Design Method for Unbiased Small Multi-port Distributors". The John A Brodie medal is awarded to the author or authors of a published paper on a chemical engineering topic with an immediate application to the science, art and practice of the discipline.

Dr Paul Gottlieb of CSIRO Minerals received a Certificate of Commendation from the Sir Ian McLennan Achievement for Industry Award for his work in the development of the QEM*SEM system for mineral analysis. QEM*SEM was developed to analyse the mineralogy of metallurgical products, size-by-size and particle-by-particle. It is used to assess the value of exploration discoveries and to streamline metallurgical processes.

awards AND ACHIEVEMENTS

"QCAT recognises that its most valuable asset is the quality of its people."

Dr Joan Esterle of CSIRO Exploration and Mining received one of only three scholarships awarded by the New Energy and Industrial Technology Development Organisation (NEDO) of Japan. Awards are given on the basis of merit and expertise in the Australian coal industry. Participants in this program visit Japanese coal research and industry facilities to enhance collaboration between Australia and Japan.

In 1998 the QCAT Consultative Steering Committee established two commemorative awards, the QCAT Work Achievement and Staff Service Award. The recipients of this years awards were Dr John Clout (Work Achievement Award) for his outstanding scientific contribution to the processing of iron ores, which generates substantial industry funding and support for CSIRO and QCAT, and Mr Alan Scott (Staff Service Award) for his tremendous contribution to the development and continuing success of QCAT and QCAT Stage 2.

research projects

CSIRO Exploration and Mining

- Airborne Gravity Gradiometry
- Geophysical Imaging Techniques
- Nuclear Logging Technologies
- Mine Design
- Open Cut Extension
- Inert Gas Generators
- Mine Ventilation Study
- Collision Warning
- Mine Gas Control
- 3D Photogrammetry
- Location and Monitoring Personnel Monitors
- Automated Underground Haulage
- Strain and Deformation Monitoring
- Microseismic Monitoring
- Gas Control in Coal
- Span Stability
- Roadway Development
- Longwall Support Characterisation
- 3D Geological and Geotechnical Modelling
- Highwall Mining - Geotechnics
- Sirojoint/Sirofrag
- Rock Cutting Techniques
- Coal Geology Modelling
- Coal Quality Services and Modelling
- Coal Strength and Fragmentation Modelling
- Mine Scale 3D and 4D Visualisation
- Borehole Logging
- Ground Penetrating Radar
- NUMBAT

CSIRO Coal and Energy Technology

- Turboflotation
- Banana Screens
- Size Classification
- Flow Visualisation
- Centrifuging Coarse Coal
- Gasification Performance of Australian Coals

CSIRO Minerals

- Comminution and Liberation
- Fine Particle Processing
- Application of QemSCAN
- QemSCAN Operations
- QemSCAN Sales
- Characterisation of Iron Ores
- Intelligent Crusher
- Improved Iron Ore Beneficiation
- Production of Direct Reduction Grade Concentrates
- Sampling Standards and Methods

CSIRO Manufacturing Science and Technology

- Computer Simulation of Casting
- Squeeze and Semi-solid Casting
- Magnesium Production Technologies
- Autonomous Underground Vehicle
- Mechanical Properties of Light Alloy Castings
- Dragline Swing Automation
- Wear Particle Characterisation
- Mining Robotics

Australian Centre for Mining

Environmental Research

- Native Understorey Species Regeneration at NSW Coal Mines
- Inoculating VA Mycorrhizal Fungi into Minesoils
- Status Report on Acid Mine Drainage in Australia
- Spinifex Re-establishment
- Definition of Research Needs for the Management and Rehabilitation of Tailings Disposal Facilities

