

MAY 2017

## CURRENT PROJECTS

This report is a summary of current projects for the months  
February, March and April 2017

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# MAJOR PROJECTS

## C20003 RISKGATE

University of Queensland  
David Cliff

Value:	\$4,229,733
Report Expected:	25/07/2017
Industry Monitor/s :	Occupational Health and Safety Task Group Tony Egan
ACARP Contact:	Keith Smith

The main objective of this project is to design, develop and operate RISKGATE [www.riskgate.org](http://www.riskgate.org), built to coal industry requirements; and populated with knowledge obtained from mining industry experts through a series of workshops. Broad participation from the mining industry has been the key factor underlying RISKGATE success.

The final work component of the current project is to prototype a topic – vehicle interactions, into the control effectiveness model, so that potential future revision and expansion of RISKGATE can be evaluated. Various templates have been received from industry monitors and the project team has synthesised these into a single prototype model. A mapping has been undertaken to take the current collision topic across to a vehicle interaction topic with control effectiveness and control erosion features. A wire frame model has been prepared based upon advice received so far. Based upon this with input from other ACARP vehicle interaction research a full prototype topic has been prepared for evaluation by the project monitor and the project team are awaiting his feedback before proceeding to the full prototype RISKGATE topic page.

Discussions are ongoing with a number of organisations about the potential application of the RISKGATE model to other areas of mining, beyond health and safety and mining. The current financial situation is making progress in these areas difficult.

## C24062 Transportable Moisture Limit Project - International Maritime Organisation Implementation Phase

Goodwin Port Solutions  
Ash Goodwin

Value:	\$957,850
Report Expected:	25/09/2017
Industry Monitor/s :	Maritime Regulation Task Group
ACARP Contact:	Anne Mabardi

In December 2014, the Australian Maritime Safety Authority (AMSA) approved the use of the Modified Proctor/Fagerberg method for Coal providing Australian coal producers with an improved method to reliably establish the Transportable Moisture Limit of coal cargoes.

The new test was developed through ACARP project C24001, and the research undertaken in developing the test was documented and submitted to the International Maritime Organisation for consideration at the Sub-Committee for

Carriage of Cargoes and Containers (CCC 2) session held in London in September 2015.

The proposal to include the modified Proctor/Fagerberg method for coal into the IMSBC Code was considered by an IMO appointed Correspondence Group (CG) earlier in 2016 and the outcomes presented for consideration in IMO paper CCC 3/5/1 - Report of the Correspondence Group on Evaluation of Properties of BAUXITE and COAL.

In September 2016, the IMO CCC 3 plenary accepted all recommendations of the Correspondence Group and has recommended the method to Maritime Safety Committee (MSC) for inclusion in the 04/17 amendment to the IMSBC code. The proposed text is included in IMO Circular Letter No.3678 (26 September 2016).

The MSC will meet to consider the proposed text in June 2017 and, if adopted, the IMSBC Code will be amended to include:

- The modified Proctor/Fagerberg test for determination of the TML for coal, with the detailed procedure, including a methodology to determine the TML of blended coal cargoes;
- Updates to the schedule for COAL to -
  - Remove the existing size criterion under which coals can be declared as group B only;
  - Add a new particle size criterion allowing coals be declared as Group B only without TML testing if the coal is coarser than the specified criterion.
  - Include a warning statement in relation to possibility of wet base in blended cargoes.

If adopted, it is likely that the modified Proctor/Fagerberg method for coal will be available through the 2018 edition of the IMSBC Code which may be applied from 1 January 2018 on a voluntary basis, anticipating its envisaged official entry into force on 1 January 2019.

It is noted that AMSA Exemption (EX.5365) is available for use by Australian shippers and allows the use of the method until 1st January 2018. (<https://www.amsa.gov.au/vessels/ship-safety/cargoes-and-dangerous-goods>)

If the IMO adopts the method, the project team, via the Minerals Council of Australia, will seek a further exemption allowing the adopted text until 1st January 2019.

The project is currently on time and within budget.

For further information on the project, including access to the references IMO reports please contact Ash Goodwin on 0419 794 837 or via email - [ash@goodwinportsolutions.com](mailto:ash@goodwinportsolutions.com).

C27001

**Maritime Regulation Project: Self Heating and Corrosivity Test Evaluation**

Goodwin Port Solutions

Ash Goodwin

Value:	\$1,197,363
Report Expected:	25/09/2019
Industry Monitor/s :	Maritime Regulation Task Group
ACARP Contact:	Anne Mabardi

In 2015 the International Maritime Solid Bulk Cargoes Code (IMSBC Code) was amended (via amendment 03-15) to incorporate mandatory requirements for shippers to test for hazard characteristics for coal cargoes using specific approved methods. This amendment came into mandatory effect from 1 January 2017.

Specifically, the Hazard section of the IMSBC Code Schedule for coal notes that when carried on board a vessel "may create flammable atmospheres, may heat spontaneously, may deplete oxygen concentration (and) may corrode metal structures." The Characteristics table in this schedule also categorises coal cargoes as a 'Material Hazardous only in Bulk' (MHB) type cargo.

In 2016, testing of coal samples identified issues with accuracy and consistency of hazard classifications when coal was tested using the IMSBC Code tests to assess for potential corrosion and self-heating hazards. The results of the test work were presented to the Australian Maritime Safety Authority in December 2016, which led to AMSA issuing:

- Exemption certificate (EX5450) allowing shippers of IRON ORE, IRON ORE FINES, BAUXITE and COAL to use an alternative method for evaluation of the MHB corrosive properties of these materials. The alternative method is by use of the standard DIN 50929-3 Corrosion of metals; probability of corrosion of metallic materials when subject to corrosion from the outside; buried and underwater pipelines and structural components as detailed in the exemption; and
- Certificate of approval (AP5416) allowing shippers to categorise COAL, meeting certain criteria which would otherwise characterise the coal as a dangerous good, to be declared MHB (SH) on the condition that extra precautions are taken.

The documents are available on the AMSA website - <https://www.amsa.gov.au/vessels/ship-safety/cargoes-and-dangerous-goods>.

The certificates provide an interim pathway for coal shippers to declare corrosion and self-heating properties of coal cargoes, however further research is necessary to identify test methods that accurately categorise these properties for coal.

The project includes research to investigate issues identified in relation to the accuracy, repeatability and reliability of the modified C.1 corrosion test when applied to coal cargoes, and provides Australian coal producers with a centralised means of participating in the International Maritime Organisation led investigation into a modified/alternative test for corrosivity as applied to solid bulk cargoes.

The project also includes research to review the N.4 self-heating test prescribed for use in the IMSBC Code in order to identify a modified or alternative testing method to accurately establish the self-heating potential for coal cargoes.

The proposed timetable will enable alternative and/or modified test methods to be considered by the International Maritime Organization in time for incorporation within the 05/19 amendment of the IMSBC code which, if adopted will result in the alternative methods being available to shippers in a voluntary form from 1 January 2020, followed by mandatory implementation from 1 January 2021.

The project has commenced self-heating research work in conjunctions with Assoc. Prof. Kenneth Williams at the Centre for Bulk Solid and Particulate Technologies (CBSPT) and The University of Newcastle, with four test ovens planned for full time use.

Scoping and commercial discussions are underway with an intention to commence detailed corrosion investigations in May 2017.

For further information on the project please contact Ash Goodwin on 0419 794 837 or via email [ash@goodwinportsolutions.com](mailto:ash@goodwinportsolutions.com).



# UNDERGROUND

## Coalburst

C25004

### Review of Australian and International Coal Burst Experience and Control Technologies: Scoping Study and Stage 1

University of New South Wales  
Ismet Canbulat

Value: \$404,000  
Report Expected: 25/06/2017  
Industry Monitor/s : Coalburst Task Group  
ACARP Contact: Roger Wischusen

This project commenced as a scoping study which was completed in April 2016. Following the scoping study, the main objective of this project is to develop preliminary coal burst control guidelines for Australian coal mines. This objective will be met by:

- Conducting an international review of coal burst practices; Reviewing Australian coal burst experience;
- Reviewing the international and local established and/or experienced failure mechanisms;
- Identification of recommended coal burst control technologies; and
- Evaluation of control technologies against the Australian experience, regulations, mine design and operational practices.

As the final outcome of this project, a framework for coal burst management plan has been developed. This framework will assist the mines to develop their site specific coal burst management plans.

A three-day risk assessment has been held. The participants included researchers, industry representatives and a mines inspector. The purpose of this risk assessment was to assess the adequacy and the effectiveness of the proposed framework. The outcomes of this risk assessment can also be adapted by the coal mines to at their operations. This project is near completion. The final report will be submitted in June 2017.

C26006

### Coal Burst Monitoring Technology Using Microseismicity

CSIRO  
Xun Luo

Value: \$230,500  
Report Expected: 25/09/2018  
Industry Monitor/s : Coalburst Task Group  
ACARP Contact: Peter Bergin

The aim of this project is to investigate possible correlations between microseismicity and coal burst events for monitoring and prediction. This first stage of the research involves three work programs:

- Installation of CSIRO microseismic monitoring systems at three mines;

- Documentation of the microseismic data sets and mining process data and make it available for scientific use for coal burst research; and
- To perform preliminary data processing and evaluation.

The geophone array was installed along the tailgate road of LW 708 and this has completed the installation of all geophones for microseismic monitoring at Appin Mine. The network has been capturing microseismic events since it was installed in November 2016, except a number of instrument downtimes due to underground power failures.

The microseismic monitoring system has captured a seismic data set consisting of events associated with rock fracturing, mining operation and local earthquakes. Investigation of weak seismic events has been carried out. The preliminary results have shown that many weak events occurred near the roadways of the tailgate roads of LW 708. These events may be used as precursory events for coal burst prediction. Further investigation of the weak events are in progress.

C26061

### Measurement of Fundamental Mechanical Parameters of Coal - Poisson's Ratio and Biot's Coefficient

Sigra  
Ian Gray

Value: \$150,000  
Report Expected: 25/05/2018  
Industry Monitor/s : Coalburst Task Group  
ACARP Contact: Bevan Kathage

This project got off to flying start because Sigra had progressed work in this area since its application for funds, and prior to the commencement of the project. The reason for this was the need to investigate the mechanical behaviour of sandstones for tunnelling projects in Sydney. This work was done using the Sigra triaxial cell with fluid injection to determine Biot's coefficient. These sandstones were shown to exhibit a significant increase in modulus with average stress and increase in Poisson's ratio with average stress and shear.

Biot's coefficient describes the effect that fluid pressure has on effective stress and deformation within the rock matrix. It is a poroelastic parameter. Values of Biot's coefficient within Sydney sandstones were found to be variable and highly anisotropic. These results meant that the initial stresses, and effects of fluid within these rocks have not been assessed correctly in the past. This is of great importance in the design of underground openings, be they tunnels or underground mines. The new knowledge of material behaviour impacts significantly on the effective stresses and deformations arrived at in numerical models.

Using the same equipment and techniques Sigra proceeded as part of this project to measure the behaviour of three coal cores that it had. These came from different seams in the Hunter Valley and Bowen Basin. Once again the moduli were found to increase with mean stress, but to quite varying extents between samples. The relation between stresses and Poisson's ratio was found to be less definitive than in the case of sandstones and has yet to be understood. Biot's coefficient was found to be close to zero, something that is not surprising.

Sigra are awaiting further core to test in their triaxial test rig. While waiting for this to arrive they are examining how the triaxial work on reasonably regular cores may be translated to less regular cores. The use of Sigra's hydrostatic test method is also being considered to measure Biot's coefficients along with Young's moduli. Hydrostatic loading cannot be used to determine Poisson's ratios.

### C26062 New Outburst Risk Determination Measures Along With Data Gathering and Analysis for Coalburst Assessment

Sigra  
Jeff Wood

Value:	\$612,200
Report Expected:	25/03/2019
Industry Monitor/s :	Coalburst Task Group
ACARP Contact:	Bevan Kathage

This project will implement the findings of project C23014 in an operational environment and investigate coal bursts using a similar fundamental approach based on energy release.

Initial site visits were completed and relevant data requested.

The project is currently in a data collection phase with initial interpretation of operational conditions and data from supporting mines (South32 and Whitehaven Coal Narrabri Mine). Further data is promised and is expected soon. Data is currently being summarised into a form suitable for comparison of parameters, particularly gas content, gas composition, diffusion coefficients, coal toughness and structural modification of these parameters.

Critical parameters including gas pressure, gas pressure in mixed gas environments, stress direction and magnitude in coal and roof and floor material, diffusion coefficient, and fracture geometry are poorly understood. Significant effort is directed towards quantifying these by direct and indirect methods. These parameters are critical to a sensible calculation of energy parameters involved in the outburst and coal burst processes.

Successful completion of this project is dependent on the provision of appropriate data from supporting operations.

### C26066 Energy, Burst Mechanics Required for Coal Bursts and Energy Release Mechanisms

University of New South Wales  
Ismet Canbulat  
Winton Gale

Value:	\$357,500
Report Expected:	25/05/2019
Industry Monitor/s :	Coalburst Task Group
ACARP Contact:	Peter Bergin

The objective of this project is to determine the energy source, magnitude required to initiate a coal burst, assess the energy release mechanisms and then to assess the risk factors.

Although this project has started in April 2017, some important progress has been achieved. An international survey has been conducted in countries where the magnitude of coal burst has

been measured and the amount of expelled coal and the severity of the events were recorded. This review highlighted that the minor coal burst events registered seismic energy levels of approximately 10kJ with approximately 10 tonnes of ejected material. Significant events, on the other hand, were recorded seismic energy levels of greater than 1 MJ (with the amount of ejected material of approximately 15 tonnes).

A numerical modelling study has also been conducted to determine the strain energy and gas expansion energy levels in Australian coal mines. In addition, an analytical model to calculate the energy due to gas expansion has been developed.

### Detection and Prevention of Fires and Explosions

#### C21016 Cheaper and More Effective Inertant Than Stone Dust

SkillPro Services  
David Humphreys

Value:	\$470,000
Report Expected:	25/05/2017
Industry Monitor/s :	Bharath Belle Peter Brisbane Russell Uhr
ACARP Contact:	Bevan Kathage

The project leader is reworking the final report at the request of the industry monitor.

### Environment - Subsidence and Mine Water

#### C20038 Standardised Subsidence Information Management System

NSW Department of Industry  
Gang Li

Value:	\$655,000
Report Expected:	25/09/2017
Industry Monitor/s :	Dan Payne Phil Enright
ACARP Contact:	Peter Bergin

The objective of the project is to develop online facilities enabling the industry stakeholders in New South Wales and Queensland to gain access to the subsidence information resource which was established as a result of an earlier phase of the project.

Work completed against each of the project tasks are as follows:

- Horizontal movements plotted against the distance to the limit of extraction (assisted by MSEC) – The first version of this query facility has been completed based on data from all New South Wales coalfields. The project team is currently working on problems related to data outliers;
- Statistical distribution of maximum strains (compressive and tensile, respectively) from defined sampling procedures – Based on the results of a trial study, the project team has now finalised the way to present the strain query facilities, which are considered to be clear and highly practical (for the

industry). We plan to commence the software development in June 2017;

- Statistical distribution of maximum tilts from defined sampling procedures - The status is the same as the strain query facilities reported above;
- Maximum subsidence plotted against selected mining parameters – No progress during this reporting period

Stage III - There are challenges in undertaking the project, especially in the area of recovering the missing mining information, such as face positions, longwall dimensions, cover depths, etc. As a result of the missing mining data, certain desired query outputs may not be possible to be completed within the project time frame. However, according to our latest review (on 7 February 2017) of the status of missing mining information in the database, the Project Team are reasonably confident that the above-listed Project Tasks can be delivered without delay (or significant delay). In addition, our review on 2 May 2017 suggests that the impacts of missing mining information on the completion of the above-listed project tasks have now been significantly reduced.

Work Schedule

TASKS	YEAR 1				YEAR 2			
	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4
<b>Stage I - Data Warehouse &amp; Caching Module</b>								
Design								
Development / Implementation	■	■						
Test								
<b>Stage II - Subsidence Query Portal for Industry-wide Data</b>								
Research (formulae & procedures)	■	■	■	■				
Design								
Development / Implementation					■	■	■	■
Test								
<b>Stage III - Subsidence Query Portal for Colliery-specific Data</b>								
Design								
Development / Implementation							■	■
Test								
<b>Stage IV - Final Report</b>								
User Guidelines/Access Procedure								■
Final Report								■

We are here

C24013

## Managing and Conserving Native Plant Species in the Mining Environment

Royal Botanic Gardens and Domains Trust, Sydney  
Cathy Offord

Value: \$168,800  
Report Expected: 25/06/2017  
Industry Monitor/s : Bernie Kirsch  
Gary Brassington  
ACARP Contact: Keith Smith

This project seeks to optimise protocols for cultivation and preservation of germplasm from a number of *Persoonia* species. Little is known regarding the ecology of this genus beyond common factors of rare species such as limited fruit set, poor seed germination and poor tolerance of transplantation. Many of these species are listed as threatened or endangered and also occur on mining leases in New South Wales, with several species the subject of mining consent conditions.

The development of recovery programs for these species urgently requires research into ecological and biological requirements for genetically robust *ex situ* recruitment. *Persoonias* are notoriously difficult to cultivate from seed making the optimisation of protocols for seed germination, tissue culturing and propagation a priority. They naturally occur in

dynamic habitats that are prone to fire, yet there are clear inter-species differences in *Persoonia* life history responses to these disturbances. In response to fire for example, some species resprout while others are obligate-seeders, relying on seedbank generated recruitment to continue in the post-fire environment. The complex life histories of *Persoonia* species give clues to understanding their seed dormancy issues. Accordingly, our research into germination takes into account numerous variables in a multi-factorial experimental approach. Comparative studies between species are also useful in highlighting possible genus based dormancy patterns.

In order to collect standardised, viable seed, useful for experimental purposes, seeds must be collected as a single cohort just following natural dispersal. This has required the use of mesh seed dispersal bags. Last year, sufficient collections were made to conduct comprehensive experimental seed work this year. Optimal seed germination temperatures for four species have been determined using a thermogradient table. Optimal temperatures for four species (*Persoonia pauciflora*, *P. levis*, *P. nutans*, *P. pinifolia*) have been determined.

A significant obstacle for large-scale, industrial use of *Persoonia* in horticulture and restoration is the physical dormancy caused by the pyrene (woody casing) enclosing the seed. Good rates of germination have been achieved for all species that have so far been worked on in this project (*Persoonia levis*, *P. pauciflora*, *P. pinifolia* and *P. nutans*). However a highly specialised, and very slow process of extraction of individual seeds by hand is required. Treatment of seeds in germination trials are therefore focused on identifying larger-scale methods of overcoming physical dormancy by weakening or removing the pyrene without damaging the seed. So far, acid treatments (indicated from ingestion experiments) and heat treatments (indicated from an initial fire signal experiment) are of interest in further investigation. Physical dormancy appears to be the most significant issue for germination of *Persoonias*.

There are strong indications that fire (heat) and ingestion (chemical) treatments as well as optimal temperatures improve germination rates. This is particularly significant as both heat and acid treatments could assist in the remove of the pyrene (woody endocarp), which is currently the biggest challenge in germinating *Persoonia* seeds, and thus including them in restoration on an industrial scale. This information strongly informs the remaining research and provide a very positive base for the next phase of the project that extends this research to translocation of plants back into the environment.

We are pleased to report that all experimentation has now been completed. Several articles are being prepared for publication in international science/restoration journals (due for completion at the end of 2017) as well as the final report on C24013. Along with the information on management biology of *Persoonia* species generated by this project, a significant legacy of the project is the extensive seed and plant materials that will be used in the next phase of the project.

## Exploration

### C24016 Automatic Determination of Lithology Boundaries From Downhole Geophysical Logs

GeoCheck  
Brett Larkin

Value: \$76,000  
Report Expected: 25/06/2017  
Industry Monitor/s : Malcolm Ives  
Patrick Tyrrell  
ACARP Contact: Peter Bergin

This project has the following objectives:

- Develop automated procedures for determining lithology boundaries from downhole geophysical logs based on the slopes, that is 'kicks', in the geophysical traces. Emphasis will be placed on determining coal/non-coal boundaries but other boundaries will also be examined;
- Derive a methodology for matching these boundaries with the lithological information in the geologist's log;
- Use the matches to combine the derived boundaries with the geologist's log.

This quarter, the methodology has been further refined to operate on holes with multiple seams with gradational boundaries. This has now been tested on the data from two holes from different projects whose geophysical data was recorded by different logging companies. It has also been refined to not only pick seam rooves and floors but also identify the location of the midpoints of dirt bands within seams and thin coal seams within the inter-burden. The derived depths for rooves, floors and bands appear to be more reliable than those in the geologist's adjusted log. The project aims have been achieved and work is now concentrating on writing up the methodologies and results for the final report.

### C24025 Use of Core Scanning and Hand Held Xray Fluorescence Analysis in Coal Quality Assessment

University of New South Wales  
Colin Ward

Value: \$157,400  
Report Expected: 25/10/2017  
Industry Monitor/s : Malcolm Ives  
Patrick Tyrrell  
ACARP Contact: Peter Bergin

This project is aimed at developing and validating new technologies for detailed non-destructive chemical analysis of cored and in-situ coal seams for the Australian coal industry, using a combination of laboratory-based core-scanning and hand-held field-portable X-ray fluorescence (XRF) techniques. Successful completion will allow mapping of variations in ash percentage, ash composition, sulphur and phosphorus in coal seams at a much higher spatial resolution than available from conventional sampling programs, and provide an improved basis for rapid but relatively comprehensive coal quality assessment in mine geology and resource evaluation programs.

Coals with a wide range of compositional parameters have been prepared and independently analysed to develop an extended series of calibration curves and equations for both types of core-scanning instrument. Scans have been carried out with the laboratory-based system using different sampling increments and measuring times, to identify appropriate balances between spatial resolution, measurement precision at low concentrations, and the time and cost of core-scanner analysis. Scanning has also been carried out on these and other cores using a hand-held XRF analyser, to establish optimum scanning times and procedures for different elements and applications.

Check analyses have been conducted on samples from several scanned cores by conventional methods, substantially validating the results obtained from both the hand-held and laboratory systems. Issues identified from this process that may affect such comparisons include variations in moisture content, especially of claystone bands, and in some cases development of coatings on core surfaces. Analyses have also been carried out on large coal blocks with the hand-held unit, to simulate its use on faces in mine exposures. These show the sensitivity of the system for analysing individual lithotype bands and layers.

A series of synthetic calibration standards has been prepared, based on intimate mixtures of low-ash coal with measured proportions of key mineral components. After a comprehensive check analysis program, it is planned to make these available to selected industry organisations, to assist with calibration of individual hand-held XRF units for coal applications. Two papers outlining progress with the project were presented at the 40th Sydney Basin Symposium in April 2017, and other presentations are planned to communicate the results of the study.

### C24065 In Seam Wireless Drill Strong Communication System: Phase 2

University of Queensland  
Eddie Prochon

Value: \$330,000  
Report Expected: 25/06/2017  
Industry Monitor/s : Brad Elvy  
Jim Sandford  
Peter Brisbane  
ACARP Contact: Russell Howarth

The technology facilitates real-time bidirectional telemetry between the drill rig and the Bottom Hole Assembly (BHA), which will improve steering of the drill through the coal whilst also enabling tools for geological mapping of the seam.

Design and manufacturing of the system is complete. The borehole tool and drill control box have been bench and lab tested over the past two months.

Intrinsic safety documentation had to be updated for the orientation survey unit in April. Intrinsic safety certification assessments are now complete. Prior to the field trial the certifier will conduct a final inspection. This is a brief check to ensure that only components that have been certified are used.

The mine site has informed us that changes are occurring with the mine plan, which is creating extra opportunities to test the tool in a 500-600m long in-seam borehole. The original boreholes

that were going to be used in the May-June period have been removed from the new plan and have been replaced by other boreholes. The timing of the boreholes is currently fluid, and we are working with the mine to ensure we can go to site in June.

### C25067

#### Seismic Diffraction Imaging for Improved Structural Detection in Complex Geological Environments

CSIRO

Binzhong Zhou

Value:	\$178,000
Report Expected:	25/12/2017
Industry Monitor/s:	Patrick Tyrrell Paul O'Grady
ACARP Contact:	Bevan Kathage

This is an extension project that builds on the recently successfully-completed project: C22016, Enhancing fault detection by seismic diffraction imaging. In C22016, algorithms were developed to extract diffractions from both 2D and 3D reflection seismic data. The extracted diffractions can then be used to identify small faults and dykes that are difficult to detect using conventional seismic reflection processing. However, diffraction extraction using these algorithms is only effective for seismic data from horizontal or sub-horizontal coal seams. The objective of this project is to evaluate the efficacy of the previously developed algorithms for improving the reliability of small fault detection, and develop new filtering techniques to extract the seismic diffraction signals from reflection seismic data with multiple coal seam and strata, dipping at different angles. The new technique will improve the efficiency and effectiveness of detecting the anomalies and discontinuities ahead of mining in a complex geological environment.

In the past quarter, the initial assessment has been conducted for the diffraction imaging analysis of the second Glencore 3D seismic data set in Area 2 as a blind test, in which no mining mapped faults were provided to the project. Based on the diffraction analysis, ~220 discrete points, which may be associated with faulting structures in the seismic area, have been mapped. These potential fault points were reviewed by the industry monitor against the ground truth mapped from underground mining. A reasonable correlation was achieved between diffraction predictions of the structures at Area 2 and what was observed during mining of the area. However, a relatively large number of false positive features were included in the diffraction prediction and also a failure to identify some actual structures found during mining. Understanding the reasons for this needs to be investigated.

Based on the above results, a project meeting was held in March. At this meeting, the following actions have been determined:

- Further investigation of the algorithm performance through engagement of a structural geologist;
- Providing a revised work scope and budget to conclude this validation project;
- Submitting the original work of the current project as an extension project proposal in the new ACARP proposal round.

All the above have now been actioned and work is currently in progress.

## Maintenance

### C23005

#### Use of Plastic Metal in Underground Coal Mines for Minor Repair on Flameproof Equipment

Simtars

Bipin Parmar

David Turner

Value:	\$182,298
Report Expected:	25/06/2017
Industry Monitor/s :	Mark Lydon
ACARP Contact:	Bevan Kathage

Additional assessment and testing of the plastic metal has been completed as the resulting of feedback from the industry, regulators and the users of certified flameproof equipment.

A draft project report was submitted to the industry monitors on 15 May 2017 and the feedback received from the monitors was reviewed and the report subsequently amended. A revised report will be finalised by the week ending 19 May 2017 and issued to ACARP. The method of repair using selected plastic metals is viable, however the material must be selected and tested as determined in the study and supported by a NATA test report issued by an accredited test laboratory.

Furthermore person must be assessed as competent to undertake temporary repair using plastic metal. Competency assessment must include reporting of the nature of repair, equipment identification and safe handling of the plastic metal.

At standards meeting (EL-023-4), it was proposed that this method of repair should be introduced in AS/NZS 2290.1. The committee will wait for the report to be published by ACARP and review before taking action.

In general, the industry monitors have accepted the findings and will support the introduction of temporary repair into AS/NZS 2290.1.

### C24007

#### Longwall Hydraulic System Over Pressurisation Hazards Prevention

Asset Performance Improvements

Henry Bartosiewicz

Value:	\$292,250
Report Expected:	25/06/2017
Industry Monitor/s :	Jarrod Sampson Shayne Gillett
ACARP Contact:	Bevan Kathage

The longwall system hydraulic pressure monitoring programs carried out at Mandalong and Newlands Northern underground mine during the ACARP C17020 project revealed the presence of anomalous and significant pressure transients in some hydraulic circuits of the Caterpillar shields. These extreme pressure transients can affect the safety, reliability and operational performance of the longwall system.

It is important to develop a good understanding of the conditions under which these over pressurisation events can occur in

practice and to identify remedial actions in order to reduce these extreme loading conditions.

The objectives of this project include:

- Establish hydraulic pressure loading profiles (including sustained and transient pressures and their frequency) during operating cycles for different designs and various ages of longwall shields currently used in Australia (i.e. Joy, Caterpillar and Nepean/Inbye);
- Investigate the root causes of abnormal and unacceptable over-pressurization issues;
- Identify remedial actions to reduce extreme loading conditions (i.e. hose diameter and length changes, bend radius reductions, valve sequencing and relief capability, tuning of control systems, improved pressure sensing devices/strategies, contamination control etc). Where practical verify the effectiveness of proposed solutions in-situ or in the test rig;
- Review the applicability of existing criteria and methodologies for general impulse and other types of prequalification tests specifications used in qualifying longwall hydraulic hoses and other system components.

