AUGUST 2018

CURRENT PROJECTS

This report is a summary of current projects for the months May, June and July 2018
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UNDERGROUND

Coal Burst

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: 25/08/2018  Industry Monitor/s: Coal Burst Task Group  ACARP Contact: Patrick Tyrrell

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.

All projects collaborators have submitted their relevant sections, the final report has been compiled and is currently being edited by the authors of each section before submission to ACARP. The final report will be submitted within two weeks.

C26006
Coal Burst Monitoring Technology Using Microseismicity

CSIRO
Xun Luo


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 in 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 microseismic monitoring system at Appin Colliery has been stopped because of the coal burst occurred on May 27. The system is kept at the mine and can be restarted any time when the mine is ready for mining. The microseismic system installed at Narrabri Mine is in good working condition. Routine data processing and interpretation are in progress. Preparation for setting up microseismic monitoring at the third site (site to be determined by the Coal Burst Task Group) is in progress.

C26053
Predict Stress State and Geotechnical Conditions Near Major Geological Structures Using Microseismic Technology and Distinct Element Modelling

CSIRO
Baotang Shen  Ismet Canbulat


Stress state and geotechnical conditions often change significantly near major geological structures (e.g., faults, shear zones, dykes) which is the cause of most major mine instabilities and/or safety hazards including coal burst, roof falls, water inrush, gas outburst, etc. This project aims to develop an integrated method of mapping the stress state and strain energy during mining near the major geological structures. After knowing the strain energy and the related stress state, the risk of coal burst in a roadway can then be quantified for risk control purposes.

One of the key tasks within the project scope is to conduct a comprehensive microseismic and stress monitoring in a selected mine site in the vicinity of a major geological structure where the risk of coal burst may be elevated. Narrabri Mine has been selected as the monitoring site where pressure bumps have been experienced in roadways due to the existence of a strong conglomerate unit in the overburden strata. The monitoring is located at a gateroad of Longwall 107 near a major dyke where the mining conditions had been observed to change significantly due to the influence of the dyke. The monitoring includes installing four microseismic geophones, four stressmeters and four extensometers in the roadway roofs and pillars on both sides of the dyke, aiming to obtain seismic and stress change data during mining.

The monitoring system was installed in November 2017 when the longwall face was about 400m from the monitoring location, and it had been recording the seismic, stress and displacement data since then. By the time of reporting, the longwall face has passed the monitoring location by more than 400m, and the monitoring instruments have been performing well. Preliminary analysis of the monitoring results have been carried out by CSIRO on a weekly basis, and the result updates have been provided to Narrabri Mine to help their mining operations. Systematic analysis of the monitoring data and numerical modelling by using 3DEC have nearly completed. Both the monitoring and modelling results showed that the stress changes in the inbye side of the dyke are significantly higher than that in the outbye side, affected by the properties of the dyke and the mining direction. Further analysis is ongoing to identify precursors of pressure bumps and quantify the stress level and the risk of coal burst near the dyke.

An additional study is being conducted by UNSW to understand the behaviour of jointed rock mass and impact of faults and dykes. Initial models have been constructed to understand the impact of faulting on coal burst. It is anticipated that modelling of a fault is relatively easier compare to modelling of dyke due to variable stress nature about the dyke interface. To date, a series of models have been completed using FLAC3D to...
simulate longwall face approaching to a fault with different fault angles. The zero-thickness interface elements, which are capable of Coulomb sliding were built in the numerical model to simulate the fault. Detailed parametric study has been conducted to analyse the influence of friction angle of fault plane and fault angle. Numerical results showed that these factors have significant impact on shear stress drop, shear slip and the magnitude of seismic energy.

The results with regard to the fault behavior during longwall extraction showed that the normal stress on the fault plane decreased when the longwall face approached the fault plane. Then it dropped gradually to zero as the longwall face crossed the fault plane. The shear slip occurred immediately along with the reduction of normal stress. The shear stress had a different variation trend compared to the normal stress. It increased first and then decreased sharply when the face was approaching to the fault. The next stage of the project is to model a dyke and its impact on coal burst using FLAC3D. A detailed analysis of the stress, seismic and geometrical data collated at Narrabri has also started.

C26054
Modelling of Dynamic Fracture Mechanisms

University of Wollongong
Gaetano Venticinque
Jan Nemcik

Value: $197,500
Report Expected: 25/02/2019
Industry Monitor/s: Coal Burst Task Group
ACARP Contact: Peter Bergin

The project objectives are:
• Using dynamic fracture modelling techniques in FLAC 2D, provide capability to model dynamic fractures and to examine the contributing mechanisms of rock/coal bursts;
• Quantifying stress conditions, intrinsic material properties and their influence on dynamic fracture formation.

Progress during the quarter:
• The dynamic fracture software written for FLAC2D is now being transferred to the FLAC3D numerical package;
• As the FLAC3D structure, commands and capabilities are very different to these in FLAC2D, substantial effort and time is being spent to re-write the software to make it executable in 3D in a correct way;
• A presentation for the 3rd International Symposium on Dynamic Hazards in Underground Coal Mines, 16-20 July 2018 has been prepared to present the up to date dynamic model of coal burst in the coal mine roadway;
• A 3-dimensional numerical simulation of the rock material heterogeneity using Weibull method (essential for the numerical dynamic analysis) has been implemented into FLAC3D. Other issues such as the determination of dynamic fracture speeds in the individual zones within the FLAC grid etc. are under way; and
• Further improvements to fracture and burst theories continue and more accurate dynamic numerical models have been currently worked on.

C26060
Mechanics of Gas Related Coal Bursts in Mining

SCT Operations
Winton Gale

Value: $273,750
Report Expected: 25/04/2019
Industry Monitor/s: Coal Burst Task Group
ACARP Contact: Peter Bergin

The aim of this project is to identify the role gas pressure in coal bursts. The project seeks to identify the mechanics of the process and provide a better understanding of risks, prediction and prevention of such coal burst events. Work undertaken has been:
• Laboratory studies of gas diffusion rate of coal samples under burst conditions;
• Review of literature regarding gas induced bursts and outbursts;
• Computer modelling of the gas induced burst process;
• Discussion with key industry personnel regarding the burst fundamentals and organisation of a collaborative approach to the problem.

Work has been undertaken to understand the role of micro fabric in the burst process. Results to date indicate that the energy available from gas within the coal fabric is available to induce a coal burst under a range of conditions. The amount is dependent on the time frame and the nature of micro and macro fractures in the coal fabric. Study of the energy required to cause a gas related burst has been undertaken, results have been presented at the Ground Control Conference in Morgantown 2018.