Cooperative Research Centre for Mining

Technology and Equipment

- Application of Geophysics to Mine Planning and Operations
- Drill Position Sensing
- Analytical, Numerical and Experimental Modelling
- Mechanisms of Tool Wear and Tool Breakage
- Oscillating Disc Cutter
- 500-tonne, 300 MPa Triaxial Testing Facility
- Dragline Automation
- Autonomous Vehicles
- Machine-Material Interaction
- Damage Detection and Machine Condition Monitoring
- Wear Debris Characterisation
- Dragline Bucket Load Optimisation

site interactions

INDUSTRY

ACIRL
 AIST – JAPAN
 AUSTRALIAN MAGNESIUM CORPORATION
 AMIRA
 AMPLATS – SOUTH AFRICA
 ANASPEC – SOUTH AFRICA
 ANI MINERAL PROCESSING
 ANSTO
 AUSLOG
 BHP RESEARCH
 BHP COAL
 BHP IRON ORE
 BHP PORT KEMBLA
 BOEING
 BRAMBLES COAL
 CALLIDE COALFIELDS
 CAPCOAL
 COBRA RESOURCES NL
 COMALCO
 D.G.M.S. – INDIA
 D.G.M.S. – INDIA
 DMT-FP – GERMANY
 ECOLE DES MINES – ALBI FRANCE
 ERNEST HENRY MINING
 EXCEL MINING
 FOOD SCIENCE AUSTRALIA
 FRACTAL GRAPHICS
 GOLDEN RIDGE MINES
 GRIFFTH COAL COLLIERY
 HAMERSLEY IRON

IMEC PTY LTD
 INTERNATIONAL LIGHT METALS
 INSITE GEOLOGY
 JAQUES
 JCOAL
 KENNECOTT ENERGY
 KOMATSU LTD – JAPAN
 KOOLYANOBING IRON
 LINC ENERGY
 McARTHUR RIVER MINING
 MIM LTD
 MINCOM
 MINSERVE
 MINTEK
 MT ISA MINES
 NEWCREST MINING
 NORMANDY MINING
 NORTH PARKES MINES
 OK TEDI MINING – PNG
 PACIFIC COAL
 PASMINGO
 PBR
 POLITECNICO – MILAN
 PORGERA JOINT VENTURE
 QLD ALUMINA LTD
 RIO TINTO
 RMI MINING
 ROBE RIVER MINING
 SAUMIN
 SEDGMAN
 SHANDONG BUREAU – CHINA
 SHELL

SIMTARS
 TAIHEITO COAL
 TARONG COAL
 TEKSID – ITALY
 VAW – GERMANY
 WMC
 WORLD GEOSCIENCE
EDUCATION
 CURTIN UNIVERSITY
 DEAKIN UNIVERSITY
 GRIFFITH UNIVERSITY
 IOWA STATE UNIVERSITY
 LONGSBOROUGH UNIVERSITY
 MONASH UNIVERSITY
 MORETON INSTITUTE OF TAFE
 NATIONAL UNIVERSITY SINGAPORE
 NOLTA UNIVERSITY
 NOTTINGHAM UNIVERSITY
 OXFORD UNIVERSITY
 ST JOHNS COLLEGE
 UNIVERSITY OF ADELAIDE
 UNIVERSITY OF CLAUSTHAL
 UNIVERSITY OF LIVERPOOL
 UNIVERSITY OF NEWCASTLE
 UNIVERSITY OF QUEENSLAND
 UNIVERSITY OF STELLENBOSCH
 UNIVERSITY OF SWANSEA
 UNIVERSITY OF SYDNEY
 UNIVERSITY OF WESTERN AUSTRALIA
 UNIVERSITY OF WOLLONGONG
GOVERNMENT
 AUSTRALIAN DEFENCE DEPARTMENT
 BRITISH CONSULATE
 DEPARTMENT OF TOURISM, SMALL
 BUSINESS AND INDUSTRY
 DMT-FP – GERMANY
 QUEENSLAND DEPARTMENT OF
 COMMERCE
 QUEENSLAND DEPARTMENT OF
 MINES AND ENERGY
 QUEENSLAND DEPARTMENT OF
 PUBLIC WORKS
 QUEENSLAND DEPARTMENT OF
 STATE DEVELOPMENT
 QUEENSLAND HEALTH
 QUEENSLAND MINES RESCUE

The QCAT Consultative Steering Committee exists to ensure that the QCAT objectives are met. The role of the Consultative Steering Committee is:

- to consult with and to provide advice to CSIRO on Research Plans to be prepared by CSIRO and
- to review annually the activities of CSIRO at the Centre against the QCAT Objectives.