The aim of this project was to undertake longwall hydraulic pressure monitoring programs at three different designs longwall systems (ie Joy, Caterpillar and Nepean) over a period of eighteen months. Unfortunately mine closures and operational issues at participating sites resulted in project timeframe needed to be extended significantly. With site access for next pressure monitoring program being delayed until August 2017 and upon further review of findings from Joy and Nepean longwall system hydraulic pressure loading profiles, it was decided to conclude the project. Final project report is being currently drafted.

#### C24066

##### Alternative Electronic Spark Test Apparatus: Phase 3

University of Queensland  
Enver Bajram

Value:	\$460,680
Report Expected:	25/06/2017
Industry Monitor/s :	Greg Briggs Peter Henderson
ACARP Contact:	Bevan Kathage

A study comparing laser interferometry measurements to results of the explosion model was completed. The investigations were already briefly described in a presentation to the IEC committee SC31G-WG4 in October 2016. An article describing the final results has been submitted to the peer reviewed journal 'Combustion and Flame'. Additional outcomes of the modelling work will be presented at the 'International Colloquium on the Dynamics of Explosive and Reactive Systems' in August 2017.

The next steps on the topic of explosion modelling and simulation will involve application of the model to comparison with ignition limits published in the IEC 60079.11 standard. The key questions to be answered are firstly, if the simulation outputs can be reasonably interpreted to reproduce the standard ignition limit curves, and secondly, to what degree the model can be simplified and still fulfil this purpose.

The research into electrical discharges and contacts is also still continuing. For the medium term, the empirical methods of previous years (ie voltage and current measurement with high speed imaging) will be continued. An upgraded experimental setup allows discharges at lower currents to be recorded, approaching ignition limit values. A physics based approach is also being pursued with collaboration partners, but this is a longer term project.

A successful demonstration of the EST device has been conducted with the industry monitors. The device will now be demonstrated to the testing industry.

#### C25063

##### Photocatalytic Destruction of Diesel Particulate Matter

CSIRO  
Yonggang Jin

Value:	\$178,400
Report Expected:	25/01/2018
Industry Monitor/s :	Brad Lucke Greg Briggs
ACARP Contact:	Bevan Kathage

The main objective of the project is to evaluate the feasibility of photocatalytic destruction of diesel particulate matter (DPM) for better control of tailpipe DPM emissions in underground coal mines. This proof-of-concept study is based on the laboratory tests of photocatalytic oxidation of model DPM.

Printex-U was used as the model DPM and photocatalytic oxidation was tested by loosely mixing the model DPM with photocatalysts and then illuminated with a Xenon lamp. Printex-U is a commercial carbon black and has been widely used as a synthetic mimic of diesel soot. Test results obtained so far have clearly demonstrated the model DPM can be efficiently destructed and fully oxidised into CO<sub>2</sub> at tested temperatures of 30 and 80°C. Water vapour was found to significantly increase the reaction rate of DPM photocatalytic oxidation. DPM photocatalytic oxidation was being tested under varied reaction temperature and humidity conditions, closely relevant to the actual wet exhaust condition for a coal mine relevant diesel engine. Various types of titania photocatalysts are being tested to determine the optimum photocatalyst material characteristics for DPM oxidation.

#### C25071

##### Towing Force Measurement of Various Mining Equipment : Part 2

BMT WBM  
Daniel Carpenter

Value:	\$41,600
Report Expected:	25/06/2017
Industry Monitor/s :	Graeme Relf
ACARP Contact:	Peter Bergin

No report received.

## C26056 Optimisation of Low and High Pressure Longwall Hydraulic Systems

Quantise Consulting Engineers  
Russell Smith

Value:	\$80,000
Report Expected:	25/01/2018
Industry Monitor/s :	Jarrod Sampson Neville Bunn
ACARP Contact:	Peter Bergin

Modern longwall hydraulic systems typically utilise two independent fluid delivery systems. Traditional 'main emulsion' systems operate at nominally 350 bar, and typically have rated flow capabilities around 1,000 – 1,600 litres per minute (LPM). 'Hi-Set' systems, are typically rated at 420 bar, and have relatively low volumetric capacities around 100 – 200 LPM. The high-volume capabilities of main emulsion systems aim to achieve high productivity; the high-pressure capabilities of Hi-Set systems aim to maximise roof security. One system is used to go fast; another system is used to push hard.

The Hi-Set system is a relatively recent 'add-on' attempting to overcome compromises between speed and safety with earlier single pressure systems. That said, the split between high and low pressure has never been optimised. Main emulsions systems operating well below 350 bar could potentially achieve greater flow (and function speeds) than existing systems with the same installed power. Lower pressure main emulsion systems will minimise stored energy, improve system safety, and reduce component damage rates. At the same time, Hi-Set systems can be used more effectively to achieve greater roof security.

The objectives of this project are to optimise a split between high and low pressure longwall hydraulic systems. Aims include quantifying potential benefits in terms of safety, productivity, roof security, and component life. Numerical modelling will be the primary analysis and assessment tool. Project deliverables include design of an in-service evaluation test program.

The project is currently on schedule; a 'functional specification' for the modelling is nearing completion, with trial simulations expected by end June 2017.

## C26070 Industrialisation of Proof of Concept Wall Flow DOC/DPF System

Orbital Australia  
Nick Coplin

Value:	\$734,217
Report Expected:	25/11/2017
Industry Monitor/s :	Andy Withers Bharath Belle Shayne Gillett Steve Coffee
ACARP Contact:	Bevan Kathage

The use of conventional wet type disposable filters is a significant cost for the underground coal sector and there are issues with the filters maintaining performance due to a range of operational reasons.

This second stage project seeks to industrialise the proof-of-concept system developed in the earlier project. The industrialisation activities include:

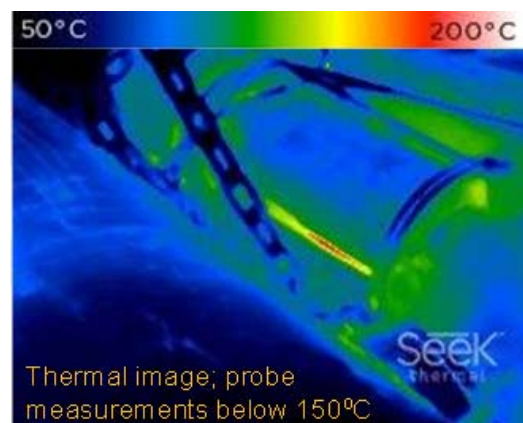
- Design and validation of the thermal and mechanical design suitable for installation as a retrofit upgrade;
- Develop and validate the requisite electronic monitoring and protection systems, including vehicle integration; and
- Achieve certification from the New South Wales Department of Industry.

The engineering approach to surface temperature control uses a mix of thermal insulation and water cooled features. Robust performance of DPF system under the lower duty cycle conditions that are typical in underground coal operations has required the use of specific DPF technology.

This quarter has seen substantial progress of the design of the mechanical and thermal systems including:

- Engineered second level prototype system prepared and initiated engine dyno thermal assessments;
- Engineering analysis for explosion and flame protection enclosure of the DPF;
- Monitoring system definition and reviews including first pass FMEAs and QRAs completed.

Dyno testing of a wall-flow DPF will continue over the next quarter as additional system samples are prepared for site trials and pre-certification assessment. Site testing is initially planned for above ground at Centennial Coal's Newstan site, followed by out-bye assessments and eventually testing within in-bye at the mine workings.



## Mining Technology and Production

C20033

### Development of a Safer Underground Explosive

University of New South Wales

Andres Castro

Duncan Chalmers

Value:	\$323,500
Report Expected:	25/06/2017
Industry Monitor/s :	Brad Elvy
ACARP Contact:	Russell Howarth

Meeting arranged with Jenny Nash to set new agreement for the use of the cannon and Gallery so that the project can be completed. Department has a new site and work is progressing to move the Gallery to this new permanent home.

Contact has been made with Dyno Nobel regarding the re authorisation of the explosives, so that testing can resume as quickly as possible once the new location is ready.

C21021

### Full Panorama View (360) Video and Laser Flameproof Enclosure

CSIRO

Ron McPhee

Zak Jecny

Value:	\$251,760
Report Expected:	25/05/2017
Industry Monitor/s :	Brad Lucke Mark Perry Peter Henderson
ACARP Contact:	Bevan Kathage

A draft report is with the industry monitor(s) for review.

C21022

### New Manufacturing Technique for Radio Transparent (Dielectric) Flameproof Enclosures

CSIRO

Ron McPhee

Value:	\$196,980
Report Expected:	25/05/2017
Industry Monitor/s :	Brad Lucke Mark Perry Peter Henderson
ACARP Contact:	Bevan Kathage

A draft report is with the industry monitor(s) for review.

C22015

### CM Self Guidance: System Hardening and Underground Deployment

CSIRO

David Reid

Mark Dunn

Value:	\$1,092,765
Report Expected:	25/06/2017
Industry Monitor/s :	Jim Sandford Roadway Development Task Group
ACARP Contact:	Roger Wischusen

The objectives of this project are to:

- Further develop the CM navigation and control technology which was developed and demonstrated during project C18023; and
- Provide a convincing demonstration of the performance and practical advantages of this advanced navigation technology in this specific underground mining application to the stage where mining companies and mining equipment manufacturers will have the confidence to take up and integrate the navigation technology into their equipment.

A fit for purpose installation of the CM guidance technology has been developed and installed on a Sandvik machine operating at Ulan mine.

Underground trials commenced producing data on 7th April 2017. The current navigation data is being analysed. Data has been acquired for 2 x 100m drives (including reversing and a cut through), with another pillar being recorded currently. Underground testing and validation will continue through June 2017, followed by the final project report.

C24023

### Gate Road Development Continuous Haulage System: Stage 3

Premron

Mick Whelan

Value:	\$1,960,000
Report Expected:	25/06/2017
Industry Monitor/s :	Roadway Development Task Group
ACARP Contact:	Roger Wischusen

This project is a continuation of project C22009 and C23017, which aims to develop an autonomous Continuous Haulage System for Mine Gate Road Development, utilising the Closed Conveyor System of the "Premron CHS" ©.

The project is based around the following key objectives:

- Manufacture and demonstrate a full scale, full length (180m), fully functional 'mine compliant' Premron CHS installed above ground (in Gladstone) and mounted on a 260m mine monorail test rig, with two opposing 90° corners;
- Continuous batch feeding during tramming, as the Premron CHS negotiates the mine monorail track;
- Confirm braking system for both trolley and conveyor belt, utilising inline Modular EXd rated brakes fitted to drive units;
- Undertake further studies on the system's performance;
- Complete mine systemisation studies.



The systemisation studies has lead Premron to complete further design and engineering surrounding the following areas:

- Coal flow studies (in/ out) of the Premron CHS. These studies are complete and we are now finalising the design for both inlet hopper and discharge chute;
- Actuation of the tail end of the CHS, to allow retraction over the panel belt. These studies are complete and we are now finalising the design for both tail and transitional trolley actuators. Premron have built a trolley prototype and are currently testing;
- Head and tail end trolley design finalisation. These drawings are now being completed in readiness to start manufacture over coming months;
- Propulsion drive design finalisation. These drawings will be completed in the coming months.

This systemisation study will ensure a successful integration of the machine into an underground coal mine.

Premron will be manufacturing a 3D scaled model to enable further systemisation reviews to take place. This will be carried out with potential host mine involvement, so that they have the opportunity to add valuable comments into the Premron CHS and its integration into their underground operation.

Premron are hopeful that a host mine can be secured during 2017, with surface testing being undertaken on the test site in central Queensland and underground trials being carried out during the second half of 2017.

#### C25058

##### Self Drilling Bolt Automation Trial

###### OKA Rock Bolt Technologies

Mark Levey  
Paul Charlton

Value:	\$1,396,000
Report Expected:	25/12/2017
Industry Monitor/s :	Jim Sandford Roadway Development Task Group
ACARP Contact:	Roger Wischusen

The project objectives are as follow:

- The OKA Technology is further refined using findings from ACARP Project C25058 and integrated into the design and development of a hazardous zone compliant retro-fit pack for a continuous miner;
- A meaningful underground trial of the retro-fit equipment at a production face is conducted. The technology is to be tested for reliability and robustness in a real production environment.

Progress to date includes:

- A review was carried out of the findings from the 500 bolt underground trial held 2016 using an airtrack bolting rig with the retro-fitted prototype to install vertical, inclined and horizontal bolts;
- Design of the production standard prototype chemical pumping and delivery system is complete;
- Procurement and manufacture of all components is in progress; and
- A host mine has committed to the trial.

#### C25061

##### Bolter Miner for Rapid Longwall Development: Phase A

###### Sandvik Mining and Construction Australia

Barry Wright  
Winton Gale

Value:	\$92,000
Report Expected:	25/05/2017
Industry Monitor/s :	Roadway Development Task Group
ACARP Contact:	Roger Wischusen

A draft report is with the industry monitor(s) for review.

#### C25064

##### Longwall Floor Coal Horizon Sensor

###### CSIRO

Jonathon Ralston

Value:	\$213,736
Report Expected:	25/09/2017
Industry Monitor/s :	Paul Buddery Rae O'Brien
ACARP Contact:	Roger Wischusen

This project aims to develop a coal thickness sensing capability intended to support the delivery of automated horizon control systems for longwall or roadway development. The project objectives are:

- Evaluate and validate radar in an outbye or NERZ area with similar geology and structure expected to be found on an operating longwall face;
- Undertake engineering tasks to design and package the radar sensing system into a form that is suitable for underground evaluation;
- Install the sensor on equipment for a short-term evaluation period.

New insight and direction has been gained by working through the results and feedback from the initial underground field evaluation process. A key outcome of this review activity has been a clearer understanding of practical operational challenges associated with deploying prototype-level equipment on a production longwall. These practical operational aspects mean that a sustained, unsupervised on-machine sensor evaluation may be difficult to achieve. In response to this challenge, the following development paths have been undertaken. Firstly, additional focus has been placed to further quantify core sensor performance as this is the enabling sensing contribution of the project; re-organisation of the radar system components is underway to provide an alternative configuration that is more amenable for underground use; and opportunities to explore evaluation of the radar system on/near a continuous miner was discussed and agreed with the RTDG.

Preparation for more field underground evaluations have been ongoing to further characterise sensing performance in different geological settings, including evaluation at Ulan and Moranbah North in the near future.

## C25069 Optimising Electrical Protection System Strategies and Technologies

ResTech  
Clint Bruin

Value: \$174,350  
Report Expected: 25/06/2017  
Industry Monitor/s : Brad Lucke  
Greg Briggs  
ACARP Contact: Peter Bergin

The key objective is to improve productivity by reducing equipment downtime due to nuisance tripping of electrical protection systems, while maintaining or improving existing levels of safety.

Following extensive literature reviews and simulation work, significant progress has been made in the following areas.

### Part A: Examining the state of the Art:

- Requirements and history for touch voltage limitation, Earth fault current limitation levels, earth leakage (E/L) trip sensitivity, E/L tripping ratio and E/L trip delay times in the USA and UK.
- A first principles examination of the E/L tripping ratio. It is suggested that two areas need to be considered:
  - the nature of the protection equipment and system loads, and
  - the overall protection system design, which incorporates choices on the earth fault limitation level and compliance with the touch potential requirements. These two areas are linked so that there is not just one 'correct' tripping ratio – as shown by the use of different values in other nations. More work was undertaken in this challenging area between February and May.
- The historical, theoretical and practical issues that determine the level of earth fault limitation current;
- Touch potential limitation requirements and comparison with practices in other industries;
- Issues related to cable capacitance have been analysed from first principles. Touch voltages in such systems can NOT be calculated as the product of the earth fault limitation current level and the total earth resistance. Equations have been developed to allow such calculations and these were validated by simulations.

### Part B: Earth continuity protection related issues:

- Developing a simulation framework to compare existing earth continuity protection schemes with proposed schemes;
- The simulation framework can evaluate earth leakage protection and adaptive protection schemes under different earth fault scenarios;
- A proposal for the addition of a multilevel pilot noise immunity test is being quantified. The specific details of a standard test are beyond the scope of this project but the principles are discussed with the hope that such a test might eventually be added to AS/NZS 2081.2;
- A first principles discussion of the functions of an earth continuity protection system has been produced. A brief evaluation of possible performance improvements is presented.

### Part C: Earth leakage protection related issues:

- Simulation of capacitive currents in realistic mine 11 kV and 3.3 kV cable models and the effect of these currents on NER selection, touch potential risk and sympathetic E/L trips.
- Examining the benefits of directional and multichannel earth leakage relays. Simulation models are used to demonstrate the potential reduction in nuisance tripping.
- Issues relating to DC earth faults.
- E/L nuisance tripping due to deficiencies in E/L current transformer design. A discussion of current transformer local saturation effects is included.

### Part D: Adaptive protection evaluation:

- The known sources of nuisance tripping have been examined and strategies are being developed to minimise them by automatically adapting protections settings.
- An analysis of the fault tolerance of an adaptive scheme is being developed.
- The project needs better data on the sources, frequency of occurrence and costs of protection system nuisance tripping.
- Developed methods that could be used for an adaptive protection system. This includes the configuration and operation of an adaptive protection system.

### Part E: Analyse, interpret, report and publish:

- Presentations were made at the Mine Electrical Safety Association Conference (MESAC) in Brisbane, the Down to Earth Conference (DTEC) in the Hunter Valley, the Electrical Engineering Safety Seminar (EES) in Sydney and MEMMES seminar, Maitland March 2017. We have also made a further presentation to NSW mines inspectors;
- A Forum was held after EES to provide more detailed information to industry and to also get feedback from industry. A total of 25 attended the Forum representing a cross section of the industry, including coal mines, suppliers and regulators. This provided valuable feedback which is being incorporated into the research;
- We are formalising system models to demonstrate the effect of changes in system parameters on the performance of earth leakage protection. This can be directly related and simplified to different cable types and lengths;
- Production of the final report documents is well underway. It has been delayed but we are now in the final stages.

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## Occupational Health and Safety

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### C24009 Establish 'At Risk' Distance from Hydraulics

University of New South Wales  
David Wainright  
Gary Nauer

Value: \$26,908  
Report Expected: 25/06/2017  
Industry Monitor/s : Paul Gill  
ACARP Contact: Roger Wischusen

Recently re-energized with active involvement of Glencore.

### C24010 Collision Awareness - Capability of Underground Mine Vehicle Proximity Detection Systems

Simtars

Andre De Kock

Value: \$482,300  
Report Expected: 25/06/2017  
Industry Monitor/s : Brad Lucke  
Jim Sandford  
Peter Nelson  
ACARP Contact: Roger Wischusen

The objective of this project is to provide an independent assessment on the effectiveness of existing proximity detection systems for use in underground coal mines against a range of relevant vehicle related interaction scenarios. The project comprises three phases, with a decision point to continue before phase three. The first phase is the accumulation and evaluation of presently available information relating to proximity and collision detection systems for use in underground coal mines. During the second phase the test specifications for evaluating the different systems will be developed. The final phase will be the testing of the different available systems against the developed tests.

The continuous miner was returned to Ravensworth. All test results were analysed and the final report is being prepared for submission.

### C24022 Holistic Evaluation of Diesel Exhaust Filters and Related Measuring Instrumentation

Queensland University of Technology  
Julian Greenwood  
Zoran Ristovski

Value: \$247,250  
Report Expected: 25/06/2017  
Industry Monitor/s : Bharath Belle  
Peter Brisbane  
ACARP Contact: Roger Wischusen

A draft report has been received by industry monitors and was found to be inadequate in both content and presentation.

### C26047 Real Time Dust Monitor

University of New South Wales  
Charles Harb  
Duncan Chalmers

Value: \$184,300  
Report Expected: 25/03/2019  
Industry Monitor/s : Bharath Belle  
Brad Lucke  
Jim Sandford  
ACARP Contact: Peter Bergin

An initial meeting has been held and planning is underway for the first series of tests to be conducted in June 2017. These tests are to be conducted in Albuquerque NM. Samples of New

South Wales coals have been obtained and samples from Queensland coal mines have been requested.

Samples will be prepared to contain large percentages of respirable fractions for testing.

These will be doped with set percentages of respirable silica.

Equipment for the tests have been obtained and will be set up ready for testing in June.

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## Roadway Development

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### C25003 Review of Roof Support Options for Next Generation Continuous Miners

SCT Operations  
Winton Gale

Value: \$43,000  
Report Expected: 25/06/2017  
Industry Monitor/s : Roadway Development  
Task Group  
ACARP Contact: Roger Wischusen

Work presented to the Roadway Development Task Group, but yet to complete a brief report.

### C25068 Automated Long Tendon Installation System

Conway Engineering  
Des Conway

Value: \$184,500  
Report Expected: 25/07/2017  
Industry Monitor/s : Roadway Development  
Task Group  
ACARP Contact: Roger Wischusen

Getting close to completion having overcome manufacturing challenges.

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## Strata Control and Windblasts

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### C21013 Improving Cavity Prediction on Longwall Faces through a Combination of Reliable Convergence, Canopy Attitude and Leg Pressure Monitoring

Golder Associates  
Bob Trueman

Value: \$696,625  
Report Expected: 25/05/2017  
Industry Monitor/s : Dion Pastars  
Paul Buddery  
Peter Corbett  
ACARP Contact: Bevan Kathage

A draft report is back with the project leaders for additional information to be recorded.

## C23008 Definition of Coal Mine Roof Failure Mechanisms

SCT Operations  
Winton Gale

Value: \$430,000  
Report Expected: 25/06/2017  
Industry Monitor/s : Brian McCowan  
Roger Byrnes  
ACARP Contact: Russell Howarth

No report received.

## C24012 Shear Testing of the Major Australian Cable Types under Different Pretension Loads

University of Wollongong  
Najdat Aziz

Value: \$389,600  
Report Expected: 25/12/2017  
Industry Monitor/s : Brian McCowan  
Jason Emery  
Roger Byrnes  
ACARP Contact: Peter Bergin

The main objectives of this project are:

- Evaluate the shear behavior of cable bolts based on the cable bolt construction structure, [hollow tube core, solid core, plain surface and spiral rib and plain or compound cable, cable diameter and number of wires; and
- Establish shear characteristics of the cable bolt with respect to the level of axial loading (pretension). All tests are to be carried out using Megabolt Single Shear apparatus.

Current status of the work undertaken to date:

- Continuing with model simulation of various cables shear using single shear rig. In particular the study evaluation the shear failure characteristics under different pretension load;
- Repeated single shear testing of Megabolt MW10 plain cables as concerns were raised about the debonding of the cable with 1.8 m long encapsulation length. Three repeated tests included -
  - MW10 P cable with six bulbs, at 15 t pretension,
  - MW10 P cable with six bulbs and at zero tonne pretension (axial load),
  - MW10 P cable, un-bulbed and subjected to 15 t pretension load,
- All three cables were debonded when tested at shear loading of < 4 mm /min vertical displacement. The findings from these tests were in agreement with early tests carried out previous in June 2016 on the samples. These tests demonstrated that plain wire cables strands were readily debond when compared with similar but indented cables;
- Numerical simulation - numerical simulation of cable bolt shearing is carried out in 2 dimensional incremental framework. Up to now, following items have been numerically simulated using FLAC 2D by extending original FISH subroutine program (embedded programing code in FLAC) as presented in UNSW Cable Bolting workshop -
  - small scale single shear test of British Standard, and
  - large scale single shear testing.

The next phase of the study will include assessing the stability of underground roadways for various cable bolt patterns, horizontal and vertical stresses, joint set and strata strength.

## C24015 Convergence Based Roof Support Design

PDR Engineers  
Terry Medhurst

Value: \$196,000  
Report Expected: 25/05/2017  
Industry Monitor/s : Brian Vorster  
Gavin Lowing  
Paul Buddery  
Roger Byrnes  
ACARP Contact: Bevan Kathage

A draft report is with the industry monitor(s) for review.

## C24018 Cable Bolt Performance Under Axial Loading and Subject to Varying Geotechnical Conditions

University of New South Wales  
Paul Hagan

Value: \$117,823  
Report Expected: 25/07/2017  
Industry Monitor/s : Brian McCowan  
Paul O'Grady  
Peter Corbett  
ACARP Contact: Peter Bergin

A two-day forum was held at UNSW with the focus on cable bolting. In attendance were over thirty persons drawn from industry, consultants and researchers that had as its primary focus work shop around four main themes with this the purpose to identify and prioritise the research needs to ensure the better use and application of cable bolting in ground support in the Australian underground coal mining industry. Consultation continued with the industry monitors and others on the draft of the final project report that will be finalised and submitted in the next quarter.

## C24020 Assessment of Longwall Mining Induced Connective Fracturing of Overburden Strata

CSIRO  
Deepak Adhikary

Value: \$297,343  
Report Expected: 25/06/2017  
Industry Monitor/s : Dan Payne  
Peter Corbett  
Richard Porteous  
ACARP Contact: Peter Bergin

The project deliverables will be new knowledge and a method for estimating the height of connective fracturing that can lead to extensive desaturation above longwall panels using commercially available geomechanics simulation software. The objectives of the project are to:

- Expand the science base and understanding of the strata caving mechanics during longwall mining;

- Develop a method to quantify the height of connective fracturing above longwall panels that can be incorporated easily into a groundwater modelling code to assess the mining impact; and
- Quantify the height of complete groundwater drainage above longwall panels.

The explicit modelling of fracture development associated with longwall mining is progressing well with the following achievements as of October 2015.

During the last three months, the following work has been completed:

- Crinum Data has been fully analysed
- Study of sponsor's site at Springvale mine is completed:
  - A detailed PFC2D model is run,
  - 3D COSFLOW is run;
- Currently we are writing report which report will be submitted to ACARP by the end of July 2017.

### C25057

#### Review of Rib Failure Mechanisms and Performance of Rib Support

##### SCT Operations

Yvette Heritage

Value:	\$186,500
Report Expected:	25/12/2017
Industry Monitor/s :	Brian McCowan Jason Emery Paul Buddery Roger Byrnes
ACARP Contact:	Peter Bergin

This project aims to review the mechanics of rib deformation over the life of the mine and to investigate effective support design to control the different mechanisms of rib deformation in order to minimise the occurrences of rib failure. The work program consists of a combined approach of deformation monitoring at underground sites and modelling to understand the mechanics of rib deformation and support interaction.

The monitoring instrumentation installed to measure rib deformation on development and retreat consists of an array instrumented bolts, shear strips and extensometers. The instrumentation is monitored throughout the change in stress distribution throughout the continuous miner advance or the retreating longwall. Results from the completed sites to date are summarised below.

Moranbah North - monitoring sites are at a depth of approximately 340m. Assessment of monitoring data has highlighted the contribution of the Tonstein Band (claystone/siltstone) as a driver for the deformation within the ribs. Both development and retreat conditions identify the Tonstein Band as the key contributor. There is also evidence on development for time dependent deformation about the Tonstein Band.

Ulan West - longwall monitoring site is at a depth of 160-190m. The key driver for rib spall on the walk side of the belt road was identified as a combination of shear fracture, forming from the longwall abutment load, and the discontinuities created by the cleat. Ulan West development site monitoring is planned to take place in May.

The next site for rib monitoring is South 32's Appin West Mine at approximately 500-550m depth. This is planned to be installed in mid 2017.

### C25059

#### Intrinsically Safe, Integrated Wireless Communications Network with a Distributed Array of Geotechnical Sensors

##### SCT Operations

Stuart MacGregor

Value:	\$339,787
Report Expected:	25/02/2018
Industry Monitor/s :	Brian Vorster Peter Corbett
ACARP Contact:	Peter Bergin

The objectives of this project are to:

- Develop a wireless communications network to interface with existing mine communications networks that has IS certification ready for submission; and to
- Develop a range of wireless capable geotechnical instruments including Tell Tales, Stress Cells, Instrumented Bolts, Shear Strips and Geophones to provide a distributed monitoring array for underground coal mines.

Work in Quarter 5 has included the following major activities.

Proof of Concept Nodes - A proof of concept radio mesh noted logging in real time wirelessly was demonstrated at the 12 month monitor meeting in late March 2017. The node was integrated with a MEMS shear indicator, although interfaces to the roof extensometer and instrumented bolts has been developed.

Bench and Initial Field Trials - A range of bench and surface field trials of the radio mesh system have been trialed during the quarter. Encouraging results have been achieved on both system hop length and power consumption (battery life) – suggesting improved distances between nodes and battery life at least equivalent to gateroad applications (2-5 years) depending on system layout and logging frequency.