C26061
Measurement of Fundamental Mechanical Parameters of Coal - Poisson's Ratio and Biot's Coefficient

Sigra
Ian Gray

Value: $150,000
Report Expected: 25/08/2018
Industry Monitor/s: Coal Burst Task Group
ACARP Contact: Peter Bergin

This research project is essentially complete and the final report will be available shortly.
C26062  
New Outburst Risk Determination Measures Along With Data Gathering and Analysis for Coal Burst Assessment

Sigra  
Jeff Wood

Value: $612,200  
Report Expected: 25/03/2019  
Industry Monitor/s: Coal Burst Task Group  
ACARP Contact: Peter Bergin

The objective of this project is to determine what common factors also affect coal bursts. The two participating mines in the project are Appin Colliery and Narrabri Mine.

The main activity over the last three months has been a visit by Ian Gray to Eurock2018 in St Petersburg. Here there were a number of papers delivered on rock bursting. Ian Gray also delivered a full day course on rock mechanics pre-conference and coal bursting and rock bursting was discussed with the 40 participants from different mining groups at the course. Apart from this the period has been one of reflection on what has been learnt in the project to date.

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: Coal Burst Task Group  
ACARP Contact: Peter Bergin

The aim of this project is to identify the energy related to a number of mechanisms attributed to possible coal burst occurrences. This covers the range of seismic energy, strain energy and gas energy. The project seeks to identify the mechanics of the process and provide a better understanding of risks, prediction and prevention of such coal burst events.

Work undertaken has been:
- Review of energy from strain energy along geological surfaces such as bedding planes and faults;
- Review of rock testing data to identify the energy within the rock mass during rock fracture events;
- Review of energy available from gas within the coal material;
- Review of energy from seismic sources and the effect of distance from a roadway;
- Review of energy available from mine geometries.

The results at this stage are consistent with expectation and the risks of bursts from these various sources. Ongoing work is being done to confirm the risks of each form of energy. Study of energy from stored strain has been reviewed in more detail.

Alleviation methods for coal bursts has been studied and reviewed. A review of energy sources and risks for coal bursts had been presented for a special edition on coal bursts in the International Journal of Mining Science and Technology.

Environment - Subsidence and Mine Water

C20038  
Standardised Subsidence Information Management System

New South Wales Department of Planning & Environment  
Gang Li

Value: $655,000  
Report Expected: 25/01/2019  
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 that has been established.

Progress during this quarter:
- We undertook a further review on 4th July of the design for the query facilities. We are now confident that the most challenging task of the project, the design and development of the query facilities (stages II and III), has been completed;
- On 13th June the subsidence data points housed in the SSIMS reached 1,000,000, collected from 686 longwalls pertaining to 27 collieries in New South Wales. Importantly, the missing mining data will now no longer have adverse impacts on the functions of the SSIMS.

The remaining tasks are:
- Developing and testing software to make the established query facilities available for on-line use. This task is the current focus of the project. We plan to complete this task by the end of September;
- Working with the Industry Monitors to decide user's access procedures (to the query facilities as the main deliverables of the project). We plan to have the final project review meeting in August or September;
- Preparing the final report. We plan to commence this task from August and complete the first draft in October. As the report will be mainly prepared by Gang Li, there is some uncertainty regarding the completion time due to other potential competing priorities related to mining operations in New South Wales; and
- Preparing the user manual will commence in October after the above-mentioned development and testing of software have been completed.

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C24013
Managing and Conserving Native Plant Species in the Mining Environment

Royal Botanic Gardens and Domains Trust, Sydney
Cathy Offord

Value: $441,300
Report Expected: 25/05/2019
Industry Monitor/s: Bernie Kirsch, Gary Brassington
ACARP Contact: Keith Smith

This project specifically focuses on two threatened Persoonia species – P. hirsuta and P. hindii – that occur on mining lease land. The outcomes of this project are to determine:

- The techniques required to optimise survival of Persoonia in the revegetation context, and
- The environmental conditions required to improve plant propagation success and plant survival.

Persoonia hindii
Soil samples taken from areas where Persoonia hindii occur across Newnes Plateau, as well as from areas where they are absent. The physical and chemical characteristics analysis results were then used to determine site suitability for P. hindii translocation on several mining and forestry rehabilitation sites on Newnes. The soil samples were collected from seven sites and two from top soil stockpiles (Figure 1). Recipient sites are being prioritised and prepared for the first experimental planting of P. hindii planning for late spring 2018. A translocation proposal is being drafted for a scientific license application, and we are engaging relevant stakeholders from New South Wales Forestry and Office of Environment and Heritage.

Persoonia hirsuta
Several propagation methods were examined for Persoonia hirsuta which has previously been difficult to propagate. There are now over 120 Persoonia hirsuta seedlings growing in the greenhouse at the Australian Botanic Garden Mount Annan (Figure 2). These plants have been germinated from fruit collections made from populations at West Cliff and Glenorie. The monthly growth rate of these plants is being recorded.

Several vegetative cuttings collected in April have struck roots in the last month. This represents a significant decrease in time to root strike from previous attempts to propagate from cuttings (requiring at least 12 months). Currently, all struck cuttings had been collected from juvenile plants at a population in Yanderra. Tip-cutting tissue cultures were successfully initiated and sub-cultured from young tissue collected from seedlings in the greenhouse. Currently there are over 90 active sub-cultures.

C25056
Change Detection in Complex Vegetation Communities

Biosis
Andrew Fletcher
Richard Mather
Tony Cable

Value: $274,700
Report Expected: 25/04/2019
Industry Monitor/s: Bernie Kirsch, Gary Brassington
ACARP Contact: Keith Smith

Imagery processing is continuing and integration of field observation into GIS for image analysis training is commencing. The major requirements for effective and reproducible canopy modelling are being identified. For high resolution imagery (<5cm) oblique imagery is necessary to capture canopy structure. Additional experimental flights using standard 12Mp RGB imagery has confirmed the need to include oblique
imagery to effectively model a range of Eucalypt canopies. Using nadir imagery at massively overlapping imagery proportions, a canopy may only be reliably identified in select few dense tree canopies. At lower pixel counts and coarser spatial resolutions, by using a multispectral camera it is possible to reconstruct tree canopies with appropriate processing settings from massively overlapped nadir imagery sets. Processing settings are responsible for a range of artefacts that will be considered as the project progresses so as to determine the best approach for monitoring and epoch comparison. Canopy models are improved by capture in early morning and later afternoon when the canopy is sunlit but the ground is shaded. Multiple capture times achieve canopy models that are repeatable. Spatial analyses will be conducted in the coming months to quantify repeatability. Cross-season image registration less than 7cm has been achieved using all sensors meaning registration of multiple epochs is possible. Methods to describe spatial error are being developed based on raster difference but will also be tested as object based imagery analysis is developed. Remote sensing models are being constructed in ArcGIS that draw on object texture as well as spectral properties. The incorporation of different remotely sensed imagery products, such as surface models constructed via triangulation or inverse distance weighting and 3D point clouds, improves the detection of young eucalyptus trees within the swamps.