Dr John G Reid (Chairperson)

Director
 Reid Resource Consulting Pty Ltd

Dr Colin Adam

CSIRO Deputy Chief Executive

Dr Bruce Hobbs

Chief
 CSIRO Exploration and Mining

Dr Geoff Dickie

Director, Resource Development Division
 Department of Mines and Energy
 Queensland Government

Professor Ted Brown

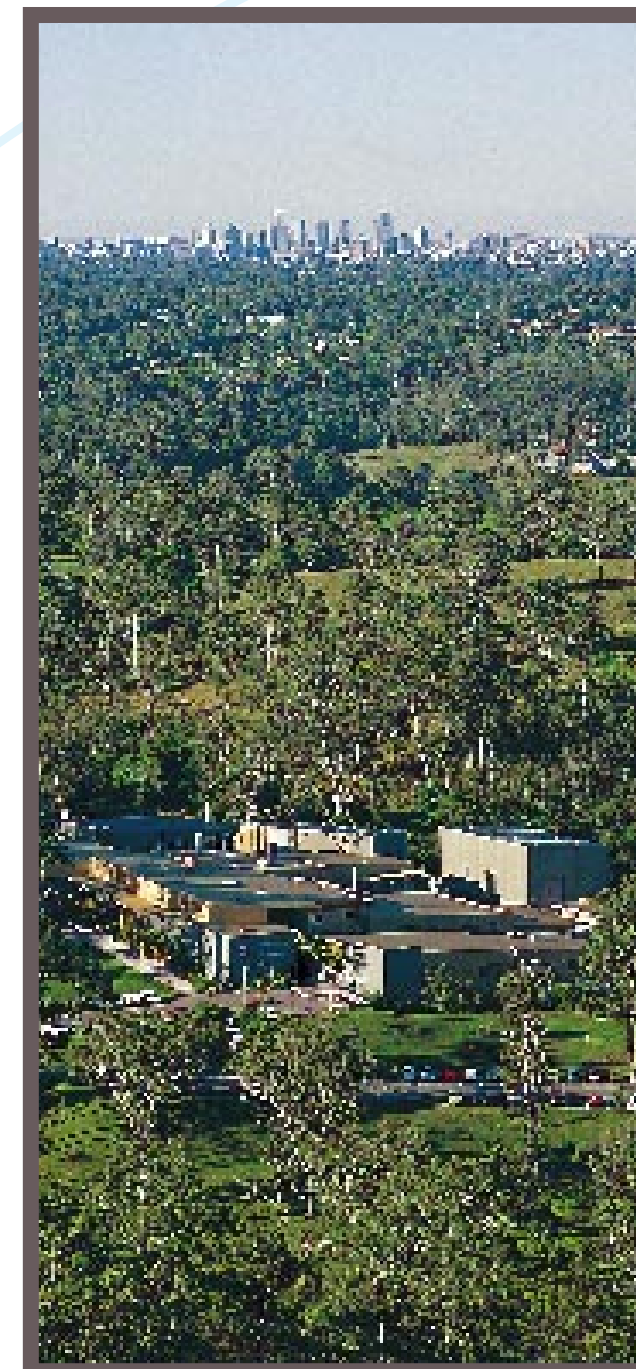
Deputy Vice Chancellor
 University of Queensland

Mr Paul Fennelly

Director
 Australian Industry Group – Queensland

Mr Bob Gannon

Special Advisor, Major Projects and Investment
 Department of State Development
 Queensland Government



Aerial view of the Queensland Centre for Advanced Technologies

QCATconsultative steering committee