Plans for Underground Trials - A preferred site has been identified for a series of underground trials that include:

- Assessment of electromagnetic interference on signal propagation underground;
- Assessment of signal attenuation in operating underground operations;
- Assessment of antenna design requirements; and
- Implementation of a limited array (nominally 20 roof extensometers) logging in real time to surface.

Underground trials are planned to commence in June 2017.

Design and Certification Requirements of Power (Battery) Units - Discussions have been held with regulatory bodies in Queensland and NSW to ensure battery design and implementation is consistent with existing and planned legislation. This is in part to facilitate timely approval once certification documentation is submitted. Preferred options have been identified for the different system components.

## C25060 Borehole Shear Monitoring Device for Routine Application in Roadways

SCT Operations  
Stuart MacGregor

Value:	\$149,863
Report Expected:	25/09/2017
Industry Monitor/s :	Brian McCowan Brian Vorster Peter Corbett Roger Byrnes
ACARP Contact:	Peter Bergin

We are proposing to construct an in-place MEMS based shear indicator that can be installed in open holes and provide sufficient resolution to resolve discrete bedding plane shear and strata failure surfaces for the range of roadway conditions present in Australian underground coal mines.

Work in Quarter 5 has focused on two main areas:

- Field Trial at Oaky North Mine; and
- Hand Held Readout Unit.

### Oaky North Field Trial

A successful field trial of a 10m long x 10 bay MEMS shear indicator was conducted at Oaky North Mine during March. The instrumentation was installed as part of a larger array, that also included a traditional strain gauged shear strip (providing potential for back-back comparison – full analysis in final report).

The instrumentation was installed into a Longwall Installation Face prior to widening, providing for a dynamic geotechnical environment suitable for field scale evaluation of the MEMS shear indicator performance.

SCT installed the instrumentation with the assistance of Oaky North personnel – with all elements providing a successful outcome:

- Sequential deployment of the mechanical anchoring system in an open hole;
- Engagement and anchoring of each individual bay;
- Correct orientation and maintenance of alignment of the MEMS axes (noting the instrument is bi-axial in the horizontal plane);
- All MEMS boards operating and logged using a project specific readout/laptop through the course of roadway widening and completion of the trial.

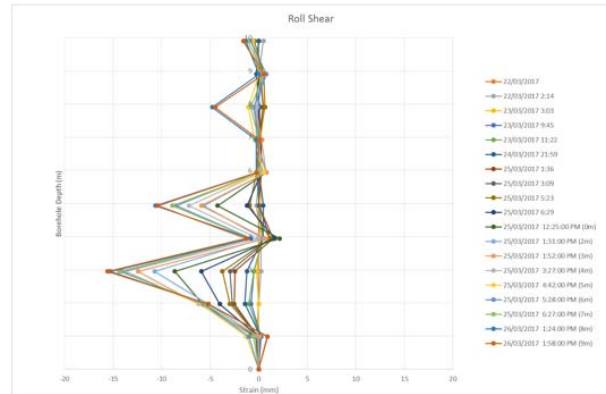
Figures below outline key elements of the installation (image at left) and monitoring (noting cabling was routed to the roadway rib-side post installation for safety and reading ease).



Successful installation at Oaky North Mine. At left – instrument being installed into open borehole, note articulation of universal

joint. At right – taking base reading on the MEMS shear indicator (full real time logging capability).

Results from the trial have been more than encouraging, with significant value and benefit being identified by Oaky North and senior Glencore geotechnical personnel. An example of the output and results from the trial is shown below – note the progression of shear into the roof and resolution achieved. Not shown here is the resolved horizontal displacement vector (derived from the bi-axial instrument) that also enables possible resolution of stress relief direction.



### Hand Held Unit

A proto-type hand held unit was displayed at our 12 month review meeting at University of New South Wales at the end of March 2017. The requirement for a robust unit was identified by industry monitors and agreed that the stainless steel prototype met these requirements.

Forward work on the hand-held unit includes finalisation of the battery design to meet IS requirements and submission of certification and testing.

## C25062 Roadway Stability Monitoring System

CSIRO  
Chad Hargrave

Value:	\$189,435
Report Expected:	25/10/2017
Industry Monitor/s :	Brian McCowan Jason Emery Jim Sandford Paul Buddery
ACARP Contact:	Bevan Kathage

The project objectives are:

- To adapt a CSIRO prototype radar system for the purposes of roadway monitoring;
- To trial this radar unit for small-change detection in a CSIRO custom-built test tunnel facility; and
- Based on the results of these in-house trials, to carry out underground trials at a suitable mine site.

The goal of the project is to fulfil these objectives to the stage where this new rapid survey capability has been established as viable, and can be demonstrated to the mining industry for future take up and integration into their underground mine management processes.

**Progress this quarter**

While initial in-house trials with the first radar prototype proved very successful, the unit was recognised as being too large and heavy for easy deployment in the underground. As a parallel activity to the project, CSIRO has funded development work on a second prototype that is smaller and lighter than the original system. This second prototype was completed and delivered during the last quarter, and commissioned at CSIRO's QCAT facility in Brisbane.

Using the test tunnel that was completed during the previous project quarter, extensive in-house testing was undertaken with the new prototype to ascertain its accuracy and precision for change detection. Modifications were also made to the scanning platform for the radar to ensure greater stability while also maintaining a light-weight and portable system. Additional testing was carried out to resolve some technical issues relating to cross-talk between the transmit and receive antennas.

Based on the in-house testing, it was determined that the second prototype was the most suitable for an underground field trial. In conjunction with Moranbah North, the supporting mine site for the trials, the equipment was reviewed and risk assessed by relevant staff including the mine electrical engineer. Necessary paperwork relating to the material construction of the sensor was submitted, and all equipment required for the trial was registered as UPEE with the mine. The first site visit to Moranbah North with the radar took place in early April. Some issues relating to the power-on characteristics of the system are currently under review, and a follow-up visit is planned for early in the coming project quarter.



### C26063 Reliable Estimation of Horizontal Stress Magnitudes from Borehole Breakout Data

University of New South Wales  
Joung Oh

Value:	\$123,000
Report Expected:	25/09/2018
Industry Monitor/s :	Rae O'Brien
ACARP Contact:	Peter Bergin

The primary objective of this project is to develop a simple and reliable method to predict in situ horizontal stress magnitudes from existing borehole breakout data. Stress measurement techniques currently available in the mining industry are expensive and time consuming. The results of this project will produce an inexpensive and reliable method that can be included in stress measurement programs to identify high risk areas where the mining conditions will be adversely affected. To

achieve this objective, the project involves four areas of investigations, namely, literature review, lab testing, numerical modelling, and back analysis.

As planned, literature review has been undertaken; completed all available stress measurement techniques and summarised pros and cons of each technique, particularly for the borehole breakout analysis to predict in situ orientations and magnitudes. It is widely agreed that the direction of the minor horizontal stress in situ stress is parallel to the breakout elongation. Estimation of in situ stress magnitudes, however, is more problematic as there are no universally accepted methods currently available. The review also includes theoretical investigations to understand the borehole failure mechanisms associated with in situ stress magnitudes.

A second component of work, laboratory study, will start soon (end of June), and thus a detailed experimental program has been established based on the literature review which identifies important factors affecting borehole breakout shape and pattern, such as different rock strength, borehole size, stress conditions, etc.

### C26064 Floor Stability: Comprehensive Investigation Into Failure Mechanisms and Controlling Factors

University of New South Wales  
Serkan Saydam

Value:	\$298,940
Report Expected:	25/02/2019
Industry Monitor/s :	Peter Corbett Jason Emery Paul Buddery Brian McCowan
ACARP Contact:	Peter Bergin

The main objective of this project is to conduct a comprehensive multidisciplinary investigation into floor failure mechanisms and controlling factors using experimental, numerical and analytical methods leading to a reliable prediction model. In addition, definitive guidelines will be provided at the end of the project to mitigate and/or eliminate floor failures. The guidelines will be supported with a combination of effective monitoring and instrumentation techniques, innovative mine design strategies and new ground support technologies. A floor classification model that describes the floor performance will also be developed.

University of New South Wales has started the extensive literature review according to the project schedule. Currently the followings have been focused in this ongoing literature study covering Australia, USA, UK, South Africa and China, and others:

- Identifying the mines that have floor heave problems;
- Collateral effects of the floor heave problem to mining activities; Identifying the gaps in the knowledge;
- Investigating floor stability problem in other disciplines;
- Investigating monitoring techniques and technologies.

In addition, an underground visit was conducted at Blakefield South Mine in March 2017 as agreed at the meeting. MG8 roadway and beltroad CTs 9, 13 and 16 were visited and water, coal and clay samples were collected. In addition, LW8 face TG8 corner, and TG8 roadway and barrier pillar were also visited.

Required visual inspection was done. After the visit a meeting was conducted with the geotechnical engineer.

Blakefield South mine provided geological, geotechnical and mine planning data. PhD student has currently been analysing this data.

In addition, Kestrel mine provided a summary report for geophysical strata rating (GSR). Jason Emery suggested to visit the Kestrel mine after November 2017.

The research team has been investigating the suitable times to visit Grosvenor, Springvale and Dendrobium mines. The next visits (May or June) will be conducted to either Springvale or Dendrobium depending on the mines availability.

A classification matrix has been developed in March and was discussed with Blakefield South geotechnical engineer. The matrix was filled using Blakefield South data, and sent to the monitors for their feedback. The classification matrix includes the following main parameters: location, mine design, geotechnical characterisation, geological characterisation, mitigating measures, history of floor heave problems.

Analytical and numerical modelling parametrisation works has been started and currently initial data collected from the literature review has been investigated by UNSW team

## Ventilation, Gas Drainage and Monitoring

### C23009

#### Improved Efficiency of Gas Capture From Boreholes Under Active Longwall Panels

SCT Operations

Winton Gale

Value:	\$380,000
Report Expected:	25/06/2017
Industry Monitor/s :	Brad Elvy David Webb
ACARP Contact:	Russell Howarth

No report received.

### C24019

#### Field Trials of Nitrogen Injection into UIS Directional Boreholes to Enhance Gas Drainage in Low Permeable Seams

University of Wollongong

Frank Hungerford

Ting Ren

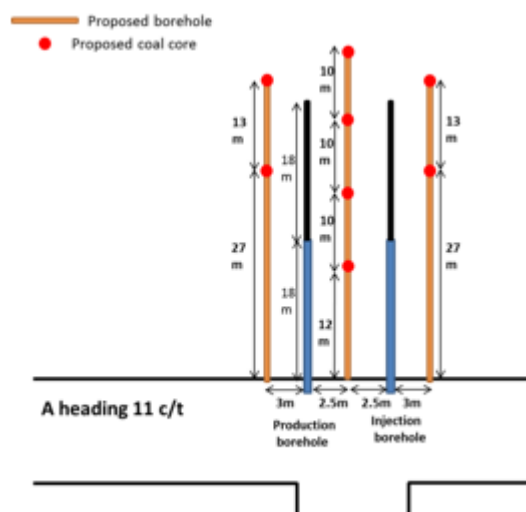
Value:	\$336,152
Report Expected:	25/11/2017
Industry Monitor/s :	Bharath Belle Brad Elvy
ACARP Contact:	Peter Bergin

The main objective of this project is to conduct field trials of the nitrogen flushing technique using UIS directional boreholes to define and determine various parameters associated with this technology, and to field demonstrate the effectiveness of such technology for enhanced gas recovery in hard to drain and low

permeability seams. Work in the last quarter has focused on the following.

#### Field trials at Metropolitan Colliery - post flushing effect assessment

We have completed analysis of field trial data collected during the trials. However the planned drilling of the three sample coring holes (shown below) have not been conducted due to tight site requirement of drilling for their development and longwall panel at Metropolitan mines. Site meeting and communications with the gas drainage engineer have been maintained with possible drilling starting in the coming weeks. The proposed drill site at Appin mine is still on hold as advised by industry monitor.



#### Experimental studies on nitrogen flushing

Additional lab experiments of nitrogen flushing were conducted coal core samples from Metropolitan and Appin mines to provide better understanding of the flushing process.

#### Final report

Whilst being advised by industry monitors to have 3-6 months extension for this project to allow extra time for the drilling to commence at Appin, we have started drafting the final project report based on work to date.

### C24024

#### Drilling for Outburst Risk Determination

Sigra

Ian Gray

Value:	\$380,500
Report Expected:	25/05/2017
Industry Monitor/s :	Andrew Lewis Bharath Belle Russell Thomas
ACARP Contact:	Bevan Kathage

A draft report is with the industry monitor(s) for review.



## C25001 Ventilation and Gas Management - Underground Coal Mines: Stage 2

Bruce Robertson  
Andy Self  
Bruce Robertson

Value: \$270,000  
Report Expected: 25/10/2017  
Industry Monitor/s : Bharath Belle  
Brad Elvy  
Jim Sandford  
John Grieves  
Peter Brisbane  
ACARP Contact: Roger Wischusen

The objective of this project is to implement a number of recommendations from the original project (review of existing ventilation and gas management practices in Australian underground coal mines) mainly preparation of guidelines and scoping reports.

The researchers have scoped the reports required and are well advance with draft documentation of several components. Workshops are proposed to facilitate industry input into the final guidelines and study reports. The project is on track for completion in October.

## C25065 Specific Gas Emission Patterns from Different Coal Seams

CSIRO  
Rao Balusu

Value: \$277,340  
Report Expected: 25/03/2019  
Industry Monitor/s : Bharath Belle  
Jim Sandford  
John Grieves  
ACARP Contact: Bevan Kathage

The objective of this project is to characterise goaf gas emissions patterns from different coal seams and develop appropriate gas emission prediction models for Australian mining conditions. The project work will involve simulation of gas emissions from different coal seams during longwall extraction using numerical and empirical models, and field studies to obtain post-mining residual gas contents of different coal seams in Hunter Valley and Bowen Basin coalfields. The project aims to obtain greater insights into goaf gas release rates from different coal seams at various distances behind the retreating longwall face. The project studies also aim to establish relationship between coal seam position and residual gas content, and develop gas emission rate profiles along the longwall panels. The project results also help in planning parameters necessary to assess gas emissions after sealing, in addition to production related gas management.

Field gas data collected from post-mining goaf holes and longwall panels is being analysed to obtain a detailed understanding of specific gas emission patterns under different mining conditions. SGE profiles derived from post-mining goaf holes data show a significantly different pattern when compared with traditional SGE prediction models. Analyses of post-mining

goaf holes data indicates that a number of mining and operational parameters also have a significant effect on actual SGE profiles during longwall extraction. Based on this data analyses, an alternative empirical model is being developed to predict SGE profiles under different mining and geological conditions. A geo-mechanical model of the Grosvenor LW panel has also been developed to obtain a fundamental understanding of gas emission patterns from various coal seams. Detailed parametric studies are being carried out to investigate the effect of various geological and mining parameters on gas emission profiles in the longwall panel.

## C25066 Gas Management and Risk Mitigation Strategies for Longwalls

CSIRO  
Rao Balusu

Value: \$289,000  
Report Expected: 25/01/2019  
Industry Monitor/s : Bharath Belle  
Jim Sandford  
John Grieves  
ACARP Contact: Bevan Kathage

The objective of this project is to develop optimum goaf gas management and risk mitigation strategies for highly gassy longwall mines to support achieving benchmark production rates. The project work will involve field studies, modelling investigations, data analyses and demonstration of optimum gas management technologies and strategies at highly gassy mines, such as at Oaky North and Grosvenor mines. The project aims to obtain a fundamental understanding of the effect of U, Z and Y ventilation systems and various other parameters on effectiveness and performance of different types of surface and underground gas drainage technologies and designs. The project studies also provide greater insights into goaf gas migration patterns under different scenarios of main fans failure, large barometric pressure variations and major goaf falls, and an assessment of the risk of irrespirable atmosphere prevailing on the face through transient modelling analyses.

Detailed CFD models of the Oaky North and Grosvenor longwall faces have been calibrated and validated with field data from the mine sites. These validated base models have been then used for simulation of different goaf gas drainage scenarios and the effect of various control strategies on gas concentration distribution patterns near the tailgate motor area under different ventilation layouts. Preliminary simulations have also been carried out with different face gas emission scenarios for detailed understanding of the gas concentration distribution patterns around the shearer. It is proposed to continue these simulations over the next few months for micro analyses of the face gas distribution patterns near the shearer under different face gas emission scenarios. It is also proposed to carry out preliminary simulations to investigate the effect of barometric pressure variations and goaf falls on tailgate gas and goaf gas distribution patterns.

## C25072 New Approaches to Mine Gas Analysis and Ratios

Simtars  
Fiona Clarkson

Value:	\$103,689
Report Expected:	25/09/2017
Industry Monitor/s :	Bharath Belle John Grieves
ACARP Contact:	Peter Bergin

The aim of the project is to identify additional gases for the detection and monitoring of spontaneous combustion. This will be achieved through three objectives.

The first objective is to conduct a survey of gases found in mine goafs, gas drainage samples, working areas and areas that include diesel vehicle traffic. The survey will establish which components of the BTEX, aldehyde and alkane low temperature fingerprint occur alongside the currently monitored mine gases.

The second objective is to investigate sealed areas which are known to have had issues with coal heating and establish if ethylene is present.

The third objective is to compare the fingerprint of these areas with that of the normal mine fingerprint and identify any differences in the two fingerprints.

A literature survey and review of relevant reports is in progress.

Stages 2 and 3 are in progress. A wider series of longwalls and mining areas are being sampled to investigate and compare the gases present with those identified from stage 1 as occurring in particular environments.

Sampling and analysis has been completed for one New South Wales mine. Sampling at a Queensland mine will take place in mid-May. A second Queensland mine is to be sampled during next reporting period. Discussions are also underway with a second New South Wales mine regarding access for sampling which will also be conducted in next period.

The results to date indicate that CO<sub>2</sub> seam gas mines have a negligible alkane, aldehyde and BTEX profile whereas CH<sub>4</sub> / C<sub>2</sub>H<sub>6</sub> seam gas mines may have butanes, and pentanes present. This presence however may not be purely a function of the ethane content.

The project reporting date has been extended to 31 August 2017 due to mine related safety exclusion periods which delayed site access in the last quarter.

## C26055 Control and Management of Outburst Risk

University of Wollongong  
Dennis Black  
Najdat Aziz

Value:	\$100,000
Report Expected:	25/09/2018
Industry Monitor/s :	David Webb Russell Thomas Sharif Burra
ACARP Contact:	Peter Bergin

The main objectives of this project include:

- Investigate the use of gas desorption rate as a sound basis for determining outburst threshold limits for all Australian coal seam conditions;
- Update Bulli seam 'benchmark' using gas data provided by Bulli seam mines, and investigate the validity of DRI900 to determine outburst threshold limit for all Australian coal seam conditions;
- Compile a database record of Australian outburst events and analyse pre-incident conditions to identify common, significant factors that can be linked to outburst events. Outburst event data will also be used to update Ripu Lama's outburst event graph;
- Research the significance of other factors, such as gas pressure, gas gradient, water saturation, coal strength and stress, that may be relevant to identifying outburst risk zones, and implementing effective monitoring and controls to reduce outburst risk.

Work in the quarter focussed on contacting the mines that committed to supply gas data and details of past outburst events, and requesting access to that data. To date, gas data and outburst event details have been received from one Queensland mine only. Efforts will continue to obtain gas and outburst data from the remaining mines that committed to support this project.

Some initial laboratory setup work has commenced with support of South32 to increase the level of detailed data obtained during core sample gas testing and Q3 gas desorption. This increased level of data collected will soon be applied to routine core sample gas testing to gather data for desorption rate analysis and updating the Bulli seam benchmark.

## C26058 Optimisation of the Coal Seam Gas Predrainage Process

Palaris Australia  
Mark Blanch

Value:	\$293,220
Report Expected:	25/09/2018
Industry Monitor/s :	David Webb Russell Thomas Sharif Burra
ACARP Contact:	Peter Bergin

This project will:

- Define the current status of gas pre-drainage design and management practices across the industry; and
- Establish a benchmark of coal seam permeability and its relationship with stress, cleat, coal rank and type, and assess how permeability measurements are best applied in the gas drainage design process.

The project will also establish a set of guidelines that will provide:

- A framework for gas pre-drainage design, management and validation; and
- A protocol for the acquisition, validation and application of key gas drainage and gas reservoir parameters.

Work in Quarter 1 has focused on:

- A literature search of coal mine gas management, gas pre and post drainage practices;
- Developing a matrix for the acquisition and assessment of mining, gas reservoir and gas drainage data.

Work planned for Quarter 2 includes:

- Completion of the literature review of coal mine gas management, gas pre and post drainage practices
- A review of the current status of gas drainage practices including:
  - site meetings at gassy mines across New South Wales and Queensland (Appin, Metropolitan, Tahmoor, Blakefield South, Mandalong, Wallarah 2, Narrabri, Kestrel, Grasstree, Carborough Downs, Grosvenor, Moranbah North, Broadmeadow, and North Goonyella Mines ),
  - data acquisition and assessment – mine planning, geology, gas reservoir, seam gas hazards and management practices.

# OPEN CUT

## Drilling and Blasting

C25005

Mine Based Trials of Alternative Explosive Formulations to Eliminate Nitrogen Oxide Emissions: Stage 3

University of Queensland

Italo Onederra

Miguel Araos

Value:	\$685,332
Report Expected:	25/09/2018
Industry Monitor/s :	Chris Bartley Ewan Mills Travis Zolnikov Vishwa Bhushan
ACARP Contact:	Cam Davidson

The main objective of this project is to demonstrate that HP based products can be safely manufactured, handled, delivered and loaded at operational amounts (1-5 tonnes per trial). This will be achieved by conducting targeted controlled mine based trials.

As part of this phase, Meandu mine was contacted and an update on the program of work was submitted. Ewan Mills from Meandu mine has agreed to be the primary contact and has confirmed Meandu's support for the trials. They have also agreed to nominate an industry monitor for the project.

With regards to trial preparation work, all the necessary equipment to manufacture the HP blasting gel in much larger quantities than previously attempted have been purchased and are currently being assembled as a modular plant. This plant will be first tested and commissioned at our Pinjarra Hills facility.

During this time, the team also visited three quarries in New South Wales owned by Bald Hill Quarries. This company is interested in supporting the development work and provide on-site support to commission the manufacturing and delivery systems, prior to conducting tests at Meandu mine.

Application for licenses to manufacture and test explosives in our Pinjarra hills facility have also been submitted to the Queensland regulator. This is necessary for the testing and commissioning of the modular manufacturing and delivery unit. The team is currently waiting for a decision by the Queensland Explosive inspectorate. A similar process will be followed with the New South Wales regulator, preliminary discussions have already taken place.

As part of the project, more human resources are being committed to the project with three new positions advertised to support the work. Interviews for both a senior and a graduate role will be conducted soon. A laboratory Chemist role has already been confirmed.

## Environment

C20015

Sustainable Management of Plantations for Rehabilitation, Carbon and Wood Products

NSW Department of Industry

Ashley Webb

Georgina Kelly

Nick Cameron

Value:	\$187,068
Report Expected:	25/08/2017
Industry Monitor/s :	Bill Baxter John Hindmarsh
ACARP Contact:	Keith Smith

The objective of this research is to quantify the benefits of an early non-commercial thinning and pruning regime on dryland forest plantations in the Upper Hunter Valley. Potential benefits include increases in biomass production, tree and stand growth and carbon sequestration. The project includes the original ACARP supported trial together with other sites to provide a valley wide perspective. This will also make the results applicable and pertinent to a number of mines.

This project aims to:

- Gather a Valley wide data base on most of the oldest tree plantations;
- Apply thinning and pruning regimes to assess the benefit of early application in dryland plantations;
- Manage existing stands via thinning to reduce risk of death and to maximise high value wood products and carbon returns;
- Provide strongly-based full rotation projections (from year 15 data) on performance of species, land type and the species/land type interaction; and
- Assess the longer term impacts of establishment techniques and soil amendments.

Milestone progress:

- All field work and data analyses for this project have now been completed;
- The final phase of this project has involved modelling timber yields and carbon sequestration for the full plantation rotation;
- A draft economic evaluation has been undertaken to assess the scale, viability and commercial aspects of future plantation forestry sites in comparison to agroforestry and grazing options;
- The draft modelling and economic evaluation results were presented to the Industry Monitors on 5 May 2017 to validate assumptions and receive constructive feedback;
- All milestones to date have been met and are on track; and
- The draft final report is due in June 2017.

### C23025 Coal Pit Lake Closure by River Flow Through: Risks and Opportunities

Edith Cowan University  
Mark Lund

Value: \$362,714  
Report Expected: 25/06/2017  
Industry Monitor/s : Colm Harkin  
Scott Diggles  
ACARP Contact: Keith Smith

The main objective of this project is to determine the risks and opportunities associated with diverting a river through a mine pit lake. Specifically, we will:

- Determine the downstream effects of pit-lake decant, with a particular focus on environmental and amenity values;
- Determine the effects of inflow on environmental values and water quality within the pit lake, (essentially a field-scale demonstration of a key finding from C21038 that larger catchments should enhance pit lake water and environmental quality);
- Understand the impact of variably saline river water on mixing within a moderately saline pit lake; and
- Develop a national standard protocol for seasonal river monitoring that could be applied by the coal industry to manage river flow-throughs (either accidental or planned), as a part of mine closure strategy.

Current activities - All data has been collected and is being analysed for inclusion in the final report that is due at the end of May 2017.

### C23032 Real Time Mine Specific Upper Air Data For Use In The Management of Mine Noise, Dust, Blast Fume and Overpressure

Todoroski Air Sciences  
Aleks Todoroski

Value: \$165,160  
Report Expected: 25/06/2017  
Industry Monitor/s : Andrew Speechly  
John Watson  
ACARP Contact: Keith Smith

Aleks has stopped communicating with ACARP. His project is under review.

### C23053 Study of Sustainability and Profitability of Grazing on Mine Rehabilitated Land in the Upper Hunter

NSW Department of Industry  
Lester McCormick  
Neil Griffiths

Value: \$200,000  
Report Expected: 25/07/2017  
Industry Monitor/s : Bill Baxter  
Nigel Charnock  
ACARP Contact: Keith Smith

The objective of this project is to answer the question 'Can rehabilitated mine land sustainably support productive and profitable livestock grazing ?'

The expected outcomes and benefits of the program are:

- A clear demonstration to stakeholders that land which has been rehabilitated can have value to the agricultural sector and wider community post-mining.
- Evidence of successful rehabilitation of grazing land to inform regulators and decision makers in New South Wales;
- Parameters for successful rehabilitation of grazing land to be used by mining operations to inform mining operation plan targets for similar rehabilitation in the region.

Progress this quarter:

- Rain in February promoted fresh growth on all sites which was recorded during pasture assessments in April;
- Cattle weight gain recorded in February was better than expected considering dry summer conditions. Weight gains from this second group of cattle following similar trends to the first group, with steers on rehab pastures on average gaining at least as much weight and often more than steers on analogue sites;
- Final weighing of all cattle to occur early June with blood samples and fat scanning at the same time;
- Progress report focusing on heavy metal and trace element testing was presented to the Mine Rehabilitation conference in Muswellbrook, March 2017;
- Grazing trial featured in the UHMD display at local (regional) field days, May 2017;
- Discussed project objectives and results to date with Gloucester Exploration Project Community Consultative Committee, April 2017.

### C24029 Development of a Toolbox for Fish Health Assessment in Aquatic Ecosystems Associated With Coal Industries

Central Queensland University  
Nicole Flint  
Sue Vink

Value: \$97,740  
Report Expected: 25/09/2017  
Industry Monitor/s : Claire Cote  
ACARP Contact: Keith Smith

The project objective is to develop practical indicators of fish health assessment that are applicable to waterway monitoring programs in coal mining regions. Since the project commenced

in 2015 we have developed and tested indicators of fish health over two years, sampling at six test locations in coal mining areas of the Fitzroy Basin. The six locations represented a range of Fitzroy Basin-relevant waterway types and land uses upstream and downstream of coal mine sites. Four field sampling trips to the test sites were conducted in:

- April 2015 (post-wet season);
- October 2015 (pre-wet season);
- April 2016 (post-wet season); and
- October 2016 (pre-wet season).

Water quality, habitat condition and fish communities were sampled at each location using a multi-method approach. Data from the test locations were used to develop a series of regionally-relevant fish indicators.