C27052

FO-RO Site Trial at Newstan Colliery

CSIRO
Ramesh Thiruvenkatachari

Value: $393,270
Report Expected: 25/01/2020
Industry Monitor/s: Claire Cote, David Randall, Paul O'Grady
ACARP Contact: Cam Davidson

This project aims to conduct a site trial demonstration of an integrated forward and reverse osmosis (FO-RO) process for the treatment of coal mine impacted water at Newstan Colliery. The site trial demonstration is the next step in the development of this technology and builds on the outcomes from the previous projects (C23031 and C21043). The Newstan water treatment trial will evaluate the stability and performance of the FO-RO system with and without conventional pre-treatment for mine water. The maximum reduction in brine volume and the quality of the treated water in meeting the discharge and reuse water quality criteria will be evaluated under varying feed water characteristics.

The work program includes modifying the existing FO-RO pilot unit according to the mine site requirements with a capacity of up to 10 m³/day, commissioning it on-site and carrying out the testing according to the experimental plan, under the actual mine site conditions. Project planning is currently underway.

C27059

Swamp Hydrology Modelling for Advancing Rehabilitation Planning and Management

University of Queensland
Thomas Baumgartl

Value: $197,800
Report Expected: 25/03/2020
Industry Monitor/s: Bernie Kirsch, Gary Brassington, Peter Corbett
ACARP Contact: Keith Smith

The objective of this project is to assess the resilience and sustainability of vulnerable Temperate Highland Peat Swamps on Sandstone (THPSS; Blue Mountain Swamps) in response to variations in water availability as a result of changes in environmental conditions like mining-induced hydrological impacts or climate variability. The variability in vegetation health in some of these ecosystems is closely linked to changes in environmental conditions. Yet, its causes have not been clearly identified.

The research will adopt a stepped approach to the investigation and simulation of the hydrology of selected Blue Mountain and Upper Nepean swamps and the interaction between water availability and health status of the swamp vegetation. These steps are:

- To quantify natural fluctuations in soil water availability and alterations caused by mining at sites in the Blue Mountain and Upper Nepean swamps;
- To project the likely long-term changes in vegetation in swamps due to soil moisture changes;
- Develop a hydrological model of the swamp soil that is applicable, under changed inputs and parameter values, to comparable swamps.

Site visits to Centennial and South32 mine sites took place at commencement of the project. This provided insights about the current situation of the swamps and data availability from existing monitoring programs.

A decision has been made to install an additional set of soil moisture sensors (water potential sensors) with a focus on the Newnes Plateau swamps of the Centennial Springsure Colliery with the objective to gain additional high resolution profile moisture data suitable for numerical hydrological modelling. The sensors will be installed at the selected sites once approval for installation has been granted by the Forest Corporation of New South Wales.

A first set of monitoring data has been provided by Centennial and a literature and data review of this information is currently underway.
**Exploration**

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

*University of Queensland*
*Joel Kok*

- **Value:** $330,000
- **Report Expected:** 25/09/2018
- **Industry Monitor(s):** Brad Elvy
- **ACARP Contact:** Patrick Tyrrell

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.

Mining3 have completed the field testing of the ISWDS tool, deploying it into a 600m cross-measure hole on the 20th April at Tahmoor underground. The field deployment was completed in a safe manner with zero safety incidents. Processing, analysis, and interpretation of the logged results is nearing complete.

A draft final report is expected to be tabled towards the end of August.

**C25067**
*Seismic Diffraction Imaging for Improved Structural Detection in Complex Geological Environments*

*CSIRO*
*Binzhong Zhou*

- **Value:** $178,000
- **Report Expected:** 25/03/2018
- **Industry Monitor(s):** Heather Schijns, Paul O'Grady
- **ACARP Contact:** Patrick Tyrrell

The first stage of this project is completed and reported. A second stage is yet to start.

**C27027**
*Advances in Acoustic Logs to Predict the Stress Redistribution in Coal Strata as a Result of Degassing-Dewatering*

*University of New South Wales*
*Hamid Roshan, Hossein Masoumi*

- **Value:** $105,860
- **Report Expected:** 25/05/2020
- **Industry Monitor(s):** Rae O'Brien, Roger Byrnes
- **ACARP Contact:** Peter Bergin

The main objective of the project is to use acoustic logging to extract the poroelastic response of the coal seam at in situ condition and predict stress redistribution as a result of degassing/dewatering.

A literature review on poroelastic response of sedimentary rocks in particular coals has been extensively conducted. In addition, a comprehensive review on acoustic signal processing to enable analysing the acoustic data is under progress. A new high pressure, high temperature, ultrasonic system has been setup and calibrated to carry out the experiment. The existing triaxial system has been also modified to measure the static poroelastic properties with inert-reactive gases. Initial experiments have been conducted to measure the anisotropic elastic properties of several coal samples. The Biot coefficient of coal samples has been also measuring using static and ultrasonic measurements.

A mathematical model within thermodynamic framework is being developed to explain the observed phenomena including non-linearity of volumetric strain with gas sorption and replacement of the Biot coefficient definition with Biot-like coefficient for reactive rocks such as coal.

**Maintenance**

**C25063**
*Photocatalytic Destruction of Diesel Particulate Matter*

*CSIRO*
*Yonggang Jin*

- **Value:** $527,192
- **Report Expected:** 25/07/2020
- **Industry Monitor(s):** Brad Lucke, Shayne Gillett
- **ACARP Contact:** Patrick Tyrrell

A draft report on stage one is with the industry monitor(s) for review. The second stage of this project which commenced in July is to develop a prototype photocatalytic reactor for destruction of diesel particulate matter (DPM) and test DPM photocatalytic oxidation by connecting the prototype reactor with the diesel engine exhaust. The main objective is to test and demonstrate the performance of photocatalysis technology in removal of DPM under the real diesel exhaust condition. Work so far has been focused on project planning and technical review. Study of photocatalytic reactor design and investigation of its integration with the exhaust aftertreatment system of a coal mine relevant diesel engine are being carried out.

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

*Quantise Consulting Engineers*
*Russell Smith*

- **Value:** $80,000
- **Report Expected:** 25/08/2018
- **Industry Monitor(s):** Jarrod Sampson, Neville Bunn
- **ACARP Contact:** Peter Bergin

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. Debugging of numerical models has been delayed. Resource allocations have now been set for completion in October 2018.
### C26057
**Electrically Safe Variable Speed Drive for Underground**

**University of Newcastle**  
Galina Mirzaeva  
Peter Stepie

| Value: | $158,202 |
| Report Expected: | 25/01/2019 |
| Industry Monitor/s: | Barrie Alley  
Brad Lucke |

**ACARP Contact:** Peter Bergin

The project was inspired by realisation that a Variable Speed Drive (VSD) in the underground mining environment can create a dangerous touch potential under a phase-to-ground fault, while the fault itself can remain undetected. The main expected outcome of this project is to develop a proven laboratory tested solution of the electrically safe VSD. The project objectives are:

- Study the available technical solutions and concepts;
- Develop a solution to both safety and EMI problems with VSDs;
- Prove the proposed concept by simulations;
- Build a laboratory scale version of the proposed new drive;
- Experimentally test the proposed CMV mitigation strategy in a physically emulated underground mining environment;
- Prepare a plan for the following future actions, adaptation to field environment and development of an industry-ready prototype.

The work for Milestone 1 Conceptual Solution Design, has been completed, namely:

- Detailed simulations have been completed for the conceptual designs. This included simulations of standard and novel drive structures operating in a typical earth fault limited underground environment. The interaction with other drives were also considered. The range of possible solutions has been narrowed down.

The work for Milestone 2 Development of laboratory scale VSD structures, is complete, this included:

- Solution 1 (Matrix Converter) has been extensively studied. The obtained results have shown that: by using a special type of a switching pattern based on rotating vectors, it was possible to significantly reduce CMV. However, a significant degradation of the current harmonic distortion, particularly on the input side, was observed with the CMV mitigation strategy in place;
- Solution 2 (an inverter with active front end) has been assembled and tested in the lab. To implement the synchronised switching pattern, an upgrade of the existing set-up was required, which has been done. Implementation of the synchronised switching patterns, as per the proposed CMV mitigation strategy, has now been completed.

Towards Milestones 3 and 4 Laboratory studies of the solution modifications, the study of Solution 1 has been completed. Milestones 3 and 4 are 50% complete; and project results obtained so far were presented at Mining Electrical and Engineering Safety Seminar in November, full paper submissions have been completed to IEEE Industry Applications Society Annual Meeting (Mining Industry Committee) in October.

### C26059
**Proof of Concept of the EST Apparatus on Existing Known Power Supplies**

**University of Queensland**  
Enver Bajram  
Rajiv Shekhar

| Value: | $114,767 |
| Report Expected: | 25/11/2018 |
| Industry Monitor/s: | Greg Briggs  
Peter Henderson |

**ACARP Contact:** Patrick Tyrrell

The Electronic Spark Tester (EST) is a concept for assessing the spark ignition risk posed by electrical devices which claim explosion protected by intrinsic safety, as per the IEC standard 60079.11. The concept is intended as an alternative to the currently standardised method of assessing this risk, which relies on mechanical spark creation and explosion tests, and has reproducibility issues. The aim of the current project is to assess the performance of the EST on a broader range of commercially available power supply units (PSUs) than previously tested.

Testing of the Prototype EST on a type of PSU with significantly different characteristics to those previously encountered has uncovered issues which require further development to resolve. A review of the project will therefore be undertaken to identify the development requirements, which will be communicated at the end of September.

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

**Orbital Australia**  
Nick Coplin

| Value: | $1,246,712 |
| Report Expected: | 25/11/2018 |
| Industry Monitor/s: | Andy Withers  
Bharath Belle  
Shayne Gillett  
Steve Coffee  
Patrick Tyrrell |

**ACARP Contact:**

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 of this 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;
- Achieve certification from the New South Wales Department of Industry.

This quarter has seen conclusion of development work to achieve compliant surface temperatures and commencement of addition system assessments with UMF Eromanga fuel. Milestones include:
• Testing and optimisation of the lower exhaust return pipe, including optimisation of water cooling to flange surfaces and gasket joints;
• Completion of 100hrs dyno of testing using the Australian Coal industry transient cycle to assess DPF sooting performance with UMF Eromanga fuel; and
• Preparation of report to support site with permit submissions required to trial the system in an underground working mine.

In-house dyno testing will focus on assessment of particle and elemental carbon characteristics of the wall flow filter system, in addition to supporting data requirements for the site work.

The next round of site testing to be supported by Centennial is planned to include outbye validation and operational duties within the mine workings.

Dyno testing for pre-delivery checks of surface temperature (setup shown on engine dyno at Orbital, DPF monitor shown without cover).

Battery Sourcing
• Lithium iron phosphate (LiFePO4), 100% complete;
• Investigate casting design and materials, 70% complete.

Preliminary design
• Design of battery and electronic hardware, 50% complete;
• Design of software, 50% complete;
• Casing material selection and setup with final material selected, 50% complete;
• Conditions met regarding size, weight and output capacity, 90% complete; and
• Liaise with Test Safe regarding the above design, 0%.

Wall-flow DPF system – surface temperature (peak load point) Note: non-DPF surfaces in the background have been masked out on the images.

C27006
Lightweight/Compact IS 12VDC UPS Portable or Fixed Supply

KRS Technologies
Kurt Schober

Value: $141,800
Report Expected: 25/03/2019
Industry Monitor/s: Graeme Relf, Graham Café
ACARP Contact: Peter Bergin

The objective of this project is to produce a light weight and compact IS portable 12VDC UPS with an extended capacity of up, but not limited to 50Ah capacity. The intention is to supply clean 12VDC power to underground field devices such as WAP'S, cameras, sensors, communications routers and LED lighting and personnel tracking systems. The package shall be easy to carry and deploy for both temporary and fixed installations.

The project has been delayed by approximately six weeks due to personal issues. Below, is work completed to date.

C27019
Underground Compressed Air Vehicle

AMM Project Development
Michael Christian

Value: $120,000
Report Expected: 25/02/2019
Industry Monitor/s: Shayne Gillett
ACARP Contact: Patrick Tyrrell

The objectives of the project are to:
• Develop a prototype machine for transporting people in an underground coal mine;
• Test the practical application of compressed air engines as a replacement for existing diesel powered transport;
• Prove this technology can travel an acceptable duration on one charge of compressed air;
• Show that mobile equipment can run intrinsically safe lighting system;
• Provide the underground coal mining industry with a personal transport vehicle that is diesel particulate free; and
• Capture adequate results which can expand the practical use of compressed air engines as a direct replacement for all underground diesel engines eg underground loader.
The period has seen significant progress on the UCAV prototype build.

Bench testing of the air motor has been completed with the design improvements being completed by the manufacturer to suit the application.

The selected all terrain vehicle was delivered. We prepared the vehicle removing all unrequired components and installing the air motor. Initial function testing has been completed utilising the workshop compressed air supply.

The compressed air storage unit design was finalised and construction has commenced. A design review has been completed with Nautitech for the Intrinsically Safe lighting system.

The throttle control system design is completed and components ordered.

Next steps will be:
- to complete the air storage unit fitment to the vehicle, fit the throttling system and air flow metering device. Commence drivability testing establishing the most practical drive ratios for the vehicle transmission;
- Complete distance versus air usage testing during various driving conditions;
- Install the IS lighting system, and finalise the braking system design suitable for underground coal mine use.