From September to December 2016 an extensive field sampling regime was conducted, collecting data on water quality, habitat condition and fish communities at 20 priority sampling sites identified in a recent review for the Fitzroy Partnership for River Health (FPRH). Data from these sites, which were situated across all of the eleven river catchments of the 142,000 km<sup>2</sup> Fitzroy Basin, were used to test and validate the proposed fish indicators. A scoring system was then developed for the new Fish Health Index, providing a set of metrics associated with fish assemblages that can be used indicate river health.

In April 2017 the Fitzroy Basin experienced heavy rainfall and severe flooding associated with ex-tropical cyclone Debbie. An extra sampling period has been added to the project to collect post-event data and test the effects of flooding on fish indicators and the Fish Health Index, at selected sites during May 2017. To allow for the collection and analysis of this additional data, the project end date has been extended (with support from ACARP and the project's industry monitor).

The fish indicators, scoring system and the data collected throughout the project, are being made available for use by FPRH for the annual Fitzroy Basin Report Card.

### C24030 Verification of the Vertical Distribution of Dust from Mining Activities

Advanced Environmental Dynamics  
Darlene Heuff

Value:	\$361,140
Report Expected:	25/07/2017
Industry Monitor/s :	John Watson Kris Sheehan
ACARP Contact:	Keith Smith

The primary objective of this study is to give both the mining industry and regulators increased confidence in the results produced by dust dispersion models by validating and improving the methodology applied to open-cut mining operations. This objective will be achieved through the determination the best methodology for calculating dispersion based on the application of the micrometeorology (option 1 and option 2) and/or PG stability curve (option 3) option within the regulatory approved dispersion model CALPUFF.

The research project is in its final stages with the field campaign nearing completion. The dust monitors are currently co-located with a TEOM for a final calibration period. Depending on the

findings during the post-deployment calibration period the dust data sets will be corrected if required.

The verified meteorological data sets will be prepared for input into the final round of dispersion modelling whilst the dust data will be used for comparison with the model outputs. The findings of the performance of the various technical options for the representation of vertical dispersion will then be finalised.

A draft report is due for completion by August 2017.

### C24031 Cost Efficient, Empirically Based Framework Using Integrated Datasets to Demonstrate Rehabilitation Quality

University of Queensland  
Peter Erskine

Value:	\$297,484
Report Expected:	25/06/2017
Industry Monitor/s :	Bernie Kirsch Paul Veivers Pieter Swart
ACARP Contact:	Keith Smith

The project objective is to correlate spatial, temporal and spectral resolutions of datasets collected by unmanned aerial vehicles (UAV) on mine rehabilitation. We are investigating the application of an object-based image analysis procedure to automate coding of rehabilitation status based on mapped landform, land-cover and vegetation biodiversity and structural information. This information should be capable of informing management activities covering a range of rehabilitation types and sites.

The draft report is close to being finalised. A few of the very large image files require further reprocessing to ensure they are included.

### C24033 Applying Risk Based Principles of Dispersive Mine Spoil Behaviour to Facilitate Development of Cost Effective Best Management Practices

Tree Crop Technologies  
Glenn Dale  
Steven Raine

Value:	\$476,104
Report Expected:	25/10/2017
Industry Monitor/s :	Craig Lockhart Jason Fittler Ross Gooley Stuart Ritchie
ACARP Contact:	Keith Smith

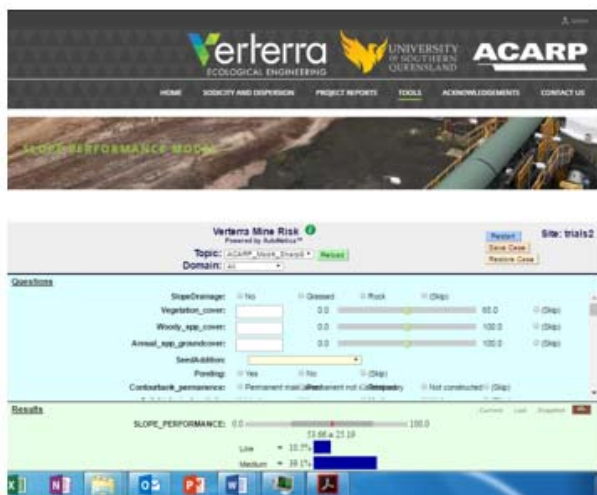
It is estimated that the current instantaneous liability for rehabilitating dispersive spoil dumps is \$2 to \$3 billion for the Bowen Basin alone and significantly more nationally. The project objective is to develop a framework to support practical, cost-effective management of dispersive spoil.

Bayesian modelling has been used to develop a mechanistic model to estimate the erosion likelihood of rehabilitated dispersive spoil sites. A web tool has been developed to present

the model as a decision support system for use by non-technical specialists. The web tool comprises three modules:

- spoil nutrition calculator;
- a slope performance model; and
- a rehabilitation cost calculator.

The spoil nutrition calculator prompts users to test the chemical characteristics of their spoil and provides a direct output of spoil nutrition (fertiliser) and stabilisation amendment (gypsum and organic matter) requirements. It also provides input to the slope performance model.



The core engine behind the slope performance module is a Bayesian network model representing the many interacting factors that influence dispersive spoil behaviour and erosion risk. The model is based on an expanded form of the Universal Soil Loss Equation (USLE) to describe both surface and tunnel erosion. The model comprises a series of sub-models, each of which incorporates factors that characterise erosive potential and management interventions.

The slope performance model estimates the probability of site erosion vulnerability (equivalent to risk consequence) and exposure to erosive forces (equivalent to risk likelihood), in order to provide a probabilistic assessment of slope performance for the inherent site characteristics, design criteria and management interventions. The model is informed by established theory and results from field assessments. Continued assessment of field trials is being used to further improve parameterisation of the model. Best management practice guidelines for dispersive spoil management are being finalised to provide a user manual to guide selection of modelling scenarios.

The final module of the web tool enables the cost implication of alternative rehabilitation design scenarios to be explored. Pilot testing of the web-tool is currently in progress prior to wider industry review.

## C24036 Incorporating Salinity into the Source Catchments Model for the Fitzroy Basin

### BMT WBM

Damion Cavanagh  
Nathan Johnston  
Tony Weber

Value: \$304,000  
Report Expected: 25/06/2017  
Industry Monitor/s : John Merritt  
Scott Diggles  
Steve Downes  
ACARP Contact: Keith Smith

This project aims to develop a salinity module within a whole of basin hydrologic model for the Fitzroy Basin. It will provide a tool within the Source modelling framework and aims to provide a better understanding of the impacts of point-source releases and other land uses (typically associated with diffuse sources) on salinity in aquatic ecosystems of the Fitzroy Basin. The project will allow stakeholders to understand the relative contributions of a range of sources and processes and how these may influence the environmental values of the Fitzroy River and its tributaries.

In this quarter, we were required to complete some additional investigation into previous results which has now been completed.

## C24038 Quantifying Coal Dust in Urban Samples

### CSIRO

David Wainright  
Graham O'Brien

Value: \$176,765  
Report Expected: 25/06/2017  
Industry Monitor/s : Bernie Kirsch  
Stuart Ritchie  
Tim Manton  
ACARP Contact: Keith Smith

The objectives for this project are to:

- Modify CSIRO's Coal Grain Analysis software so that it is able to accurately identify and provide size detail for the individual coal and the different types of non-coal particles present in dust samples;
- Develop image viewing software which will be able to be provided free with the analysis results so that the clients will in essence be able to visualize the raw image and the classified image in which size detail can be displayed for each coal and non-coal dust particle > 1 µm in size;
- In collaboration with government scientists undertake case studies at three locations around the Newcastle, Gladstone and Mackay coal ports at which samples collected monthly will be analysed to provide quantitative information on the amount and makeup of the dust present in the nuisance (>10µm), inhalable (- 10 µm + 2.5µm) and respirable (- 2.5µm) size fractions;
- Develop an effective procedure for analysing and reporting results for community supplied dust samples which are not only scientifically rigorous, but are also accepted by the general community.

The draft final report is scheduled to be submitted in mid-June 2017. It is currently progressing through an internal CSIRO review process and will be then sent to DISTI and industry partners prior to submitting it to ACARP.

### C25030

#### Guidelines that Address Uncertainty in Coal Mine Pit Void Closure

Amanzi Consulting

Dave Salmon

Value:	\$122,200
Report Expected:	25/05/2017
Industry Monitor/s :	Hayden Leary Jason Fittler Pieter Swart
ACARP Contact:	Keith Smith

A draft report is with the industry monitor(s) for review.

### C25031

#### Closure Criteria for River Diversions: An Alternative to Reference Sites

Edith Cowan University

Melanie Blanchette

Value:	\$232,293
Report Expected:	25/03/2018
Industry Monitor/s :	John Watson Michael Moore
ACARP Contact:	Keith Smith

The use of reference sites for establishing closure criteria in areas disturbed by mining activities (eg river diversions) is accepted by regulators across Australia. Sites are considered rehabilitated when their condition (as measured by physical, biological or chemical criteria) approximates that of a natural co-occurring reference site. However, this approach often creates impossible or unrealistic targets for miners seeking to close rehabilitated lands. Therefore, the broad objective of this research is to evaluate a new, more achievable approach to the closure of mine sites by comparing rehabilitated sites to the natural variability of the local environment, rather than specific reference sites. The outcome of this new approach to closure criteria will allow miners to create realistic and definable targets for relinquishing rehabilitation land, potentially simplifying closure and project approvals.

The broad aim of this research is to move from the use of reference sites in environmental assessment to a more pragmatic and robust methodology. We test this by designing realistic closure criteria based around the use of microbial communities as indicators of environmental condition. Specifically, we aim to:

- Test the validity of the approach by assessing rehabilitation sites in river diversions at Ulan and Ashton mines in the Hunter Valley;
- Compare the effectiveness of microbial communities as environmental assessment tools in relation to current monitoring programs undertaken by the companies;
- Extend and complement existing river diversion assessment tools produced by ACARP; and

- Advance development of microbial community analysis as an environmental assessment tool through testing of underlying assumptions of space, time and scale.

Field work - All fieldwork is now complete. All sites were successfully sampled for microbes, water and sediment quality (in situ and collected samples), and bio-physical variables. Outstanding field work and logistics support has been provided by the teams at both Ulan and Ashton during this project.

The microbial colonisation trial (Objective #4) began in December 2016, with support from our Montana State University colleague Professor Brent Peyton, and is now finished. This project will allow us to determine how quickly microbial communities change over time; an important aspect of determining biomonitoring 'sensitivity.' Sterile colonisation traps filled with pebbles were installed at two Ulan sites, which was harvested by Ulan staff over time to determine what microbes grow on the pebbles. The final sample collection coincided with our last field collection trip in 2017.

Logistics - In order to ensure our results are publishable and take advantage of the latest technology, we have updated our preferred DNA sequencing and bioinformatics provider to the Australian Genome Research Facility (AGRF). The AGRF has delivered excellent results and service at competitive prices on another of our DNA projects, and we anticipate submission of ACARP river samples in the next month.

Biophysical data (May-December 2016) – main messages:

- Artificially increasing base flow stability and reducing flow variability (i.e., drying periods) combined with increased light due to canopy loss likely promotes excessive growth of certain aquatic macrophyte species (reeds).
- Increased reed cover was measured throughout the study areas, although particularly within the diversions, downstream of diversions, and where flows had been altered by anthropogenic activities.
- Subtle changes in the natural flow regime by artificial diversions - undetectable by gauging stations -have an ecological effect.
- Reeds were outcompeting trailing bank vegetation in the diversion and altering benthic structure by forming layers of silt over gravel and cobble.
- Reed growth has resulted in sites becoming shallower; pools that serve as dry-season refugia for aquatic taxa are at risk of disappearing.
- The strongest relationships between sites and water quality variables occurred in May, when sites were shallower and less hydrologically connected. This is a classic phenomenon in Australian rivers, where sites evolve into unique 'mesocosms' along a drying river.

Melanie and Mark will present biophysical data (as above) from project C25031 at the IMWA conference in Finland in June 2017 in the form of a full paper and oral presentation.



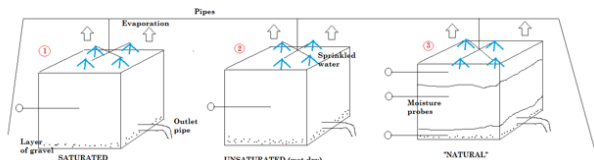
### C25039 Long Term Salt Generation from Coal Spoils

University of Queensland  
Mansour Edraki  
Neil McIntyre

Value: \$239,150  
Report Expected: 25/06/2018  
Industry Monitor/s : Claire Cote  
John Merritt  
Scott Diggles  
ACARP Contact: Keith Smith

The overall aim of the research is to develop a process for estimating long-term salinity generation rates from different classes of mine spoil and spoil pile configurations that can be used in conjunction with water balance models to predict long-term final void salinity levels or the residual risk to receiving surface water or groundwater environments.

In this quarter, work started on characterisation of spoil samples from a wide range of lithologies collected from German Creek and Rangal formations. That includes hydraulic conductivity, slaking tests, particle size distribution, EC, pH, mineralogy by XRD and petrography, shake leach, and analysis for chemical composition by ICP-OES. The correlation of spoil types from test results is in progress. Steps are being taken towards setting up the mid-scale mesocosms, such as testing the gravel liners for EC, and organising the irrigation setup and cover. The mesocosm will include a soil-like and a rock-like spoil and the experiments will run under saturated, wet-dry, and natural conditions.



The UQ PhD student, Melinda Hilton, successfully passed her 12 month confirmation of PhD candidature. She also presented at a combined CQMRG/SQLRG networking event on 28 March 2017.

### C26018 Managing Environmental Risks Effectively Post Rehabilitation for all Stakeholders

University of Queensland  
Jonathan Fulcher

Value: \$63,000  
Report Expected: 25/03/2018  
Industry Monitor/s : John Merritt  
Patrick Tyrrell  
Stuart Ritchie  
ACARP Contact: Keith Smith

The main objective of the project is to propose regulatory options and recommend achievable and practical solutions to overcome the current obstacles constraining both progressive rehabilitation certification and final surrender of coal mining leases, primarily in Queensland. The project has a focus on recommending reforms that would maximise the ability for mined land to be returned to the community for economic land

uses that are consistent with the character of the local area, while providing improved certainty for government, landholders and coal miners.

The project is currently on time and within budget. In consultation with the industry monitors, the authors brought forward elements of the consultation and 'knowledge transfer' components of the project, by engaging in consultation with the Queensland Resources Council and meeting with representatives of Queensland Treasury Corporation (QTC) in the first quarter, rather than as originally intended at the end of the project. The aim was to communicate anticipated findings of the project and discuss with QTC in a timely way, in the context of QTC and Queensland Government work on a Discussion Paper: Better Mine Rehabilitation for Queensland and a Policy Position: Financial Assurance, both released on 4 May 2017. Work on research and writing during the first quarter was primarily directed towards reaching this point, but it will now be necessary to tailor the structure so as respond to the Discussion Paper, particularly any identified gaps, with submissions closing 15 June 2017. Consequently, the timing for the research paper is also proposed to be brought forward to 5 June 2017, so that peak industry groups and government are able to make use of it.

### C26019 Prediction of Long Term Erosion at Pit Walls

Henderson Geotech  
Sue Henderson

Value: \$90,000  
Report Expected: 25/03/2018  
Industry Monitor/s : Gavin Lowing  
Jason Fittler  
Ross Gooley  
ACARP Contact: Keith Smith

The aim of the project is to provide a basis for estimating the effect of highwall and endwall erosion on the final void stability and footprint. In the first stage, the extent of erosion behind existing pit walls will be measured from imagery and survey and will be correlated to possible contributing factors such as age of wall, wall slope and depth of Tertiary. The Siberia Landform Evolution Model will then be run for at least two selected walls to extrapolate erosion effects into the long term.

The project commenced at the beginning of March, with numerous mines, mainly in the Bowen Basin, contacted to request data. Ten mines and one other mining company have agreed to supply information; to date, two mines have supplied full data and three other mines some data. Reminders have been sent to the other participating mines. From the information provided, pit walls covering a range of ages, profiles and erosion conditions will be selected and other key properties will be measured from survey. Simple statistics and graphing will then be used to look for the key drivers of erosion performance.

Two or more pits where there is a history of survey data and erosion progression will then be selected for landform evolution modelling. Erosion to date will be used to calibrate each model, which will be run to simulate 100 years exposure to predict how erosion would continue if each wall was exposed long term.

It is anticipated that results of the study will be presented as predictive graphs and/or a decision table.

## C26024 Coal Mine Particulate Emission Factor Validation

Pacific Environment Operations  
Judith Cox

Value: \$133,794  
Report Expected: 25/08/2017  
Industry Monitor/s : Andrew Speechly  
John Watson  
ACARP Contact: Keith Smith

The main objective of the project is to update the Upper Hunter Air Quality Particle Model with the Australia specific emission factors, material properties and control factors.

The intended outcome of the project is to provide a robust demonstration that the particulate emission factors developed through previous ACARP funding can be used to improve atmospheric dispersion modelling performance against actual observations. This will provide further evidence that the particulate emission factors are applicable to the Australian mining industry, and should be adopted as industry-standard.

In this quarter we have progressed with the updating of the emission inventories and completed preliminary dispersion modelling. A draft report is due by the end of July 2017.

## Geology

### C24032 Supermodel 2015 - Fault Characterisation in Permian to Jurassic Coal Measures

University of Queensland  
Joan Esterle  
Renate Sliwa

Value: \$316,730  
Report Expected: 25/06/2017  
Industry Monitor/s : Matt Grant  
Richard Ruddock  
ACARP Contact: Cam Davidson

No report received.

### C24064 Rotary Air Blast Drill Rig Top of Coal Detection While Drilling: Phase 3 Production Prototype

University of Queensland  
Enver Bajram  
Scott Adam

Value: \$245,000  
Report Expected: 25/05/2017  
Industry Monitor/s : Andrew Denman  
Kirk Henderson  
Vishwa Bhushan  
ACARP Contact: Cam Davidson

A draft report is with the industry monitor(s) for review.

## C25025 Guidelines for Estimating Rock Mass Strength from Laboratory Properties

University of New South Wales  
Ismet Canbulat  
Joan Esterle

Value: \$396,685  
Report Expected: 25/03/2018  
Industry Monitor/s : Dan Payne  
Gavin Lowing  
Gift Makusha  
ACARP Contact: Cam Davidson

The main objective of the project is to develop a guideline for downgrading the laboratory properties to the field condition through combining the conventional rock mass classification systems and Synthetic Rock Mass numerical modelling technique.

Over the last few months at UQ, a Bonded Particle Model automatic calibration function has been written and tested successfully within a 1% tolerance of the target properties (UCS, Young's Modulus, Poisson's Ratio). The function is now being expanded to adopt Discrete Fracture Network (DFN) properties for Synthetic Rock Mass modelling. CSIRO's Siromodel Open Pit Simulator (OPS) software has been used to derive the DFN properties, including joint length, orientation and spatial location. Also, more data analysis for SILC test was conducted on weak coal. Overall, it was found that the cylindrical samples reveal more consistent values than the irregular particles. Next stage includes validation of the alternative lab test results for sub-bituminous coal. The validation will consist of numerical simulation and/ or UCS tests for couple samples (non-standard size).

SCT has used Deer and Miller classification to classify the elastic moduli and UCS data. This classification can provide industry with required data for numerical modelling. The new analytical model to estimate the UCS of rock mass was validated based on some past field cases. Additionally, through statistical analysis of the database, probabilistic distribution function of UCS, E/UCS for different rock types were determined.

UNSW over the last few months has focused on modification and improvement of weak rock mass downgrading chart in conjunction with UQ and SCT researchers as well as a couple of external experts. A workshop has been held at UNSW to improve the downgrading chart. Based on the comments and suggestions received from this workshop, a series of laboratory tests are planned to be conducted on intact rocks with low UCS as well as the jointed rocks. Additionally, UDEC models have been adopted in parallel with laboratory tests to calibrate the downgrading chart.

## C25027 XCT Prediction of Breakage and Washability from Bore Cores

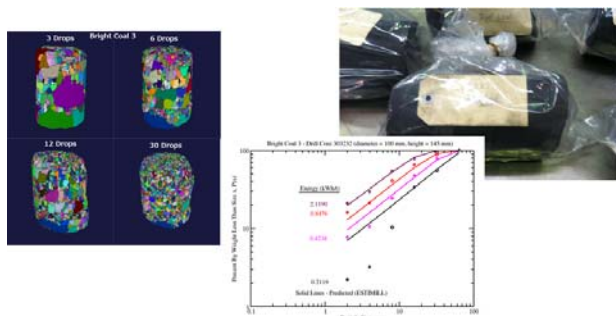
University of Queensland  
Anh Nguyen

Value: \$200,000  
Report Expected: 25/06/2017  
Industry Monitor/s : Patrick Tyrrell  
Richard Ruddock  
Shaun Booth  
Stella Martinez  
ACARP Contact: Cam Davidson

The objectives of the project are to:

- Perform 3D imaging of coal and core samples;
- Perform size reduction by progressive contained drop tests;
- Develop model of breakage characteristics and process;
- Estimation (modelling and prediction) of resulting PSD related to input energy;
- Relate the results to results from conventional laboratory crushing assessment methods;
- Model and estimate washability characteristics; and to
- Compare the predictions with washability results obtained by float-sink analysis.

Seven borehole samples from a BMA mine were obtained. Six of them, representing two samples for each of the sample types (bright coal, dull coal and sand stone) were selected for scanning and examining. The drop shatter testing and analysis to predict the sample breakage and washability were also completed. The washability experiments are in progress as the available float-and-sink facility had to be relocated and reconstructed. The team is also working on the final report, which is expected to be submitted as scheduled. Shown below are the images of the typical results.



## C25028 Coal Quality by Analysis of Scanned Images

University of Queensland  
Emmy Manlapig

Value: \$205,600  
Report Expected: 25/06/2017  
Industry Monitor/s : Justin Manalo  
Mark Laycock  
Noel Pranoto  
Patrick Tyrrell  
Richard Ruddock  
ACARP Contact: Cam Davidson

The objective of this proof of concept project is to test the CORESCAN core imaging technique and the REGI method as a rapid, non-destructive method for characterising the

processing attributes and the product quality including rank, type and grade (ash/yield) characteristics for drill core samples.

The aim of this project is to estimate the breakage characteristics and the ash-yield curves for the different sections of the entire drill core sample. In this project the team used the combination of the following technologies to estimate the hardness and washability data for the entire drill core sample:

- CORESCAN core imaging technology as the rapid and relatively low cost imaging method for providing the primary image for the entire drill core sample;
- Medical CT scan imaging technology to provide an estimate of the size distribution and density characteristics of selected portions of the drill core sample representing the typical individual lithologies or combination of lithologies;
- Laboratory testing methods to determine the actual processing properties like hardness, size distribution and density of the different sections of the drill core sample representing individual lithologies or combination of lithologies.

Using the combination of the three testing methods it is possible to characterise breakage behaviour and ash yield curves of the different sections of entire drill core sample at a relatively low cost.

The project team presented to Campbell Davidson and to the project industry monitors the summary results of the project in April 2017. The team presented:

- A description of the core scanning of Chipanga seam for this project and how the reflectance/albedo provided information on rank and type of the coal;
- The development of image analysis methods in order to distinguish the different lithotypes; and how the breakage characteristics of the coal could be related to lithotypes as determined by Corescan cluster analysis;
- The utilisation of the above method to test lithotypes for Goonyella Upper seam from BHP;
- Characterisation, modelling of coal degradation based on experimental procedures on limited number of samples and the prediction coal breakage and degradation for the entire drill core sample.
- Characterisation and modelling of washability and the ash-yield curve based experimental procedures on limited number of samples and the prediction of the parameters for the entire drill core sample.
- A description of the project work flow, the development of a potential industrial scale work flow and how the outcomes could be applied in the industry including its integration into the exploration data
- A discussion was then held on pros and cons of Corescan and the developed methodologies

The team is now preparing the final report and intends to submit as soon as it is completed.

## C25035 Coal Subsurface Mapping for Open Cut Selective Mining

CSIRO  
Andrew Strange

Value:	\$182,772
Report Expected:	25/09/2017
Industry Monitor/s :	Brett Domrow Margaret Stewart
ACARP Contact:	Cam Davidson

The objective of this project was to develop a reliable seam sensing system to provide selective mining capabilities for open-cut coal mining. The system developed in this project will scan the surface of an exposed coal roof already prepared for mining and generate a surface horizon of the coal floor or underlying interface. The generated surface horizon will then be available to an operator in the cab providing assistive guidance.

The developments over the past quarter are as follows:

- The custom data acquisition software has been completed. This acquisition software was developed to run on an industrial embedded processor board located on the mobile platform as opposed to the commercial software used previously that required a laptop computer to be connected directly to all of the sensors. The data is saved to a local database on the embedded board and is accessible via a wireless link.
- Display software has been developed so that the data can be visualised in real-time as a means to monitor the system during the data collection phase. This display software runs on a laptop and connects to the mobility platform via a wireless link, thus allowing the supervisor/operator to monitor the system from a suitable location close by.
- Software to process the sensor data and generate the subsurface maps has been developed and demonstrated. This can be executed by the supervisor/operator either directly after the scanning process has completed or at a later time more suitable.
- Software to convert and export the subsurface maps to a format compatible with commercial site management software has been completed. A DXF file containing two layers of grid points generated the system was sent to New Acland for testing. The two layers in the file correspond to the ground surface elevations and underlying coal floor surface horizon generated during the survey conducted at New Acland in August 2016. The DXF file generated by the system was successfully loaded by the site management software.

## C25040 Shear Strength Characterisation of In Pit Mud to Ensure Low Wall Stability

University of Queensland  
Adrian Smith  
David Williams

Value:	\$210,000
Report Expected:	25/03/2018
Industry Monitor/s :	Gavin Lowing Leigh Bergin Shaun Booth
ACARP Contact:	Roger Wischusen

The overall objective of this project is to identify spoil and floor materials that do not require removal prior to spoiling because they do not substantially degrade on wetting-up, and hence are unlikely to promote low wall spoil pile geotechnical instability. The specific objectives of the project are to:

- Geologically identify and sample selected fresh and degraded spoil and floor materials to assess their potential for water-softening;
- Carry out appropriate in situ shear strength assessment of water-softened in-pit spoil and floor materials that can safely be accessed;
- Characterise physically and chemically in the laboratory the representative spoil materials sampled, including testing for slake durability;
- Carry out laboratory shear strength testing on fresh, moistened and water-softened specimens of the spoil and floor materials sampled;
- Relate the laboratory shear strength of the spoil and floor materials tested to their physical and chemical characteristics;
- Confirm the shear strengths determined through the back-analyses of low wall failures due to the water-softening at the base of low wall spoil piles;
- Develop field testing protocols for the identification of degradable spoil and floor materials, and to develop design guidelines for enhancing the geotechnical stability of low walls for both durable and water-softened spoil; and to
- Disseminate the results of the Project to the industry through quarterly progress reports to ACARP, approximately six-monthly project review meetings, industry seminars, a timely final report, and conference and journal papers.

The 24-month work program began on 1 March 2016. Since commencement, the first mud sampling and testing campaign has been completed. Representative samples from BMA's Goonyella-Riverside, Peak Downs and Cavil Ridge mines have been subjected to physical and chemical characterisation, and shear strength testing.

The bulk samples of Category 1 and 3 mud types from Caval Ridge and Goonyella Mines, collected on 30 November 2016, are being subjected to a range of laboratory testing. This currently includes triaxial testing, and investigations into the rate of degradation of spoil and mud subjected to prolonged exposure to water, and to repeated wetting and drying cycles.

Efforts are being made to research viable options for the in situ testing of mud deposits, including laser-induced breakdown spectrometry (LIBS), infrared spectroscopy, and a drone system. The aim is to develop a range of cost-effective means of more reliably categorising different spoil types and the mud

derived from them, and of cost-effectively and safely investigating the geotechnical parameters of mud to enable an assessment of whether or not it can be spoiled on. Rapid identification of spoil materials prone to break down could be used on site to compliment visual categorisation.

Spoil slope stability analyses undertaken using Galena and Slide 7 are being complemented using the full mining suite provided by SoilVision Systems, which provides the ability to analyse slope stability in three dimensions.

### C26022 Real Time Prediction of Coal Top Through Guided Borehole Radar Wave Imaging for Open Cut Blasthole Drilling

CSIRO  
Binzhong Zhou

Value:	\$210,985
Report Expected:	25/11/2018
Industry Monitor/s :	David Drakeley Troy O'Reilly
ACARP Contact:	Bevan Kathage

Damage to the tops of coal seams caused by incorrect blast stand-off distances is a serious issue to the industry costing the equivalent of about one open cut mine for every ten operating mines in coal lost. To date, no effective and economically-sound techniques are available to map and characterise coal seam structures in the open cut environment.