C27068
Lithium Traction Battery for Underground Coal

Energetique Mining Vehicles
Justin Bain
Phil Coop
Richard Everleigh

Value: $100,000
Report Expected: 25/07/2018
Industry Monitor/s: Brad Lucke, Graham Café
ACARP Contact: Patrick Tyrrell

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

C27075
Advanced Pattern Recognition through Machine Learning for DAS Conveyor Condition Monitoring

University of Queensland
Fernando Vieira
Paul Wilson

Value: $271,200
Report Expected: 25/08/2019
Industry Monitor/s: Brad Lucke, Clinton Vanderkruk, David Goodale, Kevin Rowe
ACARP Contact: Peter Bergin

Distributed acoustic sensing using fibre optics generates a huge amount of data with one frequency plot per 500mm of conveyor length. In order to reduce the human workload of interpreting the frequency plots an expert system is used to analyse the frequency patterns and to estimate the type and degree of wear in the bearings of each linestand. The objective of the project is to improve the effectiveness and accuracy of the pattern recognition in order to deliver better condition reports and to do this by using the latest methods of machine learning.

The project commenced in May with two initial phases:
- The acquisition of site data to be used as correct training data for the machine learning algorithms; and
- Initial research into the state-of-the-art of machine learning and artificial intelligence.

Mining3 currently has two DAS interrogators deployed at Moranbah coal mine and Argyle diamond mine. Another interrogator has been purchased by CSIRO and can be loaned. Acquisition of data has been delayed by two events. A computer failure at Moranbah mine has resulted in an inability to obtain measurements. A field visit to Argyle mine by one of the project research team to collect reference data was cut short by a conveyor belt fire. Following the conveyor fire, Argyle staff replaced many of the conveyor rollers and we currently have very few worn ones to work with. As a result of the shortage of reference data, a completely different approach is being developed around the idea of getting rollers removed from service being sent to Mining3 for individual testing and a post-mortem.

Research into the state-of-the-art has revealed some interesting facts. Recent work in deep learning neural networks, such as the Google Deep Mind project has failed to produce any new algorithms and is described as ‘impoverished’ by Sheila Hayman at MIT’s media lab. Accordingly, the emphasis in the project is now moving away from neural networks and towards continuing the rule-based approach using optimisation methods to mechanise the machine learning. There have been some early encouraging improvements in the reporting accuracy using this approach.

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: 25/07/2018
Industry Monitor/s: Brad Elvy
ACARP Contact: Patrick Tyrrell

This project has been reactivated and an analysis is underway of the budget required to complete it. The Resource Regulator has progressed the establishment of a test site, confined space entry training is being organised for all parties involved in the recommissioning. It is expected that the commissioning will take place towards the end of August. The draft report remains as a draft pending further testing.
C24023
Gateroad Development Continuous Haulage System
Premron
Mick Whelan

Value: $1,960,000
Report Expected: 25/08/2018
Industry Monitor/s : Roadway Development
ACARP Contact: Patrick Tyrrell

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

The next stage of this project is progressing under project C27076 Underground Coal Mine Gateroad Development Continuous Haulage System.

C25058
Self Drilling Bolt Automation Trial
OKA Rock Bolt Technologies
Mark Levey
Paul Charlton

Value: $1,396,000
Report Expected: 25/08/2018
Industry Monitor/s : Rae O'Brien
Roadway Development
Task Group
ACARP Contact: Patrick Tyrrell

The project objectives are as follows:
- The OKA Technology is further refined using findings from this project 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 complete;
- The host mine released and delivered the continuous miner for modifications to adapt the OKA technology late July;
- Assembly of the chemical injection modules was completed in February;
- The software control system components and associated wiring are now complete;
- Testing and commissioning in the workshop began mid April. The IS control system programming and commissioning has been delayed due to human resource availability from the supplier. Although the work is now progressing, it has delayed the project many months. The current estimate for completion of this work is the end of August. At this time the units will be installed on the miner. The miner will then be transported to site;
- The underground trial will begin at this time.

C25064
Longwall Floor Coal Horizon Sensor
CSIRO
Jonathon Ralston

Value: $213,736
Report Expected: 25/07/2018
Industry Monitor/s : Paul Buddery
Rae O'Brien
ACARP Contact: Patrick Tyrrell

A draft report is with the industry monitor(s) for review.
The first stage of this project is completed and reported. The second stage is yet to start.

The key objective of the project is to demonstrate the value of adaptive protection techniques at one or more mine sites. Specific objectives are as follows:

- Gather existing data and experience from mines on nuisance tripping and protection settings in order to better evaluate the opportunities for productivity gains;
- Record as much relevant operating data as possible from real mines. For example, obtaining data on variations in pilot earth resistance and measured earth leakage current over long periods will be valuable;
- Examine standards and regulations to identify areas that may restrict the scope of adaptive protection unnecessarily. Proposals for changes would be made, with technical arguments;
- Construct an adaptive protection system and trial it, as best possible, in a mine as well as on a bench top model. The details on how best to implement this may evolve during the project implementation but the system envisaged would take real measurements, via the fiber network, from protection relays in a working mine and implement a protection controller at the mine surface control room. The protection controller would display and record the recommended protection settings, as well as the actual settings, for consideration by the mine personnel; and
- Analyse all data obtained and report on the results.

As well as a delay to the project start, there has been difficulty in obtaining suitable resources to program the adaptive protection system.

While progress has still been slow, the parts of the program incorporating the user interface, system model configuration, equipment and cable libraries, system analysis calculations (touch potential compliance etc), data statistical calculations and results plotting are functional and undergoing bench testing. The communication modules that collect information from the remote protection equipment are still not completed. Software that was previously produced in this area turned out to be unsatisfactory and is being rewritten.

For some time now we have had an agreement for a trial at a site that we consider to be very suitable and have recently discussed and planned some minor and temporary additions to surface equipment to support the trial. We still expect that the system functions may evolve slightly as we get initial trial results and user feedback.
At completion it is expected that a number of these enclosures will be fully manufactured and certified with a Laser assembly fully installed, ready for use underground.

Ex.D testing for this enclosure is nearly complete, this testing process has taken significantly longer than anticipated due to different issues rising during the testing process. The plastic domes have now passed all tests required by the standards to be compliant. Currently we are undergoing dimensional analysis of the enclosure and dealing with dimensional changes in the cast bases, it appears as if there has been some slight changes in dimensions of the cast bronze base after the casting has been machined. We are currently investigating this issue and once this has been identified and sorted, we will be able to complete the certification process.

Once certification has been complete we will start the unit certification process on a number of enclosures with laser scanning payloads to make these available to be installed underground.

C27055
LASC Automation 10 Years On
CSIRO
Jonathon Ralston

| Value:       | $101,770 |
| Report Expected: | 25/10/2018 |
| Industry Monitor/s: | Brad Lucke |
| ACARP Contact: | Patrick Tyrrell |

This six month project is a strategic review of current and required longwall automation capability that aims to deliver an updated assessment of longwall automation practice and future drivers. The overall intention is to provide industry with greater insight and confidence to accelerate the deployment of high-value automation to improve longwall operations.

The key objectives are to:
- Capture current automation system utilisation and directions by engaging with key longwall stakeholders;
- Assess system level details, categorise operational modes and assess system readiness; and
- Develop a state-of-the-art review and open roadmap to accelerate automation adoption.

Key activities over the past quarter have focussed on:
- Review of the original Landmark ACARP Steering Committee (LASC) ‘10-point automation plan’ developed in 2001 as baseline;
- An intensive review of existing literature from research, technical and industrial sources relevant to past, present and future longwall automation;
- Review of related processes from other domains, including space, manufacturing and digital;
- One-on-one interviews with longwall automation engineers and LW OEMs to capture specific insights and details on core LW systems.

Key themes that have already emerged through current industry engagements have highlighted the clear need for greater levels of remote operation, systems interoperability, integrated platforms. This information is in turn directly informing the level of sensing, processing, communications and control technology that will be required to achieve these operational goals. There is also a recognition of the change in personnel roles with the progressive introduction of assistive mining technologies.

The next three months will see deeper engagement with key stakeholders (mine site, OEM, R&D providers and vendors). The aim is to provide a draft report in September.

C27076
Underground Coal Mine Gateroad Development
Continuous Haulage System
Premron
Mick Whelan

| Value:       | $2,495,000 |
| Report Expected: | 25/07/2019 |
| Industry Monitor/s: | Roadway Development Task Group |
| ACARP Contact: | Patrick Tyrrell |

This project is a continuation of projects C22009, C23017 and C24023, and aims to develop an autonomous Continuous Haulage System for mine gateroad development, utilising the closed conveyor system of the “Premron CHS” ©.

The project is based around the following key objectives:
- Complete mine systemisation studies with host mine;
- Manufacture and demonstrate a full scale, full length (180m), fully functional “Mine Compliant” Premron CHS installed on the surface at Kestrel Coal Mine and mounted on a mine monorail test rig, simulating an operating gateroad;
- Production of O&M manuals, safety files and QA documentation;
- Continuous batch feeding and acceptance at host mine site (surface trial); and
- Installation and trial operation in a fully working gateroad panel (underground trial).

The systemisation studies at the host mine are complete and final report submitted.

The mine monorail test track has been supplied to the host mine and is currently being built on the Longwall pad for surface testing.

The build is continuing, with all standard trolleys being delivered to the mine site by early August and the head, tail, transitional and drive trolleys being sent to site early September. The electrical and hydraulic builds are behind schedule and are currently looking at having enclosures installed by late August/early September. Hydraulics will be fitted to tail end trolleys by end of August. Final commissioning of the CHS on the surface is currently planned for October, with three months of testing programmed. Underground trials are likely to occur early 2019.
Health and Safety

C24009
Establish 'At Risk' Distance from Hydraulics

University of New South Wales
David Wainwright
Gary Nauer

Value: $26,908
Report Expected: 25/09/2018
Industry Monitor/s: Paul Gill
ACARP Contact: Patrick Tyrrell

No report has been received from this researcher.

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
ACARP Contact: Peter Bergin

Work is progressing and the permeability tests are completed with all but one of the untreated samples demonstrating good permeability. The treated ones demonstrated that the treatment process works well as they were found to be impervious when subjected to high negative pressures.

It was clear that the carbon nylon produce had superior properties as it showed much lower permeability than the Ultem material. As suspected there is an anisotropy due to printing orientation and this will be utilized to produce the lowest permeability units. After treatment would then ensure that they would be able to support a vacuum and give the cell a longer operational life.

During the commissioning of the test prototype it was found that the laser didn’t ‘shoot’ straight, ie it was aligned at an angle from the case. A second laser that was purchased for another project was also out of alignment at a greater angle than the first. Both lasers have been returned to the manufacturer for correction. In order that this doesn’t cause a delay in obtaining data, the test bed in Albuquerque has been re-established and tests are being conducted with it to assist in the calibration process.

The prototype is being rebuilt and should be ready early to mid-August for testing.

A test rig has been established at UNSW to provide the calibration of this unit and once that has commenced an invitation to the monitors will be sent out to demonstrate the unit to them.

Investigations are also underway into ultra micro balances that can be incorporate into the design.

C26048
Improving Respirable Coal Dust Exposure Monitoring and Control

University of Queensland
David Cliff
Mark Shepherd
Nikky La Branche

Value: $250,000
Report Expected: 25/08/2018
Industry Monitor/s: Bharath Belle, Peter Smith
ACARP Contact: Patrick Tyrrell

The objective of the project is to improve capacity to prevent and manage respirable coal dust exposure of workers through:

- Creation of an up to date information resource on coal dust exposure and control technologies and their effectiveness for both open cut and underground mines, including evaluating their effectiveness;
- Evaluate the currently available real time respirable dust monitors and barriers to their use;
- Dissemination of this information Updating RISKGATE to include a specific respirable dust topic; and
- Promotion of the resources through suitable conferences and industry seminars.

Work to date has continued on:

- Collection and collation of literature relating to dust control technology;
- Collection and collation of literature relating to the science behind the setting of exposure standards for respirable dust;
- Collection and collation of literature relating to respirable dust monitoring techniques;
- The second phase of trials involving the deployment of various real time dust monitoring devices in mines has been completed;
- Workshop on respirable dust was run at Coal 2018 Conference in Wollongong;
- Respirable dust exposure data has been collected from DNRM and Coal Services and analysis has begun including on the metadata;
- A small number of samples have been sent to UNSW for particle size and chemical analysis to evaluate the feasibility of using this technique for a larger set of data;
- A small sample program has been undertaken by Coal Services and SIMTARS to send respirable dust samples to the University of Virginia for particle sizing and chemical analysis, as they already have a large database from US mines.

In the next quarter:

- The literature review will be completed;
- Analysis of the real time trials will be completed;
- Analysis of the exposure data collected from DNRM and Coal Services will be completed;
- Results from prototype particle size and chemical analysis will be completed; and
- The final report will be drafted.

There has been some delay due to the extension of the field work to include the cooperation with Virginia Tech and UNSW and also in processing all the data received from Coal Services and DNRME.
C26065
Dustless Longwall and Development Face
University of Wollongong
Peter Wypych

| Value:          | $339,700 |
| Report Expected: | 25/02/2019 |
| Industry Monitor/s: | Peter Davidson |
| ACARP Contact:      | Peter Bergin |

The objective of this project is the development of ‘dustless’ mining operations in key areas of the longwall and development face. The project is split into two phases, with the first phase focussing on the longwall and the second phase looking at the development face. For both phases of the project the objective of developing dustless operations would be achieved through:

- Identification of key areas of dust generation and the events contributing to these;
- Analysis of mechanisms contributing to significant dust events;
- Evaluation of current dust control techniques;
- CFD analysis: Firstly, of air and dust flow and then with dust suppression sprays included to understand the flow interactions and develop optimised solutions;
- Implementation of new high-energy micro-mist sprays based on solutions developed using CFD analysis and experimental testing; and
- Measurement of dust concentrations after the implementation of the new systems and comparison with previous dust levels.