This project will use conductively-guided borehole radar (BHR) waves for real-time prediction of coal top during blast hole drilling. The method uses a conventional BHR with a dipole antenna, which can image sideways around the borehole, electrically coupled to a conductive wire or steel drill-rod to induce a guided wave along the axial drill-rod. The drill-rod ahead of the BHR becomes part of the radiating antenna. The guided wave travels to the end of the drill-bit when some energy is reflected back and the remainder radiates from the drill bit. The radiated energy will be reflected by geological discontinuities such as the top of coal, and recorded by the BHR. This project will investigate the practicality of real-time prediction of coal top using this guided BHR wave imaging technique.

The project team is currently in a process to define the selection criteria for trial sites; and technical parameters for success of the trial in prediction of coal seam top by the proposed technique.

### C26029 Controls on Fluorine and Phosphorus Distribution in Bowen Basin Coals

University of Queensland  
Joan Esterle

Value:	\$141,050
Report Expected:	25/02/2019
Industry Monitor/s :	Richard Ruddock
ACARP Contact:	Keith Smith

The aim of this project is to improve the predictability of in situ fluorine and phosphorus distributions within Bowen Basin coals. The approach is to map element variability within seams across minesites, to detect domains and geological controls (primary

deposition, subsequent burial and deformation, intrusion or groundwater). Samples within and between seams in high and low domains under different settings will then be analysed to determine possible origins by geochemical (isotopic) means. This requires isolation of the mineral, commonly apatite and fluorapatite, commonly entrained within the cell lumens of semifusinite, but also occurring (less commonly) in fractures or other macerals.

During February to April the team sought to find and/or develop a suitable sample preparation method for isotopic analysis. So far, only one sample has been processed due to limited sample mass. This sample has known high phosphorus and fluorine values. The preliminary preparation method has involved two primary steps:

1. Liberating the mineral matter through crushing the whole coal sample; and
2. Separating the mineral matter from the coal (preferably apatite separation).

At this stage, we have attempted to liberate the mineral matter (inorganic fraction) by crushing the coal (organic fraction) using either a mortar and pestle or SelFrag (Sustainable Minerals Institute, Dr. Frank Shi). SelFrag stands for selective fragmentation. It is a processing method that uses electrical current to selectively break a sample along planes of weakness. This break-down occurs between components with different electrical conductivities. The SelFrag preparation method was much more successful, yielding majority of apatite separation with a top size of 20 microns.

We then attempted to separate the organic and inorganic fractions using density, selective agglomeration and hand-picking techniques. However, none of these techniques were successful in separating the apatite from the rest of the sample.

Due to the low success of the crushing and separating methods, we will now try to remove the organic fraction using low-temperature ashing (LTA) techniques. Once we remove the organic fraction, we will use X-ray diffraction (XRD) to test the sample for carbonates. If carbonates are present differential solubility methods, such as using an aqueous solution of triammonium citrate, may remove such contamination, forming a carbonate-apatite concentrate.

The primary focus for May to July will be:

- Finish developing the sample preparation method for isotope analysis;
- Start the isotope analysis for company A;
- Collect data and samples from the remaining sites;
- Interrogate the data and start the spatial analysis; and
- Explore cathodoluminescence as a fluid source indicator in coals.

### C26030 Improved Structural Mapping of Pit Walls using UAV Based Mobile Laser Scanning

University of New South Wales  
Simit Raval

Value: \$96,068  
Report Expected: 25/09/2018  
Industry Monitor/s : Adrienna Brown  
Brian Vorster  
ACARP Contact: Keith Smith

The main objective of this study is to integrate a UAV based mobile laser/LiDAR scanning system and test its capability to map structural characteristics of pit walls as well as compare the results against conventional systems (ie TLS and photogrammetry) in various weather and operating conditions. The study will result in the development of an operational guideline for optimal structural mapping of pit walls in conjunction with UAV-LiDAR system.

In this first quarter, a robust UAV-LiDAR system has been prototyped at UNSW by integrating a 3D mobile laser scanner (Velodyne VLP-16), high-precision RTK GPS, miniature inertial navigation system (INS) onto a stable tandem-rotary-quadcopter. Furthermore, a high-speed data downlink capability was realised on the UAV platform to deliver real-time data.

The system was first tested in laboratory conditions to check the integrity and communication links. It was then trialled at a mine site to map structural characteristics of a highwall. UAV-LiDAR data were acquired in multiple trajectories with varying number of transects (two and four) and range/distance (40m and 5m) from the highwall. The resultant raw data obtained from the scans were processed to produce absolute 3D point cloud model of the highwall. The primary analysis showed densities of 307 points/m<sup>3</sup> for the two transects and 918 points/m<sup>3</sup> for the 4 transects scanning from an average 40m range. The system was also able to obtain a very high resolution point cloud (8,677 points/m<sup>3</sup>) when it was flown close range at an average of 5m from the wall.

During the trial, the highwall was also mapped concurrently using a high resolution terrestrial laser scanner (Maptek I-Site 8820). These data will be used for the next stage of the comparative analysis.

### C26033 Geotechnical Hazard Awareness Video for Open Cut Coal Mines

University of New South Wales  
Ismet Canbulat

Value: \$92,000  
Report Expected: 25/03/2018  
Industry Monitor/s : Adrienna Brown  
Brian Vorster  
Gavin Lowing  
ACARP Contact: Roger Wischusen

The main objective of this project is to update geotechnical awareness and training video for open cut mines with the latest technology in animation and visualisation. A series of new

modules related to geotechnical and operational risks will also be included in this updated version.

To date, a series of topics that will be included in the video(s) have been developed. A workshop with industry monitors has been scheduled to discuss and finalise topics to be covered in the video(s). These preliminary topics cover four main areas, namely, operational hazard identification and control; mining practices; processes and systems; and equipment.

## Maintenance and Equipment

### C20030 Powerlinkoz High Voltage Electrical Connection System (PLO)

Connec  
John Keir

Value: \$450,000  
Report Expected: 25/07/2017  
Industry Monitor/s : Barrie Alley  
David Lincoln  
Tony Egan  
ACARP Contact: Keith Smith

This project sets out to complete the development of a power cable connection system for underground and surface coal mines which offers significant operational benefits with reference in particular to AS/NZS1299, AS/NZS1300 and AS/NZS60079 series of standards. The research work associated with the project may also contribute to the development of these standards.

Manufacture and testing of the 3.3KV system has been completed. Field trials of the device have also been completed with over 10,000 hours of operation achieved. IECEx and ANZ certification have been awarded.

The 11kV system has been built and the certification process has commenced.

### C25034 Mining Truck Tyre Integrity Monitoring

CSIRO  
Garry Einicke

Value: \$162,965  
Report Expected: 25/03/2018  
Industry Monitor/s : Brian Mahar  
Ivan Heron  
ACARP Contact: Cam Davidson

This project seeks to develop technology for checking the integrity of mining truck tyres. It is motivated by desires to prevent fatalities arising from explosive zipper failures due to overloading and under inflating of truck tyres. The objectives of the project are:

- Develop a portable subsurface imaging system and software (using x-ray and/or radar) for automatically diagnosing the structural integrity of mine truck tyres;
- Work with mine site personnel to develop practical and safe work procedures for using the developed portable system to

assess whether mine truck tyres should/should not remain in service;

- Transfer the developed technology to a commercial collaborator who will then be equipped to provide either a tyre integrity diagnosis service or tyre integrity monitoring technology to mine sites.

The team reports the following progress:

- A CAD design and manufacture of a manual wheel rotation is progressing at the CSIRO QCAT workshop. This will support acquiring x-rays for analysis of entire tyre walls;
- Fatigue testing of tyres are being organised. This will provide a better understanding of the level of under inflation and overloading of tyres that can lead to catastrophic damage;
- As usual, the project team would appreciate hearing from mine sites who have surplus truck tyre samples.

### C25041

#### Dynacut Fundamental Development and Scalability Testing

University of Queensland

Brad Neilson

Dihon Tadic

Joji Quidim

Steve Powell

Value: \$540,000  
 Report Expected: 25/07/2017  
 Industry Monitor/s : Ivan Heron  
 Kane Usher  
 ACARP Contact: Cam Davidson

This project directly follows project C24011, (Quantifying development risks for a high capacity surface mining continuous cutting system in waste). There are two project elements: the first aims to quantify key performance and cost factors for DynaCut technology (an undercutting disc technology for mechanical cutting) in several overburden material domains with purpose-built cutters; the second aims to develop concepts for new mining methods and approaches to exploit the benefits offered by high-capacity continuous cutting systems.

A sandstone quarry in South East Queensland was secured as a testing site, with three suitable domains validated via core drilling and mechanical properties testing. Bench sections, with a working face of approximately 3m x 5m, in each of these domains will be cut with Joy Global's DynaCut test machine using customised cutters that are under development within the project. Final preparations of the machine and target test blocks at the quarry are now underway, with the test program scheduled to commence at the end of Q2 2017.

The mine design component remains focused on preliminary economic evaluation and comparison of various mining concepts that have been developed for typical deposit types. The aim is to assess and rank the concepts based on system capital and operating cost estimates, with consideration of technical and development risks. This will provide targeted concepts for further case study evaluation.

### C26021

#### Verification of Interoperability - Collision Awareness and Avoidance Systems

CSIRO

Jeremy Thompson

Value: \$105,844  
 Report Expected: 25/03/2018  
 Industry Monitor/s : Chris Doran  
 Iain Curran  
 Paul Forsaith  
 Tim Gray  
 Tony Egan  
 ACARP Contact: Cam Davidson

This project develops an independent software verification tool to assess the compliance of proximity detection systems and vehicle control systems with an open industry communications protocol to address major gaps in systems interoperability.

The project will deliver a new software-based verification tool to formally establish the level to which proximity detection and vehicle control systems comply with open industry interoperability communication protocols. This outcome provides both equipment manufacturers and mine-sites with a consistent and simple way to ensure that the design decisions made will meet expectations. A higher rate of take-up of proximity detection systems will directly improve the safety of open cut mining systems. This project will have the following benefits:

- Provide vendor-neutral tools for compliance testing for hardware, software and communication platforms;
- Remove uncertainty around a given proximity detection system's interoperability performance;
- Improve mine industry safety by supporting the take-up and integration of proximity detection systems.

Given the updated project delivery schedule a revised work plan has been devised with progress underway. A review of the draft protocol has been undertaken to allow for work to begin on defining the compliance process ie what needs to be tested, how these tests will be undertaken and how the results will be published. Work has also begun on the software architecture required to implement the various functionality defined in the compliance process. Initial testing of hardware suitable for integrating the software with the test hardware, is also complete.

### C26031

#### Condition Monitoring and Predictive Maintenance Using AI

Endellion Technology

Gerard Wood

Richard Marshall

Value: \$77,020  
 Report Expected: 25/08/2017  
 Industry Monitor/s : David Goodale  
 ACARP Contact: Cam Davidson

The objective of this project is to demonstrate the value of applying new analytical techniques to derive fresh insights into the root cause of catastrophic equipment failure or low component life, from text and numerical data contained within existing oil sample analysis from laboratories.

We aim to demonstrate that there is not only a significant labour efficiency improvement by using these techniques to review oil sample reports and allocate the required actions semi-automatically, but additionally by improving the efficiency and effectiveness of analysis there is a much greater cost reduction to be achieved by maximising component life and improving equipment reliability.

The project commenced in February and is on track for completion in August. Steady progress has been made against project schedule and deliverables:

- Data (a complete history of D11 dozer oil samples (10,000+ over 17 years)) has been sourced from our sponsoring site and appropriate data pre-processing completed;
- A supervised machine-learning model has been developed from this data allowing the prediction / checking of analysts sample evaluation for new oil samples. These results are regularly being discussed with key personnel from our sponsoring site to validate the results;
- The model is now being expanded to allowing the automatic generation of actions against each sample to be uploaded into a site maintenance system as work orders;
- We have also begun to construct language-based networks to allow us to generate insights across 17 years of operational history of these dozers.

## Mining and the Community

C25032

### Collaboration to Maximise the Benefits and Acceptance of Land Packages for Post Mining Leases

Central Queensland University  
Jo-Anne Everingham  
John Rolfe

Value:	\$239,215
Report Expected:	25/03/2018
Industry Monitor/s :	John Merritt Stuart Ritchie
ACARP Contact:	Keith Smith

This project aims to test the use of a local expert/stakeholder panel to identify the conditions and suitable mix of agricultural uses and other functions for a mine lease to be completed, in order to gain acceptance by the agricultural sector and the local community. One focus of the project will be to establish a process where the key factors relevant to local communities and the agricultural sector (the latter as the expected future user) can be identified and assessed.

This project involves four key aims:

- To identify the key factors that are likely to be relevant to future landholders, local communities, Aboriginal traditional owners (where relevant) and other stakeholders when negotiating closure of a mining operation;
- To model the economic returns and flows from transitioning mining leases to agricultural and other land functions;
- To test the use of different local expert/stakeholder panel models to select and negotiate preferred scenarios for mine closure and subsequent land use(s); and
- To use the findings to assist in the development of a process for negotiating mine closures that aligns with local community and stakeholder needs and acceptance.

The project is now mid-way through the workshops, while work on key research papers is continuing.

Two workshops have been held in Blackwater to date:

- Workshop 1: Thursday 23rd of February; and
- Workshop 2: Thursday 27th of April.

Workshop 1 was focused on the broader regional level and planning issues around converting post-mining lands back to agriculture. It had 14 participants, with representation from the following sectors:

- 3 Mining environmental managers;
- 2 landholders (1 representing Agforce);
- 2 environmental representatives (CCC, Capricorn Catchments);
- 4 NRM representatives (CHRRUPP, FBA, DCCA);
- 1 regional business representative (CHDC);
- 2 government agency representatives (DEHP).

Workshop 2 was focused on the issues more relevant to landholders for taking on post-mining land, and involved an exercise with a 'mock-up' of a mine-site being closed. It had 13 participants, with representation from the following sectors:

- 2 Mining environmental managers;
- 8 landholders;
- 2 environmental representatives (Landcare);
- 1 government agency representatives (DNRM).

#### Next steps

There are two more workshops to be conducted, together with some additional surveys to identify how participant's views have come closer together as an outcome of the workshop process:

- Workshop 3: Thursday 1st of June (Blackwater);
- Workshop 4: July, date to be confirmed (Blackwater)

Both groups of participants have been invited to Workshop 3, as well as representatives from local government, with two key aims:

- Provide expert feedback on key issues identified in workshop 2; and
- Involve the broader group of stakeholders in the discussions.

The design for the final workshop will be driven to a large extent by the outcomes of Workshop 3 and the priorities and representation identified by the participants. It is expected that this workshop will have more focus on broader context issues around post-mining land conversion and the preferred design of a stakeholder working group, so that specific recommendations can be developed from the project results.

The project team are also working on several reports, including:

- Report 2: An evidence based proposal for stakeholder engagement in planning post-mining land uses;
- Report 3: Options for designing stakeholder panels on post-mining land uses in Queensland;
- Report 4: Economics of converting post-mining lands to grazing in the Bowen Basin.



## Occupational Health and Equipment Safety

C24028

### Interface Design for Haul Truck Proximity Detection Systems

University of Queensland  
Robin Burgess-Limerick

Value: \$235,620  
Report Expected: 25/08/2017  
Industry Monitor/s : Gavin White  
Kane Usher  
Tony Egan  
ACARP Contact: Cam Davidson

The objective of the project is to describe the relative performance of interfaces designed to convey proximity advisory information to haul-truck drivers. Specifications will be provided in the form of guidelines suitable for dissemination via EMESRT engagement with designers, and provide prospective purchasers with a principled basis for specifying proximity advisory systems. The project will also provide a research paradigm suitable for extension to examine related questions such as the impact of other factors such as false alarm rate and fatigue on the performance of proximity advisory systems.

A review of currently available proximity detection systems, a review of best practice in interface design for road vehicles, and an investigation of fatal collisions involving surface haul trucks have been completed. These outputs are available via the project webpage – [ergonomics.uq.edu.au/PDinterface](http://ergonomics.uq.edu.au/PDinterface). Software required to extract data from the haul truck simulator, and the coding required for test interfaces for use within the 'human in the loop' simulations was completed. A user interface was developed by the simulator manufacturer (5DT) which allows the creation of scenarios within the haul truck simulation required for the interface evaluation.

36 novice participants were recruited, and following training, each participant completed 7-8 hours driving in the haul truck simulator in one of three proximity detection interface conditions. Analysis of these data has been completed. Clear performance benefits of providing a more informative interface for a proximity advisory system were demonstrated. Data collection for a second experiment involving twelve experienced truck drivers will be completed by May 19.

C25024

### Earthmover Tyre Inflation Safety Device: Preliminary Investigation

Simtars  
Tilman Rasche

Value: \$74,400  
Report Expected: 25/06/2017  
Industry Monitor/s : Andrew Denman  
Tim Gray  
Tony Egan  
ACARP Contact: Cam Davidson

A draft report is with the industry monitor(s) for review.

C25026

### Reducing Risk Taking Among Australian Coal Miners

University of Newcastle  
Anna Giacomini  
Mark Rubin

Value: \$302,235  
Report Expected: 25/04/2019  
Industry Monitor/s : Bharath Belle  
Doug Kennedy  
Patrick Tyrrell  
Simon Coleman  
ACARP Contact: Roger Wischusen

This project aims to investigate the causes of dangerous risk-taking behaviours in open cut and underground Australian coal mining environments. It also aims to develop a practical intervention for Australian coal miners in order to reduce dangerous risk-taking and, consequently, accidents and injuries. The project will test the effectiveness of this risk-taking intervention and provide a numerical tool that the industry can use to assess the sustained long-term effectiveness of the intervention.

We have now ceased recruitment of participants for our first survey – Survey 1. To date, we have recruited 1,055 coal miners from 10 mine sites. We are currently in the process of collating the data from Survey 1 prior to commencing data analysis.

We have also begun recruiting participants for Survey 2. The contents of Survey 2 are similar to those in Survey 1. The aim of Survey 2 is to detect changes in miner's risk-taking, near misses, and accidents in the 3+ month period since they completed Survey 1. Our recruitment approach involves contacting those miners who provided their contact details and revisiting mine sites that previously participated in the completion of Survey 1.

C25029

### Practical Application of Open Path Boundary Monitoring for Operational Dust Control

Pacific Environment Operations  
Damon Roddis

Value: \$135,432  
Report Expected: 25/05/2017  
Industry Monitor/s : Andrew Speechly  
John Watson  
ACARP Contact: Keith Smith

A draft report is with the industry monitor(s) for review.

### C25033 Automated Musculoskeletal Disorder Risk Assessment

JointAction Group  
Michael Lawrence  
Steve Cowley

Value: \$293,232  
Report Expected: 25/06/2017  
Industry Monitor/s : Mathew Hyde  
Simon Worland  
ACARP Contact: Cam Davidson

The project has developed a simple-to-use App that receives data from wearable sensors about the wearer's posture and physical actions. The app analyses the received information and generates scored manual handling risk assessments. The App works on phones and tablets using a machine learning system to analyse data and present it on intuitive screens in simple report formats.

After laboratory work to prove the collection and delivery of movement data by the App, mine site trials were undertaken. Sensors were attached to a range of mine personnel undertaking a diverse range of maintenance tasks including truck maintenance, conveyor maintenance, scaffolding handling and under-truck inspection and maintenance. Sensors were attached to the back, hip, head and wrist of the workers enabling assessment of discrete as well as combined movements such as simultaneous bending and twisting.

The sensors transmitted data to the App while simultaneously data logging. This enabled real time assessments including video collection as well as post hoc data analysis where workers were remote to the researchers.

Following the mine site trial, expert ergonomist assessment of the collected video and sensor data validated the App assessments and identified areas for refinement. Those refinements have been completed in preparation for a second and final mine site trial in May during which final proving will be completed.

### C25036 Risk Control Knowledge: Two Case Studies

University of Queensland  
Jim Joy  
Maureen Hassall

Value: \$259,500  
Report Expected: 25/05/2017  
Industry Monitor/s : Doug Kennedy  
Mike Oswell  
Occupational Health and Safety Task Group  
Tony Egan  
Troy O'Reilly  
ACARP Contact: Roger Wischusen

A draft report is with the industry monitor(s) for review.

### C25037 Health-e Mines: Virtual Health System to Improve Mental Health

University of Newcastle  
Brian Kelly  
Frances Kay-Lambkin  
Ross Tynan

Value: \$289,985  
Report Expected: 25/04/2018  
Industry Monitor/s : Occupational Health and Safety Task Group  
Tony Egan  
ACARP Contact: Roger Wischusen

This project has three key objectives:

- To develop an online portal ('Health-e Mines') through which Australian coal miners can access confidential, evidence-based online treatments for mental health, alcohol/other drug use, and physical health concerns;
- To evaluate the use of Health-e Mines and associated online treatment programs in pilot mine sites in New South Wales and Queensland in terms of feasibility, acceptability, reach, and effectiveness; and
- To develop a clear plan for dissemination and sustainability of Health-e Mines beyond the current grant.

To ensure that the development of the portal is fit for purpose, the initial stages of the project involve seeking feedback from employees (potential end users) about their needs. We are now finalising analysis of data from the initial three sites (approx. 600 miners) and online survey (approx. 70 miners). Logistics of data collection at the final site is currently being organised.

The survey has provided a snapshot of the participating sites current mental health, personal experience with mental ill-health, their access to the internet (device used, frequency and duration of access) and has helped to identify perceived barriers and facilitators to accessing online mental health programs. We have used this information to inform, guide and refine development of the Health-e Mines website prototype. We are now in the process of finalizing the website prototype, and will be taking to participating sites to seek critical feedback regarding the look, feel, and messaging associated with the final prototype throughout the next quarter.

### C26026 Continuous Monitoring of Whole Body Vibration and Jolts and Jars Associated with Operating Earth Moving Equipment

University of Queensland  
Robin Burgess-Limerick

Value: \$298,704  
Report Expected: 25/03/2019  
Industry Monitor/s : Ellen Roots  
Ross Di Corleto  
Shane Apps  
Troy O'Reilly  
ACARP Contact: Keith Smith

The objectives are to:

- Develop, demonstrate, and evaluate iOS and server software to allow continuous monitoring and analysis of

earth-moving equipment operator vibration exposures using off-the-shelf hardware;

- Utilise this system to obtain an enhanced understanding of the sources of elevated whole-body vibration and impact loads associated with haul truck and dozer operation at a surface coal mine; and to
- Make the software freely available for adoption by other sites.

Six meetings have been held between UQ staff and Peabody Energy Australia staff, and a seating supplier, to define the technical requirements of the system to be initially trialed in a haul truck at Millennium mine. Draft specifications for the software interface have been prepared and software development is underway.

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## Overburden Removal

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C24037

### Automated Bulk Dozer Push: Reducing the Cost of Overburden Removal

University of Queensland  
Ross McAree

Value:	\$341,400
Report Expected:	25/06/2017
Industry Monitor/s :	Andrew Denman Geoff Gribble Hans Hayes Tony Egan
ACARP Contact:	Cam Davidson

The aim of this project is to improve the execution of pivot push dozing by semi-automating the process. The project is a collaboration between The University of Queensland, Caterpillar, and Peabody Energy. The primary research questions are to determine:

- How to choreograph the operation to be performed by an autonomous dozer to achieve the most efficient (fastest, lowest unit cost) dozer operation, and ensure the material moved by the dozer is cheaper than the next best option (truck and shovel);
- How to best execute manual and automated CDX (Cast Doze Excavate) dozer operations.

The project has built from the Caterpillar Semi-Autonomous Tractor System, also known as SATS, extending it to be capable of semi-autonomous pivot push dozing. This system has been deployed at Wilpinjong mine. A methodology for understanding dozer productivity has been developed and data collected from the SATS tractor while operated in manual mode has enabled analysis of three alternate pivot push strategies.

The SATS system has been extended to implement pivot push dozing and the technology has been implemented at Wilpinjong mine. The project has undertaken a comparison of manual verses semi-autonomous operation. The final project report is near to submission.

C25038

### Dragline Excavation Sequencing: Phase 2

University of Queensland  
Andrew Jessett  
Ross McAree

Value:	\$1,129,000
Report Expected:	25/04/2018
Industry Monitor/s :	Andrew Denman Geoff Gribble Win Klass
ACARP Contact:	Cam Davidson

This project aims to develop and test an operator assist that determines how to sequence dragline excavation and provides guidance to the operator to help improve their execution. An excavation sequence is the set of locations the dragline should position itself at, the material it should remove at each position, and the locations it should spoil that material to. The technology being developed aims to deliver:

- More consistent production;
- Faster lineal advance rates down the strip; and
- Continuous assurance of ability to fit the spoil in the forward operation.

The methodology for sequencing is to find excavation sequences subject to constraints that impose structure on the problem. These sequences are presented to the operator giving guidance on where to position, where to dig from and where to spoil. Implementation of the Generation 1 system is to be trialed at Caval Ridge, with the aim to evaluate the benefits of the technology.

In the last quarter the project has:

- Developed and tested a decision tree framework that allows construction of candidate sequences from a set of constrained walk and excavation strategies;
- Developed interfaces to the Pegasys and DTM systems; and
- Planned the initial trial of the system at Caval Ridge.

# COAL PREPARATION

## Major Projects

C22046

Reflux Classifier to 4mm Top Size - Full Scale Trial  
(Construction of Test Rig)

University of Newcastle  
Kevin Galvin

Value:	\$1,318,748
Report Expected:	25/05/2017
Industry Monitor/s :	Kevin Rowe
ACARP Contact:	Nerrida Scott

This project will move an innovative process improvement from the laboratory and pilot scale to a trial in an operating plant at full-scale. The project has a committed host site, with strong engineering and scientific support from contributors.

A larger size feed, up to 4mm, will be directed to the Reflux classifier, thereby reducing the load to the dense medium cyclones. This will in turn increase the capacity of the slimes screen which has been the limiting factor in the capacity of coal preparation plants. The work has the potential to increase plant throughput for a given Capex, and may even deliver higher yield.

In a second project, C20052, the facility will be used to undertake a full-scale trial of cascading Reflux Classifiers, involving gravity separation and then desliming of the final overflow product. The goal is to provide alternative methods for processing fine coal, extending the recovery to lower particle sizes via the controlled desliming of the clean coal product.

From a research perspective, this construction project is a major undertaking, involving four organizations and other consultants. The final construction phase for the first research project, C19001, was completed in November 2015. The project work was then undertaken through 2016, and the draft final report lodged in January 2017.

In preparation for Project 2, C20052, a modified circuit was required. The modifications commenced in the second half of 2016 and were largely completed by the end of November 2016. Thus commissioning of the new circuit was undertaken by December, followed by initial experimentation. The need for a number of circuit adjustments was identified and some changes were made to improve the operability. The need for these adjustments reflects the substantially lower processing rates for the much finer feed. The -1 mm feed is sourced from a -16 mm feed, hence it is still necessary to convey particles up to 16 mm in size onto the large screen. The diameter of the pipe on the main pump inlet side is too great, hence there is a tendency for the feed to segregate and cause a blockage. This pipe was replaced allowing the work to resume.

The facility works very well, generating high quality gravity separation and desliming as noted in the quarterly report on Project 2, C20052.

The final stage of this project will follow the completion of Project 2 much later in the year, and will involve the dismantling of the facility, retrieval of the proprietary equipment, and disposal of the remaining material.

## Dewatering

C24040

Improving the Dewatering Efficiency of Fine Flotation Concentrates by De-Aerating Froth Products

University of Queensland  
Yongjun Peng

Value:	\$213,600
Report Expected:	25/08/2017
Industry Monitor/s :	Alvaro Diaz Lema
ACARP Contact:	Nerrida Scott

The overall objective of this project is to improve dewatering efficiency of fine coal flotation products by de-aerating froth products. Both physical methods and chemical methods will be developed to break the stable froth. Strategies will be developed to combine different methods to minimize energy consumption and reagent costs while maximising the dewatering efficiency.

For the mechanical defrothing, various devices have been developed and tested in the laboratory. A spinning basket is found to be the most effective mechanical device which was able to break more than 70% of coal froths at an optimized condition. The ultra-stable froth which cannot be broken by spinning basket was formed by very fine bubbles (below 100  $\mu\text{m}$ ) and the bubble surfaces were covered by superfine particles (below 5  $\mu\text{m}$ ). Breaking these ultra-stable froth was beyond the capability of mechanical forces.

For the chemical defrothing, more than twenty different defoamers and surfactants have been tested. The most effective type of defoamers is found to be the surfactants with a hydrocarbon chain and a polar group which work by detaching the coal particles from the bubble surfaces. The best surfactant which not only effectively eliminates the froth but also significantly improves the dewatering has been identified.

In addition to the chemical defoaming, microwave has been developed as an effective physical technique to break the ultra-stable coal froth. Microwave selectively heats water rather than coal. The fast heating of water leads to the rapid increase of bubble inner pressure due to the water vaporization, and the bubble is broken after the bubble inner pressure reaches a critical value.

Strategies have been developed and tested to maximize the defoaming efficiency and reduce the reagent consumption. It was found that pre-separating the ultra-stable froth from slurry before defoaming, applying mechanical defoaming to break most of the froth, and then adding chemicals or using microwave to break the ultra-stable froth, can significantly improve the defoaming efficiency and also reduce the chemical and energy consumption. Both thickening and filtration of coal flotation products were significantly improved after the froth was eliminated.

In the future work, the developed defoaming techniques and strategies will be directly tested and optimized in the plant laboratory and the best strategy suitable for each plant will be identified.

### C24047 Steam Pressure Filtration Targeting Step Change Reductions in Filtercake Product Moistures

QCC Resources  
Andrew Swanson  
Bob Drummond

Value: \$347,049  
Report Expected: 25/06/2017  
Industry Monitor/s : Rod Fox  
Ryan Flanagan  
ACARP Contact: Nerrida Scott

A draft report has been written and is currently being internally peer reviewed. The report will be submitted to ACARP very soon.

### C25010 Optimising the Performance of Solid Bowl Centrifuge for Tailing Dewatering

University of Newcastle  
Rohan Stanger

Value: \$125,560  
Report Expected: 25/06/2017  
Industry Monitor/s : Ryan Flanagan  
Tom Wilson  
ACARP Contact: Nerrida Scott

This project is based on providing analytical insight into the performance of a solid bowl centrifuge for coal tailings dewatering. Currently the project has characterised one suite of feed/cake/effluent from a single seam and used the material to develop a laboratory centrifuge test that could be used on other potential tailings types. The samples were tested for laser particle sizing, XRD and SEM-EDS to understand the particle and mineral characteristics. Overall, the project has been delayed by the availability of samples from the minesite during 2017, though samples are expected to be available from May onwards.

### C25012 Dewatering of Ultrafine Coals and Tailings by Centrifugation: Pilot Scale Studies

University of Queensland  
Anh Nguyen

Value: \$220,000  
Report Expected: 25/03/2018  
Industry Monitor/s : Naomi Pritchard  
Penny Walker  
Rahul Patel  
ACARP Contact: Nerrida Scott

The objectives of the project are to:

- Apply the high-g centrifugation effect on dewatering fine coals and tailings;
- Evaluate the Somerset dewatering technology at pilot scale and in continuous mode;
- Optimise the fine coal dewatering by using the concepts of split dewatering and combined centrifugal and chemical-enhanced de-wetting forces; and to
- Compare pilot-scale findings to full-scale results.

This report covers project activities and outcomes during February, March and April.

The pilot-scale unit was successfully moved from UQ to Mackay for the planned compliance modification and certification, and commissioned at P&S in Mackay. The training for both the project team and BMA staff was also successfully finalised at P&S in Mackay. The pilot-scale unit was then moved to the selected BMA CHPP in the Bowen Basin and successfully installed for the pilot trials.

The initial pilot-scale trials were successfully completed. The feed samples were the tailings of the fine coal flotation circuit. The percent solids in the feed sample were 2-3%. The details and outcomes of the initial pilot trials can be summarised as follows:

- Encouragingly low moisture contents for flotation tailings (<30%) were achieved by the pilot-scale solid bowl;
- The ultrafine tailings contained large amount (~60%), ultrafine (3.5 microns) clay particles of negative surface charges;
- Flocculants used for pre-treatment did not help with dewatering ultrafine tailings, in fact final moisture of dewatered tailings increased;
- Early results look very promising but more tests are planned.

The laboratory-scale testing for the samples of the initial pilot trials was also successfully completed. The test work included the sample characterisation and dewatering kinetics. In the next stage of work, the dewatering testing using the laboratory- and pilot-scale dewatering units will be continued.

### C25018 Improving Solids Recovery and Moisture Reduction in Ultrafine Coal Dewatering

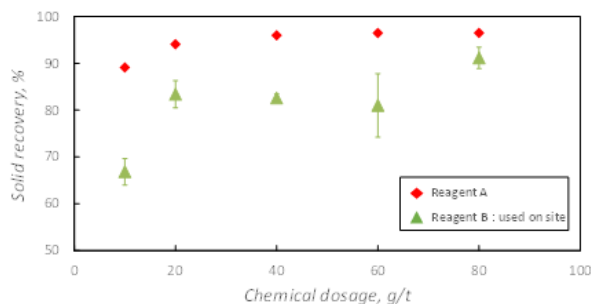
University of Queensland  
Liguang Wang

Value: \$184,000  
Report Expected: 25/04/2018  
Industry Monitor/s : Justin O'Neill  
ACARP Contact: Nerrida Scott

The objectives of this project are to:

- Develop an effective method to improve the solids capture and product moisture reduction in dewatering ultrafine coals with screen bowl centrifuge (SBC); and
- Conduct a cost-benefit analysis to compare the cost of the chemicals to the increase in solids recovery.

In the last quarter, we tested more chemical reagents for centrifugal dewatering at batch mode. It was found that the Reagent A outperformed Reagent B in improving solids recovery (see the figure shown below). Reagent B is currently used on the site. At each dosage tested, Reagent A had a better solid capture than that of Reagent B while the product moisture was comparable. Further dewatering tests at pilot scale will be carried out to corroborate this finding.



Next, a continuous pilot-scale screen bowl centrifuge with bowl diameter of 150 mm will be installed at University of Queensland. We will use it to further evaluate the reagents and methods developed during the first half stage of this project. We will also characterise the structure of the cake discharged from the pilot-scale test unit.

## Environmental Improvement

### C25006

#### Test Procedures to Achieve More Cost Effective Minimisation of Coal Dust Emission During Rail Transport

Introspec Marketing Services

John Planner

Value: \$40,000  
 Report Expected: 25/06/2017  
 Industry Monitor/s : John Watson  
 Stuart Ritchie  
 ACARP Contact: Nerrida Scott

This Project will recommend modified coal surface treatment for mine to port rail transport to achieve significant annual cost savings by largely eliminating the use of chemical surface veneer treatment, and replacement by water spray.

Wind tunnel simulation modelling of mine to port rail transport has now been completed on sixteen representative Queensland coal types, to determine dust emission following pre-departure coal surface treatment options. Treatment options include:

- Chemical surface veneer solution;
- Water spray with no chemical;
- Nil surface treatment.

Laboratory test results indicate that a majority of coal types can meet Regulatory requirements without use of chemical. These results will be confirmed through field trials. Field trials comprise loading and despatch to port of two trains with the nominated coal surface treatment, and receipt of data from continuous rail track monitoring. Four coal types with modified surface treatment (no chemical) have been despatched by trial trains from mine to port. Continuous rail trackside opacity data indicates readings well below requirement for Regulatory Compliance. In addition to compliance by the four tested coal types, other coal types not included in the Project, have been railed to port, and all have achieved Regulatory compliance with no chemical surface veneer application.

Field trials on other coal types have been delayed by cyclone and flood damage, but will re-commenced when conditions return to normal.

## Fine Coal

### C20052

#### Full Scale Gravity-Desliming Using Cascading Reflux Classifiers

University of Newcastle

Kevin Galvin

Value: \$215,480  
 Report Expected: 25/10/2017  
 Industry Monitor/s : Kevin Rowe  
 Tom Wilson  
 ACARP Contact: Nerrida Scott

The objective of this project is to investigate the performance of cascading Reflux Classifiers (RC2020) in the gravity separation and desliming of fine coal at full-scale. This project is an extension of the former project C18037, the aim being to assess the scale-up. While there is existing industrial knowledge concerning the gravity separation of fine coal in a Reflux Classifier there is no previous industrial investigation of the RC2020 desliming process at full-scale or of the synergy achieved using the cascading arrangement. There is always uncertainty associated with the question of scale-up given the potential for non-uniform separation to occur in large scale devices.

A cascading sequence of two full-scale Reflux Classifiers will be used to generate a clean coal product from a feed within the size range 2.0 to 0.0 mm. The objective is to use gravity separation to produce a clean coal product down to a particle size of about 0.038 mm or higher, and to deslime the product with minimal coal loss.

Modifications to the testing facility to support this project were completed and commissioned in December allowing some initial experiments to be done. The need for a number of other circuit adjustments was then identified.

The modifications to the circuit were completed successfully, and formal experiments commenced during the last quarter. The first data has only recently been obtained. The work has shown that the two-stage system works very well, with good recoveries produced and high quality desliming achieved. Overall product ash values of less than 6 % have been obtained based on the size range down to zero. It is noted that these feeds, which have not passed through the cyclones, carry very significant slimes content. It is likely the results would be even better following filtration. With these positive results, a request has since been made for more complete analysis of the runs.

Further experimental work has since been conducted. Most of the focus has been on the desliming unit, with a single low cut point applied to the gravity circuit. The main variables have been the fluidization rate and set point. Ultimately it will be necessary to run the system to the point of failure to determine how hard the system can be driven. This includes increasing the set point of the first stage gravity unit. One future design option is to create a metallurgical coal product from the gravity-deslime circuit, and send the 'reject' to a further gravity unit to obtain a thermal product

C22032

**Measurement and Control of the Reflux Classifier**

University of Newcastle  
Kevin Galvin

Value: \$132,730  
Report Expected: 25/05/2017  
Industry Monitor/s : Clinton Vanderkruk  
Kevin Rowe  
ACARP Contact: Roger Wischusen

A draft report is with the industry monitor(s) for review.

C23036

**New Approach to Coarse Coal Flotation**

University of Newcastle  
Kevin Galvin

Value: \$141,457  
Report Expected: 25/06/2017  
Industry Monitor/s : Kevin Rowe  
Tom Wilson  
ACARP Contact: Roger Wischusen

The objective of this new study is to investigate the performance of the Reflux Flotation Cell at a laboratory scale in coarse particle flotation up to 2mm. The fundamental knowledge produced by this study will be used to support a larger, pilot scale, study, and in turn a full scale trial. This project addresses a long standing problem in flotation, extending the size range to coarser particles. Success in this project will lead directly to pilot and full scale investigations of coarse coal flotation. The plan is not to replace gravity separation of the coarser size particles, but to bridge the gap between the different circuits. This project will provide an understanding of the coarse particle flotation mechanism, and the precise conditions required to succeed.

More recent experiments have been conducted using particles in the range 1.4 to 2.0mm, at an average of 1.7mm. Under these dilute tracer particle conditions the recovery has dropped to 50% over a wide range of the gas flux. This finding is consistent with achieving a buoyancy limitation. For a fixed bubble size, larger particles will have a smaller specific surface area (area per unit volume), and hence the bubbles that pack across the surface of the particle deliver less buoyancy compared to the increase in the buoyant particle weight. Unfortunately examination of the effects of the bias flux provided no additional insight here.

Following on from the success achieved in floating coarser particles at tracer level concentrations, we conducted actual separations using cyclone overflow covering the size range from 0 to 2mm. The initial work was conducted at very low pulp densities of order 1 wt%. Very high recoveries were achieved across the size range 0 to 1mm, with gradual drop off to 2mm, with significant recovery at 2mm. The findings were compared with the yield at a sink-float density of 1.6, thus using the ideal bench mark. The gas flux was maintained at relatively low levels in line with the tracer work. These experiments were then repeated at a higher feed pulp density of about 5% solids.

The work conducted at 5% solids showed an increased drop off in recovery as the particle size range increased when no wash water was added, and for a low wash water addition corresponding to a neutral bias. However, when a much higher

wash water rate was used, the coarse particle recovery increased to high levels across the full size range. This finding was surprising given that additional wash water often results in a loss in recovery due to disturbance of the froth. We suspect the frother in the wash water stabilized the recovery.

A new program of work was conducted using 0-2mm feed at 5% solids, using different bias fluxes, and gas fluxes. The experimental findings are clear. At a gas flux of 0.5 cm/s or lower the flotation is very efficient at recovering particles across the full size range. However, as the gas flux increases there is a strong collapse in recovery at the coarser sizes.

Experiments were undertaken to determine the performance using the low gas flux at a feed pulp density of 15% solids over the size range from 0-2mm. This was the feed to the cyclones. We only have the data on the finer -0.125mm portion, however, the observation made during the experiments is that the recovery of the coarse particles across the full size range was high. The project work has been completed, and the final draft report is currently being prepared.

C23038

**Improving the Treatment of Clay Minerals in Coal Flotation in Saline Water - Plant Tests**

University of Queensland  
Yongjun Peng

Value: \$253,176  
Report Expected: 25/05/2017  
Industry Monitor/s : Alvaro Diaz Lema  
ACARP Contact: Nerrida Scott

A draft report is with the industry monitor(s) for review.

C23039

**Characterisation and Flotation of Oxidised Coal**

University of Queensland  
Yongjun Peng

Value: \$168,600  
Report Expected: 25/05/2017  
Industry Monitor/s : Alvaro Diaz Lema  
ACARP Contact: Nerrida Scott

A draft report is with the industry monitor(s) for review.

C24041

**Improving Coal Flotation With Oscillatory Air Supply**

University of Queensland  
Liguang Wang

Value: \$108,000  
Report Expected: 25/06/2017  
Industry Monitor/s : Diego Dal'Molin  
Kevin Rowe  
ACARP Contact: Nerrida Scott

A draft report is with the industry monitor(s) for review.

## C24042 Pilot Scale Study of Fast Flotation

University of Newcastle  
Kevin Galvin

Value:	\$95,180
Report Expected:	25/06/2017
Industry Monitor/s :	Kevin Rowe Ryan Flanagan
ACARP Contact:	Nerrida Scott

The objective of this project is to undertake a pilot scale study of Fast Flotation in order to validate the findings from our previous laboratory scale work. The new technology, which operates as a 'rougher', allows the volumetric feed flux to be increased to 10 cm/s, permitting residence times as low as 10 to 20 seconds, depending on the vessel height. This pilot scale study will then form the basis for a full scale study and commercialisation of the technology.

The project will commence with a series of modifications to the existing pilot scale Reflux Flotation Cell in order to permit much higher gas and feed fluxes, incorporating a finer gas sparger. This device, which is 0.3m x 0.3m in cross-section, and 3.0m high, is already on location at Bloomfield, and should not be difficult to reconfigure. The objective will be to operate the system at up to 500 L/min, considerably higher than the 50 L/min currently being used. The unit will generate a product at up to 100 L/min, which will be collected, for some runs, and returned to our laboratory for second stage processing. Experiments will be conducted at different volumetric feed rates to assess the throughput limit against what has been achieved at the laboratory scale. This work will require experiments at different gas and feed fluxes, as well as reagent doses.

It is noted that a new sparger design suitable for the old and new pilot scale systems and future full scale systems has been developed, and has been trialled in our laboratory. This system will greatly simplify changes to the system, maintenance, and modification by allowing the sparger unit to be removed easily. The design also simplifies the gas delivery to multiple spargers within the downcomer. The novel pilot scale sparger system still needs to be built.

The initial Fast Flotation experiments have been conducted using the existing pilot scale device which is already on site. Following this work, we have upgraded the system to permit experiments up to 500 L/min, or ten times the usual flotation throughput, incorporating a new pump, and 2 inch lines. A 4 inch poly-tee connection has been installed beneath the hydrocyclone overflow tank to provide a connection for a 3 inch hose. A new 500L mixing tank has also been installed to condition the feed with reagent. The recent work, however, was undertaken at 300 L/min using a gas flux of about 3.5 cm/s. These values are equivalent to about six times the usual flotation feed rate, hence represent a significant test, and hence basis for assessing the technology. The performance of the Fast Flotation at this high feed rate appears to be excellent based on observations of the samples, notably a very black product, and grey tailings.

The Fast Flotation work has now been completed, demonstrating consistent performance across the full range. Applied to a 2.0m diameter RFC, the range covered is equivalent to about 1000 m<sup>3</sup>/h, which is 360 m<sup>3</sup>/m<sup>2</sup>/h, about ten

times that of a more conventional system. Naturally, the RFC generates a rougher product under these conditions, with a liquid split between 10 and 30% to overflow. Tailings ash levels were typically 69%.

The draft final report is currently being prepared.

## C24043 Simultaneous Gravity Separation and Desliming of Fine Coal - A Novel Concept

University of Newcastle  
Kevin Galvin

Value:	\$141,380
Report Expected:	25/06/2017
Industry Monitor/s :	Alvaro Diaz Lema Tom Wilson
ACARP Contact:	Nerrida Scott

The objective of this study is to investigate a novel system and method for achieving simultaneous gravity separation and desliming of fine coal in the one vessel. This work will be undertaken at a laboratory scale using an Inverted Reflux Classifier, the aim being to assess the viability of the approach. If successful the work would ideally move to pilot scale. An Inverted Reflux Classifier will be established consisting of a vertical fluidized bed section above a system of inclined channels. A fluidization chamber will be located above, with a discharge valve used to regulate the overflow rate of product from the unit. The feed coal and fine magnetite will be fed into the unit from the side, and allowed to fill the system. The fine coal will then segregate in the upwards direction towards the discharge point, while the denser particles will segregate in the downwards direction. This reject material will then be discharged from below at a relatively high rate.

Previously a series of experiments was conducted, the dense medium density being the primary variable. Some trial and error was required in the first series of runs to develop an initial appreciation of the conditions required to achieve a satisfactory separation. In one of the runs the medium density was 1,735 kg/m<sup>3</sup> and in another 1,537 kg/m<sup>3</sup>. When the density was too high it was not possible to achieve a low product density as particles of a relatively high density were sufficiently buoyant to report to the overflow. Here, the overflow rate was lower than the optimum hence the coarser particles (of low density) displaced the finer particles of low density. This meant that a low yield of higher density product was produced, with the yield of the fines lower than the yield of the coarse particles. This is the opposite of what happens in a water-only medium. So, it was necessary to drop the medium density sufficiently to 1,537 kg/m<sup>3</sup>, until a suitable product density could be reached. We then observed a product yield that was largely independent of the particle size, suggesting a high quality dense medium separation. The net result was a feed density of 1,481 kg/m<sup>3</sup>, product density of 1,338 kg/m<sup>3</sup>, and reject density of 1,978 kg/m<sup>3</sup>.

New experiments covering a broader size range from 0.063 mm to 1.0 mm, with operation at significantly higher solids feed rates were undertaken as planned, achieving approximately 20 t/m<sup>2</sup>/h capacity. This throughput level is considerable given the need to accommodate very high volume fractions of fine magnetite. In fact the magnetite slurry rate and downwards fluidization rate were equivalent to the volumetric feed rate to the system. The



primary control parameter was the volumetric overflow rate of the product. The data suggests a strong density based separation, where ideally the density cut is nearly independent of the particle size. What we do not know at this stage is the extent to which the fluidization has produced the necessary level of desliming of the product. If the volumetric overflow rate exceeds the fluidization rate then slimes should appear in the overflow.

We have completed the final experiments, and requested additional external analysis to obtain the overall partition curves. The project is thus nearing completion, having provided a strong assessment of the gravity-desliming proposition.

The draft final report is currently being prepared.

### C24045 Adaptation of Coal Grain Analysis to Improve Yield Estimation

QCC Resources  
Andrew Swanson  
Bruce Atkinson

Value:	\$120,456
Report Expected:	25/06/2017
Industry Monitor/s :	Dion Lucke Naomi Pritchard
ACARP Contact:	Nerrida Scott

Accurate prediction of flotation yield is difficult.

Modelling of density separation processes is reasonably straight forward, however existing methods of modelling of flotation yield are poor.

This project offers further development of an already commercially available analytical tool (Coal Grain Analysis – CGA) that is likely to be able to solve the problem and provide a more accurate basis for modelling flotation yield. The information will be generated in a form that will enable direct utilisation in the likes of LIMN process models.

The first project (C24045) involves sampling of four separate CPP flotation circuits with CGA determined on each of fresh feed, concentrate and tailings streams. The CGA data have allowed flotation response of each grain type to be evaluated.

The preliminary data demonstrate correlations between steady-state flotation rate constant and particle size for each of vitrinite and inertinite. Interestingly, vitrinite rate constant increases with increasing particle size, while inertinite rate constant decreases with increasing particle size.

Sampling of the fourth circuit for C24045 (Microcel) has been delayed but is hoped to be completed during the next Quarter.

One site (mechanical cells) has been sampled for the second project, C25019. Five further sites have agreed to participate: 2 x Microcel, 2 x Jameson and 1 x Mechanical. It is anticipated that all of those sites will be sampled prior to the end of 2017.

### C24049 Performance Enhanced Diesel Collector for Coal Flotation

CSIRO  
Shenggen Hu

Value:	\$148,013
Report Expected:	25/06/2017
Industry Monitor/s :	Alvaro Diaz Lema Clinton Vanderkruk
ACARP Contact:	Nerrida Scott

In laboratory tests, it has been found that a performance-enhanced diesel collector can achieve increased collecting abilities than diesel alone. The objectives of this project are to carry out preparation plant based assessment/demonstrations of the performance-enhanced diesel collector for:

- Increasing the recovery of both coarse and fine coal particles; and/or
- Reducing the consumption of diesel oil while maintaining good flotation performance;
- Improving collector addition methods with enhanced dispersion of collector.

Plant-based trials were carried out at a CHPP site to investigate the effectiveness of two reagents (PES 80 and PEK 12) for enhancing collector performance.

Results from plant-based trials indicated that the performance-enhanced reagent (PES 80) can increase the collecting ability of diesel. The combustibles recovery obtained with this performance-enhanced diesel collector can be up to 5% higher than that with the same dosage of normal diesel collector if the intensity of mixing is sufficiently high. The performance-enhanced diesel collector does not cause negative impact on the dewatering of flotation concentrate.

### C25008 3D Flotation of Fine Coal

University of Newcastle  
Kevin Galvin

Value:	\$185,260
Report Expected:	25/06/2017
Industry Monitor/s :	Ryan Flanagan Tom Wilson
ACARP Contact:	Nerrida Scott

Conventional 2D Flotation involves the agglomeration of fine particles to the surface of rising air bubbles. Residence times have not changed significantly in the past 100 years. This new project is concerned with 3D Flotation in which the fines are attached to a novel binder. The coal particles then become embedded within the 3D matrix of the binder, producing a very low density product that floats to the surface. The final product can also be washed over a screen.

The objective of this study is to establish 2m<sup>3</sup>/h and 20m<sup>3</sup>/h laboratory pilot scale facilities for demonstrating the novel 3D Flotation Technology. This system will allow assessment of separation performance across a range of coals, while providing further validation of the system scale-up, and assessment of economic potential.

This is the second report since the exchange of the contracts. We have already achieved successful beneficiation through a semi-continuous approach, forming agglomerates via a high shear nozzle, capturing the agglomerated suspension, followed by dewatering. The key challenge now is to make the system fully continuous.

The experiments conducted over the past quarter demonstrated some difficulty with achieving continuous dewatering of the agglomerates via a dewatering screen. Prior to the commencement of this project the dewatering had been undertaken in a semi-batch manner following the continuous steady state formation of the agglomerates through a nozzle. The agglomerates were collected in a bucket and then poured over the screen for final separation. But now the goal is to establish a continuous process. While initial separation is achieved, extended operation leads to a decline in the separation, most probably due to the deformability of the agglomerates and their potential to blind the screen. We have trialled several methods of operation. There is also the need to wash the concentrate over a second screen after removing the bulk of the water.

It has previously been established that these agglomerates are buoyant hence they tend to rise naturally relative to the water. We therefore sought to exploit that property. We have completed the construction of a suitable system to promote the buoyant separation of the agglomerates. We have also returned to undertake more fundamental experiments associated with the continuous steady state agglomeration. Those systematic experiments are concerned with reproducibility, dependence on flow rate, dependence on pressure drop, and dependence on binder addition. This comprehensive program of work has confirmed the robust nature of the agglomeration, the selectivity of the process, very low oil addition required, and the ultrafast nature of the process. Previously we had achieved agglomeration at a rate of 40 L/min via a 25mm diameter pipe and valve arrangement. Since then we have explored a broad range of feed rates, pressure drops, and binder doses. In one case, we successfully processed the agglomerates at over 130 L/min through a 25mm diameter pipe. In general, as the pressure drop and flow rate increase, binder oil requirements continue to decrease. The work is now ready for assessment using the new flotation system.

### C25009

#### Rapid Extraction of Frothers from Process Water

University of Newcastle

Jamie Dickinson

Value:	\$122,965
Report Expected:	25/06/2017
Industry Monitor/s :	Alvaro Diaz Lema Kevin Rowe
ACARP Contact:	Nerrida Scott

Residual frother in recirculating CHPP process water can lead to a number of frothing issues, including inefficient operation of DMCs, thickeners, sumps and pumps. To avoid these issues, frother dosage rates are frequently scaled back at the expense of the flotation circuit performance. The trade-off between the two can lead to significant losses in fine coal yield and plant performance.

The objective of this project is to investigate at laboratory scale the rapid extraction and recovery of common frothers, such as MIBC, from process water using innovative Reflux Flotation technology. The aim is to achieve an increase in the throughput rate, up to ten-fold, over existing conventional flotation techniques. Ultimately, long-term success in this project would lead to the development of a new technology that would readily retrofit to existing flotation circuits, thus allowing flotation circuits to operate at optimal frother concentration, while ensuring efficient plant operation.

Initial experiments demonstrated promising results using desliming cyclone tailings containing around 8 to 10 ppm MIBC, feed flux of 1cm/s and relatively coarse bubble sizes of up to 1.5mm. The results indicated reductions in the residual tailings concentration of around 50%. Respectable combustible recoveries and tailings ashes were obtained, averaging 85% and 82% ash respectively, from a 47% feed ash.

Early sample analysis involved the use of gas chromatography to measure MIBC concentrations. Future experiments will rely on a more precise combination of solvent extract and gas chromatography to distinguish MIBC from MIBK and improve the accuracy of evaluating the separation performance. This action will be particularly important for low MIBC concentrations.

A number of model frother-in-solution experiments have been completed, examining the window of operation to best achieve rapid frother extraction rates. The research has focussed on reducing the bubble size down to the order of 100  $\mu\text{m}$ , to push the specific bubble surface area to high orders of magnitude of around 60 - 200  $\text{m}^2/\text{m}^2\text{s}$ , noticeably beyond the conventional operating range of 30 - 80  $\text{m}^2/\text{m}^2\text{s}$ , using high feed fluxes relative to bubble size. This has generated knowledge surrounding the propagation of very fine bubbles through the system, and its impact on minimising a low entrainment of the feed liquid to the overflow, while maximising frother upgrade and feed throughput.

Moving forward, experiments will build upon recent learnings to examine MIBC extraction from flotation tailings. The effect of recycling recovered frother back to the flotation circuit will be examined, as well as multi-stage processing to assess the quality of extraction obtained using a single-stage of separation.

### C25013

#### Evaluation of Residual Frother Minimisation Strategies

CSIRO

Philip Ofori

Value:	\$167,714
Report Expected:	25/10/2017
Industry Monitor/s :	Justin O'Neill
ACARP Contact:	Nerrida Scott

No report received.

### C25014 Plant Scale Testing of Safe Aerosol Frother Addition to Reduce Residual Frother and Reagent Costs

CSIRO  
Philip Ofori

Value:	\$165,582
Report Expected:	25/10/2017
Industry Monitor/s :	Alvaro Diaz Lema Justin O'Neill
ACARP Contact:	Nerrida Scott

No report received.

### C25017 Leveraging Detailed Maceral Component Information from CGA

QCC Resources  
Bruce Atkinson  
Karryn Warren

Value:	\$71,696
Report Expected:	25/07/2017
Industry Monitor/s :	Dion Lucke Justin O'Neill
ACARP Contact:	Nerrida Scott

In the period since coal grain analysis (CGA) became available, the CSIRO image analysis software has been transitioned and it is now evident that more detailed information could be generated by further extending and re-coding the software calculations. This will allow previous CGA images to be re-analysed to extract additional information of tremendous value to coal characterisation, washability and liberation behaviour.

Liberation information will be critical to the future development of the coal industry. New commercial forms of coal utilisation need to be developed, and the concept of ultraclean coal is likely to be pivotal. CGA offers immense benefits for the purpose of characterising coals and their potential beneficiation routes.