Work in the past quarter has included:

- CFD modelling of air flow patterns along the longwall with integration of sprays allowing determination of suitable nozzle sizing and positioning
- Commencement of modelling of the development phase of project
- Completion of the dust suppression system design for longwall trials
- Dust monitoring at Mandalong mine
- Surface trials at Komatsu for a dust suppression system to be installed on Mandalong longwall
- Supply of equipment for underground trial at Mandalong mine

In the next quarter it is aimed to:

- Trial dust suppression system on longwall at Mandalong mine;
- Evaluate effectiveness of installed systems through observations and further dust monitoring;
- Evaluate nozzle positioning and dust suppression options for the continuous miner based on CFD results; and
- Supply equipment to Grosvenor mine for trials on Continuous miner.

C27007
Assessment of Pyritic Coal Dust Induced Pneumoconiosis
B3 Mining Services
Basil Beamish
Graeme Zosky

| Value:          | $93,000 |
| Report Expected: | 25/02/2019 |
| Industry Monitor/s: | Bharath Belle, Brad Lucke, Sharif Burra |
| ACARP Contact:      | Patrick Tyrrell |

The main objective of this project is to assess whether the findings of recent US studies on pyrite in coal as a contributing factor in CWP can be translated to Australian coals. The project will answer two key questions: does Australian pyritic coal dust pose a health hazard (produce bioavailable iron) and what is the severity of the physiological response (degree of toxicity)?

The pyritic samples have been assessed for bacterial endotoxin content (Limulus amebocyte assay) to ensure any responses observed in the toxicity studies are not due to the bacterial content of the samples. For almost all of the samples bacterial contamination was below the limit of detection.

Iron bioavailability (Ferritin assay) has been assessed on both fresh samples and after exposure to a humid atmosphere for one, three and six weeks. Iron bioavailability has also been assessed in fluid that simulates a lung environment and fluid that simulates the environment inside a macrophage (a cell in the lung that engulfs particles). There is a wide variability in iron bioavailability between the samples, which will allow correlation between cell responses and iron bioavailability.

The study is assessing the response to coal samples with varying pyrite content in three cell types: epithelial cells (the cells that line the airways); macrophages (the cells that engulf the particles); and fibroblast (the cells that cause the lung scarring in Black Lung). To date the exposure experiments for the epithelial cells and most of the exposure experiments for the macrophages have been completed. The analysis of results and data collection for these experiments is ongoing. The exposure experiments for the fibroblasts are yet to commence.

Supporting microscopic images of the mode of the pyrite present in the coal samples have been obtained and scanning electron microscope images of the pyrite reaction products with humid air have been arranged through the University of New South Wales.
C27010
A Clinical, Occupational and Radiological Review of Lung Disease

Uniting Care Medical Imaging
Bob Edwards
Katrina Newbigin
Rhiannon McBean

Value: $119,600
Report Expected: 25/08/2019
Industry Monitor/s: Bharath Belle, Brad Lucke, Sharif Burra
ACARP Contact: Patrick Tyrrell

This project aims to review positive cases of CMDLD within Queensland, doing so via close examination of radiological images, lung performance, medical charts, and occupational histories.

Added Support
The Queensland Department of Natural Resources, Mines and Energy has recently formally endorsed the project with the provision of research funds. This added endorsement will allow us to expand our case identification capabilities through information sharing with Queensland government organisations, such as WorkCover. The additional funds will be utilised to cover the increased travel and time of collaborators, which will be required with the expansion of case identification.

Ethics Update
An amendment was prepared for review by our governing ethics committee to incorporate the expansion of case identification through information sharing with external bodies. This amendment was recently approved.

Data Collection
The research team have now identified 87 cases of dust-induced lung disease within Queensland miners. A retrospective review of radiological images has been performed for 25 of these cases, with an additional 30 being partially complete. Medical chart review has been completed for 52 cases.

Early findings suggest a predominance of crystalline silica-associated disease. For this reason, the focus of the last few months has been a refinement of the study questionnaire and data collection methods to ensure capture all of relevant information. The questionnaire is near complete and has been converted, from being paper based to an electronic version for ease of distribution and data analyses. Due to the questionnaire’s complex nature, a pilot study will be performed within the next month with a small group of participants before wider distribution.

C27015
Coal Characteristics and Pneumoconiosis

University of New South Wales
David Waite

Value: $348,800
Report Expected: 25/02/2020
Industry Monitor/s: Bharath Belle, Brad Lucke, Sharif Burra
ACARP Contact: Patrick Tyrrell

Coal workers’ pneumoconiosis (CWP) has been related to the presence of reactive iron minerals such as pyrite and mackinawite in US coals, but very little information on the factors contributing to reactive oxygen species (ROS) generation by Australian coal dusts is available.

The key objectives of this project are:
- To quantify the toxicity of dust particles of Australian coal to human lung epithelial cells and to determine whether any relationship exists between the toxicity of coal dust particles and the elemental and mineral composition of the particles;
- To quantify the extent of ROS production by dust particles of Australian coal and to determine whether a relationship exists between the oxidant generating capacity of the particles and the elemental and mineral composition of the coal particles;
- To develop a protocol for screening Australian coal dust particles with regard to potential toxicity and to recommend approaches to managing coal with particular toxicities; and
- To develop guidelines relating to best practice dust management and control for Australian coals considered particularly problematic with regard to CWP risk.

The initial three months of the project was spent characterising the 44 coal samples supplied. Specifically, our work focused on the extraction of a range of (redox-active) elements, particularly assessing the forms of iron present in different freshly crushed coal seams (via standard sequential extractions and Synchrotron analysis). Our progress has resulted in us gaining a better understanding about the nature of the coal materials and identifying a range of coal dust samples with differing iron geochemical properties. Over the coming months, the ROS toxicity production from these coal materials will be explored.

C27049
Mine Rescue Vehicle Radar Sensing Integration

CSIRO
Gareth Kennedy
Lance Munday

Value: $254,405
Report Expected: 25/08/2019
Industry Monitor/s: Brad Lucke
ACARP Contact: Patrick Tyrrell

The project objectives are to:
- Develop an integrated radar sensor and user interface that is applicable to a wide range of fixed and mobile sensing applications in underground coal mines;
- Provide robust ranging and mapping that is tolerant of both airborne and sensor-surface contamination caused by dust, smoke and water vapour; and
• Trial the system in an underground coal mine and evaluate performance.

The goal of the project is to fulfil these objectives in order to deliver a pre-commercial prototype system that can be rapidly brought to market by a commercial partner. Key benefits of the system are:

• Improved health and safety, whereby persons in any part of a mine, who are subject to disorientation or severely impaired visibility, are able to find their way out of the mine.
• Enhanced productivity for mining machinery, where operation is impaired due to dust, smoke or water vapour.