Further development of the image analysis software is necessary to determine component maceral and mineral size (within each grain/particle), for each grain type. That will facilitate a more fundamental characterisation of the coal and mineral matter in each particle size and grain class, and will provide direct information as to any liberation potential from any specific particle sizes.

The project involves:

- Calculation of maceral component size (within grains) for approximately 150 previous CGA raw data images, covering each of three coal types (5 size classes and 9 RD fractions for each coal type characterisation, plus validation raw coal analyses). (completed);
- Re-assessment of the more detailed C18041 CGA data in order to identify any further correlations which may further improve the accuracy of the resultant washability predictions. (in progress);
- Consideration of impacts of new form of data in relation to possible future re-assessment of C24045 data. (in progress).

Data assessment is proceeding, with the aim of reporting being complete by June 2017.

### C25020 Flotation Tailings Online Measurement

A & B Mylec  
Alan Bennetts  
Todd McDonald

Value:	\$45,200
Report Expected:	25/06/2017
Industry Monitor/s :	Alvaro Diaz Lema Naomi Pritchard
ACARP Contact:	Nerrida Scott

No report received.

### C25021 Coarse Particle Flotation for the Plant of the Future

University of Newcastle  
Graeme Jameson

Value:	\$148,169
Report Expected:	25/07/2017
Industry Monitor/s :	Clinton Vanderkruk
ACARP Contact:	Nerrida Scott

This project aims to test a new device for the flotation of coal over a wide range of particle sizes. It utilises the NovaCell separator, which combines the capabilities of a gravity separator and a froth flotation machine. In a continuous operation, a fluidised bed of coarse ash is created in the bottom of a column. The bed is maintained by recycling a stream of water from the top of the column. Air bubbles are generated in the recycle stream, and mix with new feed prior to injection into the base of the column.

In conventional coal processing, fine coal less than 2mm, and ultrafines less than 300 to 500  $\mu\text{m}$ , are treated in several stages. The fine coal is treated in gravity devices such as spirals or hindered bed separators. The ultrafines are treated by froth flotation. As a replacement for the two-stage approach, the NovaCell can carry out both the gravity and the froth flotation steps in a single operation.

Earlier in the program, the NovaCell was used in batch mode to treat a coal with top size of 2mm, and the results were very encouraging. Subsequently, a continuous cell has been constructed and operated, which delivers two product streams – a froth product as in conventional flotation, and a coarser product recovered from a 500 $\mu\text{m}$  wedge-wire screen placed in the recycle line. The balance between the solids flowrates of fines and ultrafines can be controlled by the air rate. The cell delivers two tailings streams – an underflow of ash particles in the range 500 $\mu\text{m}$  w/w to 2mm, and an overflow of top size 500 $\mu\text{m}$  w/w. A number of runs have been carried out at various air rates and solids loadings and are undergoing size-by-size ash and solids analysis and mass balancing. The results will be included in the final report due in June.

Advantages arising from the use of the NovaCell separator include reduction in area needed for a given solids flowrate; transfer of much of the production from the froth to the gravity overflow, and much higher capacities in terms of tonnes/hr/sq m

of cell area. The production of a coarse tailings with a high percent solids is also an advantage

### C26001

#### Impact of Sub Optimal Operation: Stage 2

BA Firth  
Bruce Firth

Value: \$41,500  
Report Expected: 25/03/2018  
Industry Monitor/s : Ryan Flanagan  
ACARP Contact: Nerrida Scott

The objective of the parent project C24039 'Impact of Sub-Optimal Operation' was the 'Quantification of the effects of sub-optimal operation' in a coal preparation plant. A methodology for a consistent approach to the analysis of the issues involved was developed by employing the concepts from 'The Intelligent Plant' project. This was tested with 19 case studies which covered a number of activities in the plant operation, and in all cases a successful description of the situation was obtained in a consistent manner. The methodology for this project required the entry into 'The Intelligent Plant' diagnostic system via a different starting point to that used in the original system.

Given the successful outcome of the original project, it was recommended that a second phase project is carried out with the objective to modify the existing 'Intelligent Plant Diagnostic' System to access not only from a Symptom/Measurement entry, but also via a Sub-Optimal Operation (Health Issue) option.

Work on this project has just commenced.

## Gravity Separation

### C20050

#### Linkage of Dynamic Changes in DMC Circuits to Plant Conditions

CSIRO  
Mike O'Brien  
Peter Holtham

Value: \$492,502  
Report Expected: 25/05/2017  
Industry Monitor/s : Ryan Flanagan  
ACARP Contact: Roger Wischusen

A draft report is with the industry monitor(s) for review.

### C22031

#### Investigation of the Graviton Separator at Pilot Scale

University of Newcastle  
Kevin Galvin

Value: \$271,120  
Report Expected: 5/25/2017  
Industry Monitor/s : Kevin Rowe  
ACARP Contact: Roger Wischusen

A draft report is with the industry monitor(s) for review.

### C24050

#### Options for the Addition and Control of Non Magnetic Material in Correct Medium

CSIRO  
Mike O'Brien

Value: \$205,490  
Report Expected: 25/06/2017  
Industry Monitor/s : Clinton Vanderkruk  
Justin O'Neill  
ACARP Contact: Nerrida Scott

The objective of this project is to investigate various options for the addition or maintaining/controlling the level of non-magnetic material in the correct medium following a period where the concentration of non-magnetics in the medium is low, eg after a shutdown or outage. The most prospective of these options and any operating procedures will be tested at a plant.

A hose was connected from the thickener underflow to a control valve above the correct medium sump. The magnetite concentration was continuously monitored using an off-take from the correct medium sump outlet and this together with the correct medium density measured using the nucleonic gauge was used to calculate the amount of non-magnetic material in the correct medium. Non-magnetic concentration was used as the input to a PI control system which operated the control valve for the addition of the thickener underflow. The test consisted of two periods with the control system on and two periods with the control off. Samples were taken at regular intervals during these periods and the instrumental data monitored. The results are shown in Figure 1 This data shows the non-magnetics increasing when the control system was on and decreasing when the control system was off. The density differential, while low during all of the test work, increased when the control system was off and decreased when the control was on.

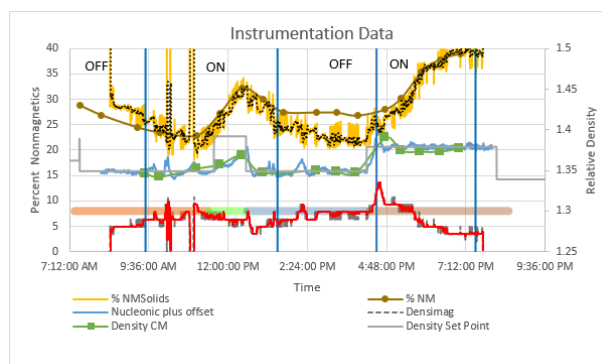


Figure 1 Instrumentation data from the test work

This test work was carried out under already high non-magnetic concentration and low differential conditions and while it showed that the system works and is capable of maintaining a constant low-density differential by the addition of the non-magnetics a further test is planned at low density with low non-magnetics.

**C24051****Effect of Particle Crowding at the Vortex Finder and Spigot on Cyclone Operation**

CSIRO

Mike O'Brien

Value:	\$145,255
Report Expected:	25/07/2017
Industry Monitor/s :	Alvaro Diaz Lema
ACARP Contact:	Nerrida Scott

This project aims to quantify the changes in DMC operational conditions on particle crowding of the vortex finder and spigot. The major outcomes of this project would be an improved understanding of the influence of particle crowding and medium stability on DMC cleaning capability. The understanding is based on well-defined experiments, and the availability of improved quantitative relationships allows for better management strategies for DMC operation.

Additional vortex finder crowding experiments have been completed with the addition of up to 60kg of the vortex finder crowding material to the feed. Some of the results are shown in Figure 1 below.

With the addition of the extra material, the densities approach the feed densities with the differential decreasing as would be expected.

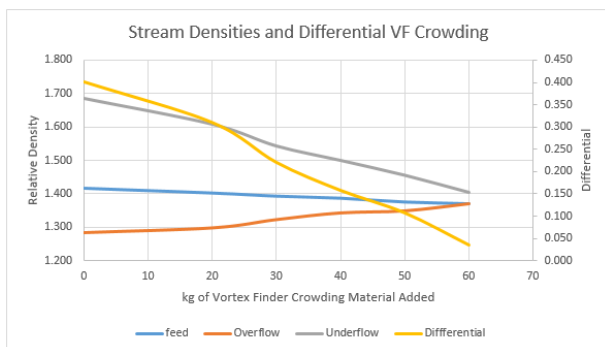


Figure 1. Vortex finder experiments showing the densities and the differential.

Currently in the process of data analysis and report writing with the possibility of another experimental run to help quantify some of the outcomes from previous experiments.

**C25015****Pilot Plant Scale Testing of Modified Downcomer in Jameson Cell**

CSIRO

Shenggen Hu

Value:	\$184,149
Report Expected:	25/10/2017
Industry Monitor/s :	none
ACARP Contact:	Nerrida Scott

The objective of this project is to carry out large pilot scale investigations of the modified downcomer at a mine site for a comprehensive assessment of improved combustibles recovery and scalability, via:

- Designing and constructing a pilot scale test rig;

- Comparing the performance of the modified downcomer with that for the unmodified downcomer in terms of the combustibles recovery and product ash value under normal plant feed conditions and assess the scalability of the modifications;
- Carrying out residence time distribution tests to determine the effectiveness of modified downcomer in improving cell hydrodynamic behaviours.

The pilot scale test rig is being developed by modifying a 500L Jameson cell from Glencore Technology with mass flowmeter and RTD test facilities. Two mine sites were visited to collect information for planning field trials. Approval for site access has been obtained from one mine.

**C25016****G Force Reduction and Failure Monitoring of Multi Sloped Screens**

CSIRO

Mike O'Brien

Value:	\$190,282
Report Expected:	25/07/2017
Industry Monitor/s :	Clinton Vanderkruk
ACARP Contact:	Nerrida Scott

This project has two objectives, it will provide a detailed proof of concept on desliming and drain and rinse screens by:

- Determining the effect of further reducing the screen g force on desliming and drain and rinse screens on screening efficiency; and
- Monitoring a screen continuously for failure indicators using the CSIRO/ACARP-developed system to show that the system is viable for use as a long term indicator of imminent screen failures. (The output from the ACARP/CSIRO monitoring system will be published to a secure web interface so that plant operators and metallurgists can observe the motion of the screens, displacement, stroke and failure indicators in near real time).

Equipment has been manufactured to make the removal of the pins from the screen weights an easier task this consist of a jig which fits over the weights and a hydraulic ram that can be manually operated or pneumatically via a foot switch. Currently testing this equipment on used and rusted screen weights courtesy of FLS.

Inductions for this work have been delayed due to the necessity to now have chest x-rays prior to the site induction.

## Process Control

C22033

Advanced Control and Optimisation of DMC Operation

CSIRO

Shenggen Hu

Value:	\$236,685
Report Expected:	25/06/2017
Industry Monitor/s :	Rahul Patel
ACARP Contact:	Roger Wischusen

The objective of this project is to develop, implement and demonstrate an advanced control system that optimizes DMC operating conditions under which a target product ash and/or a given incremental ash can be achieved.

Plant-based trials for 6 different seams have been carried out to compare the predicted product ash values with those from coal analysis. The largest difference between predicted and analysed ash value was 1.5%. The average error of 6 cases was less than 1%.

An approach for on-line estimating the relationship between instantaneous ash value and density has been developed and validated using data from 6 different coal seams. The relationship has two parameters. One parameter is determined from the observation that for a given coal mine instantaneous ash values of all seams at density of 1.61 are close to each other. Another parameter can be related to the washability curve which can be online estimated from measured DMC product yield and medium densities in feed, overflow and underflow streams.

Due to file damages caused by computer virus, a significant amount of time was spent to redo data analysis and software for the sensitivity analysis of errors. The sensitivity analysis of errors in ash-density curve and washability curve was carried out based on baseline values from plant-based trials for 6 different seams.  $\pm 1\%$  (absolute error) ash change at RD=1.27 in ash-density curves will cause  $\pm 0.8\%$  change in the predicted product ash over the possible range of cut-point.  $\pm 5\%$  error (absolute error) in the ash value at the density of 1.65RD can cause about  $\pm 0.22\%$  error (absolute error) in the predicted DMC product ash value at the DMC cut-point of 1.36RD and this error is  $\pm 0.69\%$  at the cut-point of 1.50RD and linearly increases with an increase in the DMC cut-point.

The final report is being modified after first internal review.

C25011

Effect of Flotation Water Chemistry on Coal Chemistry, Fluidity and Coke Quality

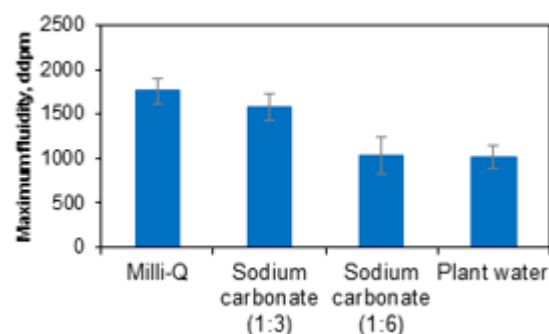
University of New South Wales

Noel Lambert

Seher Ata

Value:	\$150,000
Report Expected:	25/09/2017
Industry Monitor/s :	Rebecca Fleming
ACARP Contact:	Nerrida Scott

The use of recycled water in mining and mineral processing is driven by stricter government regulations. Recycled water generally contains a higher quantity of inorganic compounds and dissolved minerals. A loss in the plasticity of high rank coals has been observed as a result of using recycled water. The aims of this project are to find evidence of the link between the use of recycled water and the loss of coal fluidity. The mechanism by which the loss of fluidity occurs is under investigation in order to propose corrective strategies.



Maximum fluidity of coal samples treated for 7 days in different solutions.

High grade large coals were crushed and classified. A test was designed to be allowed solution to be in contact with the coals for an extended period of time. The coal sample was placed in process water or inorganic electrolyte solutions on a 1:3 or 1:6 (coal:water) weight basis, dewatered (approx. 30% water), and stored for 7 days in an air tight container. The sample was subsequently dry with nitrogen gas. There was no significant difference when samples were stored in nitrogen or air. The treatment statistically affected the maximum fluidity. Other inorganic electrolytes are being tested including  $\text{CaCO}_3$ ,  $\text{CaCl}_2$ ,  $\text{MgCl}_2$ ,  $\text{KCl}$ ,  $\text{K}_2\text{SO}_4$ ,  $\text{Na}_2\text{SO}_4$ .

In some theories on plasticity a loss of thermoplastic properties is associated with a more highly cross-linked macromolecular structure of the liquid mass. An attempt has been made to determine the quantity and nature of the functional groups on the coal surface, which may affect the amount of cross-linking at elevated temperature. For this work, the Boehm titration method was used. More work is needed in this area, which may involve removing the mineral matter from the coal particles prior to perform the Boehm titration.

## General

### C25007

#### Derrick Stack Sizer In Plant Evaluation

##### WPE Process Equipment

Brian Packer

Darren Mathewson

Value:	\$150,800
Report Expected:	25/06/2017
Industry Monitor/s :	Naomi Pritchard Rebecca Fleming
ACARP Contact:	Nerrida Scott

In many plants, both thermal and coking, millions of tonnes of saleable quality ultrafine coal are ultimately discarded into tailings dams along with the high ash slimes material. Based purely on the principle of size classification, the Derrick Stack Sizer is a small footprint, high capacity technology capable of recovering coal from fine waste streams and reducing the ash value of existing fine product streams. The Stack Sizer can be used as a replacement for classifying cyclones, to recover coal from thickener underflow, to scavenge flotation tailings or even to replace flotation. It therefore has the potential to be a 'gamechanger' and revolutionise the industry for both thermal and coking coal mines.

The Derrick Stack Sizer test work has been completed at two sites. A high % solids oversize (ie without 'flooding') was sought for the low flowrate runs with the flowrate increased to slight 'flooding' for the medium flowrate runs and definite flooding for the high flowrate runs. The view was that a screenbowl centrifuge (for example) will remove most of the entrained high ash -45 micron particles from the higher flowrate runs. The results were very encouraging.

Diluted thickener underflow was tested at 45 and 75 micron slot aperture. The Whiten/Lynch classification equation was used for curve fitting to the AS4156.7 raw partition curves with cutpoints of 87-140 micron, alphas of 6.0-10.6 and bypass of 0% (actual bypass 0-4%) modelled from the 75 micron screen. Cutpoints of 49-81 micron, alphas of 2.0-6.3 and bypass of 0-2% (actual bypass 0-30%) were modelled for the 45 micron screen.

Desliming cyclone feed was tested at 75 micron slot aperture. Spiral product thickening cyclone feed was tested at 75 and 180 micron slot aperture.

The pilot plant has been delivered to the final site and will be promptly commissioned and tested.

### C25019

#### Adaptation of Coal Grain Analysis to Improve Yield Estimation

##### OCC Resources

Bruce Atkinson

Value:	\$165,584
Report Expected:	25/09/2018
Industry Monitor/s :	Dion Lucke
ACARP Contact:	Nerrida Scott

Accurate prediction of flotation yield is difficult. Modelling of density separation processes is reasonably straight forward, however existing methods of modelling of flotation yield are poor.

This project offers further development of an already commercially available analytical tool (Coal Grain Analysis – CGA) that is likely to be able to solve the problem and provide a more accurate basis for modelling flotation yield. The information will be generated in a form that will enable direct utilisation in the likes of LIMN process models.

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The preliminary data demonstrate correlations between steady-state flotation rate constant and particle size for each of vitrinite and inertinite. Interestingly, vitrinite rate constant increases with increasing particle size, while inertinite rate constant decreases with increasing particle size.

Sampling of the fourth circuit for C24045 (Microcel) has been delayed but is hoped to be completed during the next Quarter.

One site (mechanical cells) has been sampled for the second project, C25019. Five further sites have agreed to participate, 2 x Microcel, 2 x Jameson and 1 x Mechanical. It is anticipated that all of those sites will be sampled prior to the end of 2017.

### C26016

#### Benefits of Online Thickener Underflow Rheology Measurements

##### Clean Process Technologies

Noel Lambert

Value:	\$251,000
Report Expected:	25/03/2018
Industry Monitor/s :	Naomi Pritchard Ryan Flanagan
ACARP Contact:	Nerrida Scott

This project will find how useful are the rheology measurements generated by the Thickener Underflow Monitor (TUM). The TUM was developed by Clean Process Technologies (CPT) with ACARP assistance (project C24048).

The TUM is currently able to generate information regarding the rheology of coal thickener underflow (as well as solids concentration m/m and v/v, slurry density and particle density), but the usefulness of this information is not well understood.

It is the purpose of this project to determine if and how these rheology measurements can be applied to standard thickener operations, paste thickener operations, secondary thickening operations, belt filter presses and other mechanical dewatering devices to see if online rheology measurement of tailings thickener underflow can be used to:

- Optimise thickener operation;
- Optimise paste thickener operation;
- Reduce flocculant consumption to belt filter operations;
- Reduce flocculant consumption in secondary flocculation;
- Provide a means for maintaining more consistent operation of all the above systems.

In March we visited site (Bulga CHPP) to perform an inspection on possible installation locations.

Met with Michael Carnell, process engineer for Bulga CHPP. Discussed and investigated multiple installation locations and potential streams to be analysed by the TUM. There is thickener #1, thickener #2 and also the paste thickener which could be potential locations for installation.

It was decided that next to thickener #2 would be the ideal installation location for a few main reasons.

- Close proximity to thickener #2 underflow pump;
- Close proximity to paste thickener feed line (which contains material from both thickeners);
- Close proximity to paste thickener underflow line. This gives the potential for paste thickener underflow to be fed into the TUM;
- Good access for light vehicles for installation, operations and sample collection;
- Availability of compressed air and 24VDC power if required;
- Bunded area to contain spills and TUM waste material.

TUM unit is being constructed and commissioned at CPT facilities, awaiting samples from Bulga CHPP. Bulga flotation circuit is not yet operational due to a delay in commissioning. Scheduled to be commissioned by the end of this month. We will then endeavour to perform a site visit and collect samples to be tested in the CPT facilities.

C26038

### CGA Workshop Series - Driving Implementation

CSIRO

Basacon Services

Bruce Atkinson

Graham O'Brien

Value:	\$44,910
Report Expected:	25/12/2017
Industry Monitor/s :	Angus McIntyre Chris Urzaa
ACARP Contact:	Nerrida Scott

ACARP has invested in excess of \$4 million in total, on more than 20 projects dealing with coal grain analysis (CGA).

CGA, as developed by CSIRO, is proving to be an invaluable tool for the enhanced characterisation of coals. More particularly, the investment in the technology has resulted in demonstrating the application of CGA to a wide range of practical fields in the coal industry, such as:

- Correlations of CGA maceral and mineral composition with conventional coal chemistry;

- Direct measurement of particle size and density distribution within the analysis sample, and its direct application in fine coal preparation;
- Prediction of size and washability distributions at top size (e.g. 50 mm) based on -1 mm samples; and its application to advanced determination of coal reserves;
- Assessment of caking characteristics;
- Assessment of amenability of coals for advanced utilisation such as direct injection combustion engines;
- Identification and quantification of components in urban dust samples;
- Fundamental information to support liberation studies.

This project is solely about Technology Transfer, and involves up to four one-day Workshops to assist the industry to understand CGA and its applications. In addition, the Workshop presentation topics will be recorded as webinars and made available to personnel who are unable to attend the Workshops.

Workshop dates are - Brisbane 25 May; Newcastle 21 June; Emerald 19 July and Sydney 23 August. The Emerald and Sydney. Workshops are subject to adequate demand, with registration/registration of interest for Emerald and Sydney, available at <https://events.csiro.au/Events/2017/April/3/Coal-Grain-Analysis-Workshop>.



# TECHNICAL MARKET SUPPORT

## Metallurgical Coal

C23049

Coke Analogue to Examine the Effect of Mineralogy on Coke Reactivity: Part 3

University of Wollongong

Brian Monaghan

Value: \$469,208  
 Report Expected: 25/06/2017  
 Industry Monitor/s : Kim Hockings  
 Oliver Scholes  
 Tim Manton  
 ACARP Contact: Dave Osborne

The overarching aim of this project is to understand the impact of mineralogy on the reactivity of metallurgical coke using a coke analogue material in a pseudo CRI test. Specifically, for Part III. Key outcomes of the project will be:

- Development of a validated index used in predicting coke reactivity from its mineralogy;
- A brief review of CRI and MBI academic literature.

Key outputs of the project:

- Literature review of MBI/CRI equations (complete);
- Model of the coke analogue reactivity (report section in draft);
- Experimental analogue work for model validation and data (report section in draft);
- Sole oven pilot cokes to test the effects of Fe and Ca on reactivity (currently being produced for testing).

The majority of the originally planned work is complete and the final report is in draft form. Once the production and testing of the sole oven cokes are complete they will be incorporated into the report. There were some delays in the washing of the coals for the sole oven pilot cokes that have delayed the final report.

C24053

Effect of Coke Reactivity Upon Coke Strength With Focus on Microstructure

CSIRO

David Jenkins

Merrick Mahoney

Value: \$161,032  
 Report Expected: 25/05/2017  
 Industry Monitor/s : Nick Andriopoulos  
 Oliver Scholes  
 Stephen Brant  
 ACARP Contact: Dave Osborne

A draft report is with the industry monitor(s) for review.

C24054

In-situ Study of the Plastic Layer Formation in Coking Coals using a Lab Scale Test Furnace

University of Newcastle

Jianglong Yu

Merrick Mahoney

Value: \$213,530  
 Report Expected: 25/04/2018  
 Industry Monitor/s : Oliver Scholes  
 Sean Flanagan  
 Shaun Booth  
 ACARP Contact: Dave Osborne

A draft report is with the industry monitor(s) for review.

C24057

Estimating the Fusible Content of Individual Coal Grains and its Application in Cokemaking

CSIRO

David Jenkins

Karryn Warren

Merrick Mahoney

Value: \$230,026  
 Report Expected: 25/06/2017  
 Industry Monitor/s : Kim Hockings  
 Nick Andriopoulos  
 Oliver Scholes  
 ACARP Contact: Dave Osborne

The objectives of this project are to use three recently developed analytical techniques to obtain new insights into the link between the size distribution of the fusible and infusible macerals and minerals and resultant coke structure and strength. This has applications in optimising the preparation of coal for coking and in obtaining the highest strength coke from coals. The techniques to be used are enhanced Coal Grain Analysis (CGA), the analysis of 3D microstructure of coke from Computed Tomography (CT) scanning and the analysis of fracture surfaces using fractographic techniques.

The project leaders have made progress on the draft of the final report. In the next quarter we plan to integrate the sections of the report and submit the draft report.

C24058

Microscopic Properties of Coal and Coke: Comparing Coal Grains with the Optical Properties of Coke and Determining their Relationship

ALS Coal

Bill Cash

Philip Bennett

Value: \$42,600  
 Report Expected: 25/05/2017  
 Industry Monitor/s : Ashley Conroy  
 Kim Hockings  
 Oliver Scholes  
 Stephen Brant  
 ACARP Contact: Dave Osborne

A draft report is with the industry monitor(s) for review.

### C24059 Volatile Release During Pulverised Coal Injection as a Factor in Determining Combustibility

University of Newcastle  
Liza Elliot  
Terry Wall

Value: \$149,000  
Report Expected: 25/05/2017  
Industry Monitor/s : Nick Andriopoulos  
Phil David  
Shaun Booth  
ACARP Contact: Dave Osborne

A draft report is with the industry monitor(s) for review.

### C25042 Mechanistic Model for the Understanding of the Sole Heated Oven

CSIRO  
Joan Boulanger  
Merrick Mahoney  
Richard Sakurovs

Value: \$159,105  
Report Expected: 25/11/2017  
Industry Monitor/s : Graeme Harris  
Kim Hockings  
Oliver Scholes  
ACARP Contact: Dave Osborne

This project is aimed at using the previously developed dilatometer and sole heated oven models to build a detailed mechanistic model of plastic layer behaviour in a coke oven and to use it to predict aspects of coke microstructure that can be related to coke properties.

This project started on 1st June 2016. Moisture movement in the early stages of heating has now been implemented into the general model, as has heat conductivity. The details for the plastic layer, and the enthalpy, heat capacity, microstructure and porosity as a function of temperature and their interrelationships are now being developed for incorporation into the general model.

### C25043 Strength of Interfaces in Coke and its Influence on Coke Abrasion

University of Newcastle  
Hannah Lomas  
Richard Sakurovs

Value: \$120,410  
Report Expected: 25/06/2017  
Industry Monitor/s : Kim Hockings  
Stephen Brant  
ACARP Contact: Dave Osborne

Techniques used in tribology, i.e. the science and engineering of interacting surfaces in motion, can be applied to metallurgical coke to better understand the strength and properties of the interfaces between the different solid phase components, known as textures.

Three sets of cokes/ coals were selected for this project. These included pilot oven cokes, cokes in which the size of the grind of the inertinite and vitrinite rich fractions was varied, and lab scale sole heated oven cokes, including cokes from blends of maceral concentrates.

This project has demonstrated that tribological testing techniques are a promising approach to determine the relative fracture toughness and resistance to abrasion of the distinct microtextural constituents as a function of the rank of the parent coal(s). In addition, we have used the acoustic emission profiles and frictional force data obtained from progressive loading linear scratch tests to identify distinct acoustic emission peak signatures. These signatures were then correlated to the strength of the interaction between the inertinite and reactive maceral derived components, as a function of the rank of the parent coal(s).

In the last quarter, we have completed the analysis of the wear modes, severity of damage and other parameters for both the rotational tribology and linear scratch tests with acoustic emission measurement, using a combination of high resolution imaging techniques. In the last month, we have completed the compilation of the data and quantitative analysis of the results. This included comparing the different cokes in the study and relating the key findings to the properties of the parent coals and industrial coke cold strength indices. The final report for this project is currently 40% complete, and we expect to submit this report to the project monitors at the end of June.

### C25045 In-Situ High Temperature Strength of Low CSR Cokes

University of New South Wales  
Pramod Koshy

Value: \$104,000  
Report Expected: 25/04/2018  
Industry Monitor/s : Kim Hockings  
Nick Andriopoulos  
ACARP Contact: Dave Osborne

A draft report is with the industry monitor(s) for review.

### C25046 Using High Range Mass Spectrometry to Study the Link between Coal Structure, Coke Strength and Thermoplastic Chemistry in Blends

University of Newcastle  
Rohan Stanger

Value: \$104,240  
Report Expected: 25/07/2017  
Industry Monitor/s : Kim Hockings  
Nick Andriopoulos  
ACARP Contact: Dave Osborne

This project has evaluated the use of Laser desorption/ionisation mass spectrometry (LDI-TOF-MS) to characterise coking behaviour for a range of coal types. Currently 4 coals have been completed with a 5th coal to be tested. Coking behaviour has been evaluated using semi-cokes produced at softening, max fluidity and resolidification temperatures. These samples were solvent extracted to isolate

metaplastic components and compared to analysis of the solid semi-cokes. Solvent extracts were found to extend to 3000g/mol in size whilst solid state analysis showed material present with molecular weights up to 7,000g/mol. This work has shown that the extractable components differ at key points in the plastic process. It has also shown that the plastic phase contains larger amounts of these lower molecular weight compounds compared to the coal or resolidified semi-coke.

#### C25048

### Automated Optical Image Analysis of Coke Texture and Structure and their Connection with Coke Porosity, Reactivity, Strength and Parent Coal Blend

CSIRO

Eugene Donskoi

Value: \$149,913  
 Report Expected: 25/12/2017  
 Industry Monitor/s : Oliver Scholes  
 Sean Flanagan  
 ACARP Contact: Dave Osborne

The main objectives of this project are:

- Further develop structural coke characterization which will include the identification of different types of IMDC and RMDC.
- Develop novel automated image analysis methods for coke texture characterisation.
- Determine the most important parameters characterizing coke structure and texture and achieve a more integrated understanding of relationships between the different characteristics of coke and the parent coal blend through examining relationships between coke micro/nano-porosity, different IMDC and RMDC structures, coke textural characteristics, reactivity and strength, and characteristics of initial coal blend.

The project work is currently at the following stage:

- Task1: Coke selection, data collection and polished blocks preparation;
- Task2: Development of Software for controlling the Motorized Rotating Polarizer, collecting images and producing and analysing Maximum/Minimum reflectance and Bireflectance maps;
- Task3: Porosity measurements and proper data processing have been completed and corresponding analysis performed.

During the collection of data for identification of different carbon types and testing of the system it was realized that the available microscope configuration creates non-uniform illumination under different polarization angles. That was affecting the measurements of bireflectance. A literature study suggested using polarization-specific microscope hardware parts to reduce this effect. The producer of microscope, Zeiss, has been contacted and they suggested that they can supply a solution to the problem. In parallel the project team was trying to solve the problem with other means. Unfortunately half a year later Zeiss have withdrawn their promise to solve the problem. Fortunately we managed to fit the appropriate part from Leica to Zeiss microscope and are currently working on optimization of bireflectance measurements. When this work will be finished and the database of different carbon types will be collected we will start Task 4 - the imaging of coke samples. Our estimation

of the delay in the delivery of the project because of the described obstacle is 5-6 months.

#### C25049

### Fusibility of Coal Blends and Behaviours of Minerals in Coking

CSIRO

Merrick Mahoney

Priyanthi Hapugoda

Value: \$172,860  
 Report Expected: 25/11/2017  
 Industry Monitor/s : Stephen Brant  
 Susan Ellis  
 ACARP Contact: Dave Osborne

No report received.

#### C25051

### Links Between Microstructure Development in Softening Coal and the Characteristics Controlling Coke Quality

University of Newcastle

Merrick Mahoney

Richard Sakurovs

Value: \$139,715  
 Report Expected: 25/06/2017  
 Industry Monitor/s : Nick Andriopoulos  
 Oliver Scholes  
 ACARP Contact: Dave Osborne

The project is an extension of ACARP C23048 "Investigation of the links between microstructure development in softening coal and the characteristics controlling coke quality" and develops on the successful outcomes of the previous project. This project addresses the questions of how coke structure is formed within the plastic layer during coking and how these structures control strength of the final coke. It also addresses the question of how different inertinites in coal affect the development of structure and strength in coke. Specific project objectives are:

- Further develop understanding of the relationships between key microstructural features of coke and coke failure mechanisms and strength indices;
- Understand the development of key microstructure features by identifying key processes in the plastic layer contributing to the development of coke microstructure;
- Develop some understanding of how different inertinite types can influence structure development by modifying processes in the plastic layer.

CT images were collected in July for the samples at the Australian Synchrotron and analysis of the images is approximately two thirds complete. It is expected that the draft report will be delayed until October 2017.

## C25052 Concentrating Coke Oven Sized Inertinite Particles: Behaviour in Targeted Coking Blends

University of Newcastle  
Wei Xie

Value: \$91,690  
Report Expected: 25/06/2017  
Industry Monitor/s : Tim Manton  
ACARP Contact: Dave Osborne

The objectives of this project are to:

- Concentrate coke oven sized inertinite particles that contain various semi-inert contents;
- Study the influence of these coke oven sized inertinite particles on coking behaviour of another "standardised" coal measure; and
- Establish relationships between the concentrated inertinite particles reflectogram and the measured physical and chemical changes of the targeted coking blends, to provide support for predicting coke strength.

To achieve these objectives, the project combines CATA for swelling, permeability, DETA for volatiles evolution and Pearson Coal Petrography for coke fusibility analysis. The coke oven size inertinite particles (1.6-2.0 mm) have been obtained by using an upgraded Reflux Classifier.

Because our colleagues had used the reflux classifier for concentrating small size macerals for their ACARP projects, this project was delayed about six months. In last quarterly report, we mentioned that we are expecting to complete all CATA and DETA tests for the blends of the separated inertinite particles from the two inertinite rich coking coals with the standard strong and weak coking coals. To date, we have run a number of experiments; the results indicated that the concentrated macerals showed different impacts on swelling for the tested two standard coking coals. However, we have one issue for the reproducibility of these swelling tests because the particles are from a large range between 0 and 2.0 mm, which affected the particles distribution in the one inch quartz tube. We are trying many different packing methods to obtain reproducible results. Over the next quarter, we are expecting to solve this issue and complete all coking tests for CATA and DETA.

## C26041 Australian PCI Coals Under Industry Scale Conditions of Ironmaking Blast Furnace using 3D Computer Modelling

University of New South Wales  
Yansong Shen

Value: \$100,000  
Report Expected: 25/04/2018  
Industry Monitor/s : Chris Urzaa  
Morgan Blake  
Stephen Brant  
ACARP Contact: Dave Osborne

This project aims to evaluate the performance of Australian black coals in the operation of pulverized coal injection (PCI) in the raceway of ironmaking blast furnace (BF) under industry-scale BF conditions, rather than lab- or pilot-scale conditions. In particular, the project will assess the suitability of two types of

calculations of coal combustion efficiency (termed burnout) under real BF conditions for a range of Australian black coals i.e. burnout calculation over the entire raceway surface vs. burnout calculation along the tuyere centreline only.

Progress during this quarter

- Dr FY Meng and Mr JH Liao started their work in this project;
- The use of Bluescope BF data has been approved by Darryle Lathlean through Paul Zulli. Paul Zulli will be involved in this project and coordinate Bluescope-related issues;
- The use of Baosteel BF data has been approved by Baosteel through Dr Shen's connection in China. This simulator should be helpful for exploring Chinese PCI market further;
- PCI model has been tuned by using these BF data for developing Australian BF version PCI simulator and Chinese BF version PCI simulator, respectively;
- Significant effort has been made to improve the PCI model by including more details, for example birdnest in the coke bed; and
- ACARP's TMS Committee has initiated procurement of samples to support project needs.

## C26043 Characterising the Degradation of Cokes made from Australian Coals and Subjected to Simulated Blast Furnace Operating Conditions

University of New South Wales  
Paul Zulli  
Xing Xing

Value: \$167,640  
Report Expected: 25/02/2018  
Industry Monitor/s : Stephen Brant  
Tim Manton  
ACARP Contact: Dave Osborne

The main objective of the project is to develop the understanding of degradation of metallurgical cokes under simulated BF ironmaking conditions (measured gas and thermal profiles within the furnace). This project will provide both a fundamental and applied means to assess coke performance, related to inherent coal and coal blend properties.

Progress to date (against Milestones M1-M9, see below):

- M1 – Six pilot oven cokes were provided by BHP Billiton, Anglo American and Vale for this project. These cokes were produced from the coals with Romax from 1.0 – 1.66;
- M2 – Initial workshop completed on 28 April 2017;
- M3 – Gasification for four cokes under simulated blast furnace conditions has been completed. Gasification for the other two cokes will be completed in May;
- M4 – Annealing for four cokes has been completed. Annealing for the other two cokes will be completed in May;
- M6 – The tensile strength and crystallinity of four cokes have been determined using tensile testing and XRD.

Preliminary results indicated that the coke made from coal with lowest rank showed highest resistance to degradation after gasification with subsequent annealing under the blast furnace conditions, and it showed lowest increase in the crystallinity after gasification and annealing.

Table 1. Project Gantt chart

Research Activity	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
M1												
M2												
M3												
M4												
M5												
M6												
M7												
M8												
M9												

M1 - Collection and characterisation of coal and coke samples including feed coke, parent coals

M2 - Initial workshop

M3 - Coke gasification

M4 - Coke annealing

M5 - Interim workshop

M6 - Characterisation of cokes treated under the simulated BF conditions

M7 - Characterisation of cokes treated under more aggressive gas conditions

M8 - Preparation of final report and publications

M9 - Final workshop

Next quarter work - the gasification and annealing of all six cokes under simulated blast furnace conditions will be finished. The gasification for two selected cokes with high and low CSR under the more aggressive conditions will be completed in the next month (M3 and M4). Interim workshop will be held in July (M5). Detailed studies will be carried out on the properties of cokes treated under the simulated blast furnace conditions (M6).

## C26045

### Mineralogy Effects on the 3D Porosity of Coke

#### University of Wollongong

Brian Monaghan

Richard Sakurovs

Value:	\$189,140
Report Expected:	25/04/2018
Industry Monitor/s :	Kim Hockings Oliver Scholes Tim Manton
ACARP Contact:	Dave Osborne

The specific focus of the proposed work will be to utilise the coke analogue in combination with 3D micro CT analysis to evaluate not only the effects of mineralogy on reactivity but specifically how the minerals are effecting porosity development with time and temperature.

Key outcomes of the project will be:

- A brief review of 3D measurement and characterization techniques applied to coke; and
- A validated and extensive 3D data set of coke reactivity data with time and temperature that can be used to inform extant CSR/CRI data and its application.

#### Progress

Dr Dong focus is on the modelling. He is progressing developing a methodology for 3D analysis. Using synchrotron coke analogue data to:

- Develop transformation protocols, 2D to 3D;
- Validate against 2D coke analogue analysis;
- Obtain preliminary 3D porosity for the data; and
- Learn how to use GeoDict.

Other modelling work:

- We have obtained a time limited licence for GeoDict from the software vendor Access ends week of the 15th of May;
- We are in the process of finalising access to CSIRO's GeoDict software.

Review of 3D measurement:

- Work has started and a large number of papers have been identified. These are currently being summarised.

Ms Jayasekara primary focus will be on the experimental work:

- Some industrial coke has been identified (currently one feed coke from the Illawarra and one pilot coke from a coal supplier (South 32). Details have yet to be discussed with the wider research team;
- Production of analogue representing the Illawarra coke is underway.

## General

### C25044

#### Trace Elements in Coal: Status of Test Methods in use and Applicability to Industry Needs

#### QCC Resources

Ian Anderberg

Value:	\$235,227
Report Expected:	25/01/2018
Industry Monitor/s :	Graeme Harris Greg Wickman Kahlee Saunders Kay Palmer
ACARP Contact:	Dave Osborne

This project extension has two key objectives:

- To provide confidence in the level of precision and accuracy for analysis of As, Cd, F, Hg and Se performed by Australian coal testing laboratories; and
- To evaluate the potential for bias on fluorine for a wider range of Chinese coal reference materials.

Work conducted to date has centred on planning the interlaboratory test programs in a manner that maximises the benefit of the program to industry.

Seven laboratories have agreed to participate in the interlaboratory test program. This will involve the issue of blind coal reference materials and unknown samples generated from Australian coals to the participants over three rounds of testing.

The reference materials have been purchased, however delays have been experienced in obtaining unknown samples (which must be registered and/or obtained through the ACARP Coal Bank) due to impacts of the recent Queensland cyclone. The first, of the three, interlaboratory test programs is now expected to be complete during July 2017.

## C25047 International Carbonisation and Coke Testing Round Robin

### ALS Coal

Adrian Reifenstein  
Philip Bennett

Value: \$86,500  
Report Expected: 25/06/2017  
Industry Monitor/s : Ashley Conroy  
Oliver Scholes  
ACARP Contact: Dave Osborne

Previous ACARP projects examining the influence of coking conditions have clearly demonstrated that coking conditions do impact on the CSR of the coke produced. The heating rate when the coal undergoes plastic deformation was found to be a key process variable impacting coke quality. It is expected that for most coals the coking conditions influence the microstructure of the coke via variations in the heating rate at the time of plastic layer formation across the width of the oven.

There have been very limited round robins between different laboratories in the past comparing the results from different pilot or smaller coke ovens. This project aims to organise and collate the results from the testing of the same coal sample in facilities in Australia, Japan, China, France, Germany and Canada. The participants in this project are ALS, SGS and BHPB (Australia), DMT (Germany), SAIL (India), Beijing Institute of Coal Chemistry (China), CANMET (Canada), TATA (Holland, UK and India), NSC (Japan) and CPM (France).

A coal blend consisting of several coals from Australian producers has been homogenised before sub-sampling to meet the needs of the participants. These sub-samples from 100kg to 1000kg have been air freighted to all participants in early October 2016. Only the samples to India have had difficulties passing through customs, these issues were believed to be resolved with ALS agreeing to meet all custom charges. The coal sample to SAIL was finally delivered in January of 2017.

The test work for this project has been completed. A draft report was forwarded to the round robin participants on 13 April 2017. Three participants responded with comments and these items have been addressed.

A draft report is with the industry monitor(s) for review.

## C25050 Overview of ACARP and NERDDC Outcomes

### CSIRO

Richard Sakurovs

Value: \$130,000  
Report Expected: 25/11/2017  
Industry Monitor/s : Ashley Conroy  
Kim Hockings  
ACARP Contact: Dave Osborne

The main objective of this work is to present an overview and synthesis of the main findings generated by ACARP and NERDDC activities to make them more accessible to the coal industry and researchers entering the coal and coke research areas.

At this stage about half of the reports have been examined in detail and their assessments are continuing. One finding presented on PCI coals needs promoting. In the project "High rate PCI and the interaction with coke quality" performed at the then-called BHP Billiton Innovation Laboratories a rig was used that involved exposing a series of coke cylinders to a pulverised coal injected into a flame to mimic blast furnace conditions. The depth of penetration of the coal flame or mineral matter into the coke was greatest for the highly reactive coke. This finding is important because it contradicts the current belief that highly reactive cokes react only on the coke surface (and low reactive cokes react throughout the coke particle) and highly reactive coke keeps its strength in the blast furnace because only its surface reacts.

## C25053 International Coal Bank

### CSIRO

Keith Vining  
Lukas Koval

Value: \$70,000  
Report Expected: 25/09/2018  
Industry Monitor/s : Kim Hockings  
Technical Market Support  
Committee  
ACARP Contact: Dave Osborne

The main objective of this project is to operate the coal sample bank to make them available to researchers and to enhance the systematic provision of the samples for research projects funded by ACARP.

This project started in March. At this stage all necessary forms have been developed (coal order, despatch and quality), confidential database created and stored with the directory with limited access. Brand new sample storage facility with operating temperature of -18°C have been purchased and storage of the coal and coke samples commenced at CSIRO. Storage located within CSIRO will significantly improve the provision of the coal and coke samples to the researchers and decrease the samples despatch time. Up to this stage 4 coal samples were delivered and stored and their details updated in the database.

## C26003 Management of SA and ISO Coal Technical Committees Work Programs

### Carbon Connections

Barry Isherwood

Value: \$104,750  
Report Expected: 25/08/2018  
Industry Monitor/s : Kim Hockings  
ACARP Contact: Dave Osborne

This project is a continuation of ACARP support for the management of and input into both Australian and ISO Coal Sampling, Preparation and Analysis Standards.

A meeting of ISO TC27 Coal and Coke is scheduled to be held in Brisbane in October 2017. Planning for this meeting has been underway for over 12 months, with the Marriott Hotel selected as the venue. In the final stages of negotiations with the hotel in February, we were advised that our dates were no longer

available as they now clashed with a Bledisloe Cup Rugby game to be held in Brisbane, and that the hotel had accepted a booking from the All Blacks team. This required the selection of an alternative hotel venue, with the meeting moved to the Stamford Plaza, and lengthy contract negotiations between Standards Australia (SA) and the hotel have only just been concluded at the end of April, and thus delayed planning for our meeting.

SA Committee MN/1/1 (Coal Analysis) held a meeting in March in Sydney and the work preparation and schedule for the upcoming ISO TC27 meeting was discussed. A presentation on ACARP Project C25044 (Trace Elements in Coal – Status of Test Methods and Applicability) was provided as part of the project's deliverables and the finding will now be considered for inclusion in the future update of the relevant ISO analysis methods.

SA Committee MN/1/2 (Coal Preparation) held a start-up meeting in Newcastle in April, to revise AS4156 (Float Sink Testing of Coal). This long overdue revision of an old Standard with questionable health related issues, will draw on an ACARP Project C17045 (OH&S Review of the Use of Organic Heavy Liquids for Float Sink Testing) for input and reinforce the need to develop alternative and safer media for coal testing.

#### C26005 Coal Self Heating Investigation

University of Newcastle  
Ken Williams

Value: \$194,800  
Report Expected: 25/10/2017  
Industry Monitor/s : Ash Goodwin  
Maritime Regulation Task Group  
ACARP Contact: Anne Mabardi

Current small scale laboratory tests, such as the UN test N4, have a limited test volume size (100mm sided cube). This may limit their utility for Australian coal due to prevalence of large coal particle sizes (up to nominal 50mm). It is possible to improve its use for coal self-heating assessment by increasing the size of the test chamber that is used for the N4 test. Other self-heating test methods such as the R70 / RIT test may be more applicable to Australian coal assessments. The aim of this project is to determine the optimum testing protocol for spontaneous combustion potential of Australian coal.

The specific objectives of the research will be:

- Test the suitability of UN test N4 for measuring the self-heating potential of Australian coal.
- Investigate larger test cells for incorporating larger coal particle sizes using the N4 procedure
- Review alternative tests for spontaneous combustion potential of coal.
- Recommend an appropriate approach for measuring the spontaneous combustion potential of Australian coal applicable to coal storage and transport systems.
- Report on the range of results for Australian coals.

The following progress has been made this quarter:

- Purchase of an additional two dedicated ovens;
- Modification of ovens to be compliant to University Safety requirements;
- Installation of CO, CO2 and O2 monitors (room and personnel);
- Finalisation of documentation of test risk assessments and Safe Operating Procedure, Training of Personnel;
- Construction of additional larger test cells;
- Currently testing sensitivity of UN.N4 test on:
  - upper particle size,
  - sample preparation methods,
  - compaction type,
  - oven airflow circulation,
  - oven air exchange values,
  - basket configurations,
- Completion of supporting documents:
  - literature review on self-heating including the origins of the N.4 test method (based activated carbon self-heating behaviour),
  - test summaries for AU6 and AU7,
  - supporting information document and presentation for additional AMSA meetings.

#### C26037 Australian Participation in Development of ISO Methods for Sampling, Analysis and Coal Preparation and National Technical Committee Support: 2017/2018

Standards Australia  
Ahshanur Rashid

Value: \$117,500  
Report Expected: 25/01/2018  
Industry Monitor/s : Kevin Rowe  
Kim Hockings  
Rebecca Fleming  
ACARP Contact: Dave Osborne

Item	Description	Meeting year (2017)
1	International Secretariat ISO/TC27/SC5	No meeting since 2015, next meeting Oct 2017. Seventeen active projects.
2	International Secretariat ISO/TC27/SC1	No meeting since 2015, next meeting Oct 2017. Four active projects.
3	National Mirror Committee Support	See Item 1.1
4	Travel support for delegates TC27 (x1), SC5 (x2), SC1 (x1), and SC4 (x1)	SA and MN-001 Committee will nominate close the ISO TC27 Meeting (Oct 2017)
5	Travel Support for SA PM	SA Project Manager will attend the ISO TC27 Meeting (Oct 2017)
6	Host meeting costs - Brisbane	See Item 1.2

SA support for Australian Mirror Committee—Schedule of meetings:

- MN-001 (Coal and Coke)—Mirror Committee for ISO/TC27, Chairman: Mr Barry Isherwood
- Next meeting: 27th July 2017, BHP Office, Brisbane

MN-001-01 (Coal analysis) —Mirror Committee for ISO/TC27/SC3 and SC5 Chairman: Barry Isherwood:

- Last meeting: 23rd March 2017, SA Office, Sydney;
- Next meeting: 27th July 2017, BHP Office, Brisbane;
- Meeting objective: Review ISO/TC27/SC5 and SC3 documents including systematic reviews and finalise Australian mirror Committee position on ISO ballot (and comments).

MN-001-02 (Coal Preparation) —Mirror Committee for ISO/TC27/SC1 and SC4, Chairman: Dave Osborne:

- Last meeting: 15th February 2017, CSIRO, Pullenvale, Brisbane;
- Next meeting: 10th August 2017, NIER, Newcastle;
- Meeting objective: Review of ISO/TC27/SC1 & SC4 documents including systematic reviews and finalise Australian mirror Committee position on ISO ballot (and comments). Review update on national Standards and projects.

MN-001-05 (Coal Mining and Geology), Chairman: Walter Pickel:

- No meeting planned; Subcommittee has no work program.

MN-001-06 (Determination of Gas Content), Chairman: James Sandford:

- No meeting planned; Subcommittee has no work program since publication of AS 3980-2016.
- 1.2 Organise ISO/TC 27 Meeting in Australia —15-20 October 2017
- SA management approved hosting the ISO/TC27 Plenary Meetings, 15-20 October 2017, Brisbane;
- Host Country (Standards Australia) invitation forwarded to ISO/TC27 for 2017 plenary meeting;
- Funding arrangements: A contract signed between SA and Coal Industry (ACARP) in March 2017;
- Meeting Venue: Stanford Plaza, Brisbane. A contract recently finalised and signed/
- Meeting Website: SA has created a Website for ISO TC 27 meeting. ISO/TC27 Secretariats (and delegates) will be using this in preparation of the meeting documents;
- <http://www.standards.org.au/OurOrganisation/Events/Pages/ISO-TC-27---15-20-October-2017---Brisbane---Australia-.aspx>;
- SA Events Team and SA Project Manager continue to support ISO/TC27, SC Secretariats and MN-001 Committee to make the meeting successful.



# MINE SITE GREENHOUSE MITIGATION

C23052

Stone Dust Manifold Gas Switching Thermal Swing Reactor: Abatement of VAM Streams with Ultra Low Methane Concentration Phase 4

University of Newcastle  
Behdad Moghtaderi

Value: \$1,219,962  
Report Expected: 25/02/2019  
Industry Monitor/s : Jim Sandford  
Trevor Stay  
ACARP Contact: Roger Wischusen

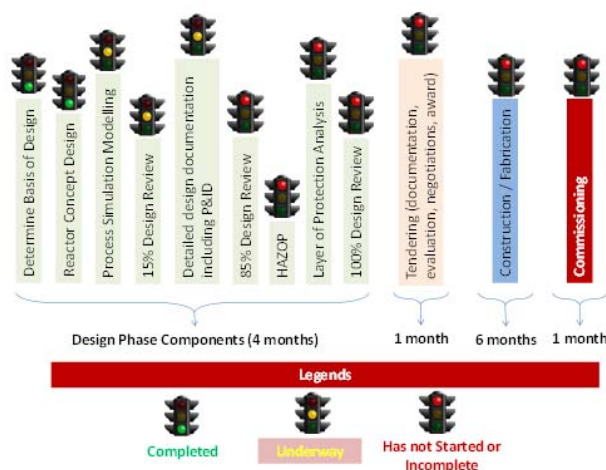
The current project is Phase-IV of a multi-phase project that is concerned with the development and demonstration of the Stone Dust Looping (SDL) process for abatement of the ventilation air methane (VAM).

Previous ACARP funded projects on this topic designated as Phase-I to Phase-III primarily focused on prototype development and pilot-scale demonstration of the SDL process without the option for regeneration of stone dust particles. However, the vision in Phase-IV is to furnish the SDL process with the necessary means for in-situ regeneration of these particles. This is driven by the fact that additional heat is released when the CO<sub>2</sub> formed by the oxidation of VAM reacts with the calcium oxide particles undergoing the in-situ regeneration. This in turn, enables the SDL process to reach the state of auto-thermal operation (ie self-sustaining) at methane concentrations as low as 0.2 Vol% and temperatures well below the auto-ignition temperature of methane (about 450oC).

The Phase-IV project aims at pilot-scale demonstration of the above configuration as well as determining its scaling principles and techno-economic merits. Phase-IV has been defined as a two-year project with the primary aims of:

- Design, construction, commissioning and field trials of a 200 m<sup>3</sup>/hr (~56 L/s) twin-reactor SDL unit fitted with a manifold gas switching (MGS);
- Derivation of the scale-up rules for the twin-reactor in the MGS configuration;
- A detailed techno-economic assessment of the twin-reactor in the MGS configuration.

The focus of the first year of the project is on objective (i) and so far the following progress has been achieved against the relevant milestone tasks.



C24061

Proof of Concept Photocatalytic Destruction of Methane for Coal Mining Fugitive Emissions Abatement

CSIRO

Yonggang Jin

Value: \$179,120  
Report Expected: 25/07/2017  
Industry Monitor/s : Ben Klaassen  
Jim Sandford  
ACARP Contact: Neil Alston

The main objective of the project is to evaluate the feasibility of photocatalytic oxidation of ventilation air methane (VAM) for coal mining fugitive emissions abatement. This proof-of-concept study is based on laboratory tests of photocatalytic oxidation of the simulated VAM.

VAM photocatalytic oxidation has been tested with a continuous flow photocatalytic reactor and evaluation of effects of varied flow rates, reaction temperatures and humidity on the CH<sub>4</sub> conversion is being carried out. The results show that over 96% of CH<sub>4</sub> in 0.1% VAM can be completely oxidised to CO<sub>2</sub> when continuously flowing through the photocatalytic reactor. No CO was detected in the product gas using the upgraded gas analysis system capable of measuring ultralow levels of CO<sub>2</sub> and CO. The project has used a Xenon lamp as the light source in VAM photocatalytic tests, producing the light that mimics nature sunlight, with a low proportion of UV output. As photocatalysts for use in the tests can only be activated by UV, the intensity of UV is a key factor determining the reaction rate. A high-intensity UV LED light source has recently been purchased and is expected to arrive in end May. VAM photocatalytic oxidation with the UV LED will be performed for performance comparison and estimate of energy consumption, which will be the last part of experimental work for the project. The final report is currently being prepared.

**C26004****CFD Modelling of Reverse Thermal Oxidisers for VAM Abatement: Phase 1**University of Newcastle  
Behdad Moghtaderi

Value:	\$154,320
Report Expected:	25/10/2017
Industry Monitor/s :	Donna Dryden Jim Sandford
ACARP Contact:	Roger Wischusen

This project is part of a larger multi-phase program of study aimed at Computational Fluid Dynamics (CFD) modelling of Ventilation Air Methane (VAM) abatement systems. The study consists of two phases with Phase-I focusing on CFD modelling of ceramic-brick RTO devices and Phase-II dealing with CFD modelling of RTO fixed-bed systems.

Following the engagement with LEAP Australia (a leading CFD provider and the official agent for ANSYS in Australia) and ANSYS-India, the CFD modelling activities commence from early March 2017. The University team and CFD consultants (in Australia and India) have had several teleconferences and skype meetings to lay down the scope and framework of the tasks to be undertaken to meet the broad objectives of the project. It was, therefore, decided to:

- Initially focus on the development and validation of a basic explosion model (thereafter refer to as "Base-Model") using the wealth of data available from the University of Newcastle's detonation tube experiments;
- Modify the Base-Model by incorporating other necessary sub-models so that a ceramic-brick based RTO device can be simulated;
- Carryout simulations using the modified model for a range of scenarios of interest.

Task (a) is currently underway (see preliminary results in Appendix A) and is expected to be completed by the end of July 2017. The other tasks will commence immediately after with an expected completion date in December 2017. By and large the project remains on time and budget.