A prototype LED display was built and tested during the quarter. The display measures 650x100x50mm and houses a 64x8 matrix of RGB LEDs. Hardware was selected to interface with the LEDs, and microcontroller code was written to generate text and graphics on the display.

Viewing tests where then undertaken. The display was found to be highly visible in all lighting conditions; from full darkness to bright sunlight. This was one of the reasons for choosing a LED matrix over other display technologies. The display was placed at the intended distance and angle from the viewer to simulate placement in front of the driver (ie above the top edge of the windscreen). Text and graphics where found to be readable, but the viewer tended to turn his head when scanning the display. He also found some of the display data difficult to interpret, given that only 8 lines of vertical resolution where available.

While the display is within the acceptable viewing zone for detection tasks (according to standard AS4024.1902), it was concluded that the display was too large and could be distracting to the driver. Therefore, a smaller LED matrix display was obtained; it has a much higher LED count and density (64x32 matrix). Setup and testing of the new display is underway. The smaller display will also provide more placement options within the cabin of the Driftunner vehicle.

The candidate radar sensor was configured and tested. Code was written to parse the radar data and display it on a standard desktop monitor as matrix of large RGB ‘pixels’. The horizontal and vertical resolution of the readout is user-selectable, which will allow the code to be easily implemented on the chosen LED display device. Radar sensor performance was also verified; both static and moving objects could be discerned in the readout. More in-depth radar testing is underway.

### Roadway Development

C25068
Automated Long Tendon Installation System

Conway Engineering
Des Conway

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<td>ACARP Contact:</td>
<td>Patrick Tyrrell</td>
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No report has been received from the researcher.

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### Strata Control and Windblasts

C24015
Convergence Based Roof Support Design

PDR Engineers
Terry Medhurst

| Value: | $245,800 |
| Report Expected: | 25/08/2018 |
| Industry Monitor/s: | Brian Vorster, Gavin Lowing, Paul Buddery, Roger Byrnes |
| ACARP Contact: | Patrick Tyrrell |

This Stage 2 extension in which a roof beam based support design model was produced for development conditions but needs to be extended for secondary support. The work program includes review and analysis of roadway instrumentation data in relation to longwall extraction influences. Initial studies were completed to provide input parameters for the roof beam model for maingate and tailgate loading conditions using information from central Bowen Basin mines. A 3D modelling parametric study has been undertaken to evaluate the influence of varying principal stress direction on both maingate and tailgate roof conditions. Sensitivity studies have been completed and an update to the analytical roof beam model has been undertaken. Further testing based on available site data has commenced.

C25057
Review of Rib Failure Mechanisms and Performance of Rib Support

SCT Operations
Yvette Heritage

| Value: | $186,500 |
| Report Expected: | 25/08/2018 |
| Industry Monitor/s: | Paul Buddery, Roger Byrnes |
| ACARP Contact: | Peter Bergin |

This project aims to review the mechanics of rib deformation during development and longwall retreat 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 results are summarised below.

Moranbah North – 340m depth
Assessment of monitoring data has highlighted the contribution of the Tonstein Band (claystone/siltstone) as a driver for increased deformation within the ribs. Once the Tonstein Band loses its shear strength, the rib observes a step change in magnitude of deformation and an increase in depth of softening.
Ulan West – 160-190m depth
The key driver for rib spall on the walk side of the belt road was identified as a combination of vertical shear fracture, forming from the longwall abutment load, and the discontinuities created by the cleat.

Appin Mine – 530m depth
The mechanism for deformation within the ribs was observed to be vertical shear failure occurring to at least 6m into the ribs. The key stages of the rib deformation observed form the monitoring include:
- A zone of high strain prior to longwall extraction to 1.8m into the rib;
- Deformation on existing failure planes to 6m into the rib after installation of instrumentation (longwall distance of 150 to 350m from the site);
- Multiple new failure planes between 2m and 6m into the rib once the longwall was 15m from the instrumentation site.

The monitoring to date suggest that the role of rib support is to stop the progression of failure further into the rib through controlling kinematic failures and generating confinement of the failed near rib. The site specific failure mechanisms are therefore required to be understood in order to effectively implement these controls.

C25059
Intrinsically Safe, Integrated Wireless Communications Network with a Distributed Array of Geotechnical Sensors

SCT Operations
Stuart MacGregor

| Value:     | $339,787 |
| Report Expected: | 25/08/2018 |
| 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.

Progress during the quarter:
- Access to an underground site for remaining field trials has proved difficult over the last quarter. Our proposed site in New South Wales had a range of access issues that has resulted in the project team seeking alternative sites. At this stage, we are proposing to conduct underground field trials in the Illawarra area. We are working closely with our industry monitors to facilitate access to the field trials.
- Documentation has been completed on all IS certification and a preferred supplier for the certification has been chosen. Documentation has been submitted and likely to be approved in a nominal three month period.

C25060
Borehole Shear Monitoring Device for Routine Application in Roadways

SCT Operations
Stuart MacGregor

| Value:     | $149,863 |
| Report Expected: | 25/08/2018 |
| Industry Monitor/s : | 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.

During this quarter:
- All IS design, certification and documentation has been prepared and a chosen provider chosen to conduct the certification. We expect a nominal three month period for approval;
- The final report is in write-up and expected to be completed through August 2018.

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, Roger Byrnes |
| 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.

During this quarter, field data analysis is being undertaken. Data is extracted from geophysical and acoustic logs using WellCAD and Excel. Particular focus is on two boreholes where overcoring was conducted. Breakout geometries and rock properties in these two boreholes were used as input of the existing analytical model, whereas the stress measurements at nearby depths were used for model validation.

Results showed that the reliability of the existing method has to be improved. As planned, further development of existing model is being carried out and additional field data is expected to be collected and analysed. Thereby, more experimental and
numerical works are also performed for detailed breakout studies.

Acoustic data from 0 to 360° (left: amplitude; right: travel time)

Cross-sectional breakout

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

University of New South Wales
Serkan Saydam

Value: $298,940
Report Expected: 25/03/2019
Industry Monitor/s: Adam Lines, Brian Vorster, Patrycja Sheffield, Paul Buddery, Peter Corbett, Peter Bergin

ACARP Contact:

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. The project aims to develop a reliable floor failure prediction model and definitive guidelines for mitigating or eliminating 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 mine floor rating system that describes the floor performance is also sought to be developed.

Progress
Installation of floor instrumentation at Moranbah North has been completed during July. The remote reading tell tale systems and shear strips have been installed at four sites in the mine. The instrumentation will assist in investigating the effect of longwall retreat on floor heave. The in-situ monitoring is planned to be completed by January 2019.

In addition, two sites in Springvale coal mine, where a significant floor heave is expected to occur, are planned for installation of the GEL extensometers and shear strips.

Numerical modelling is currently being conducted using UDEC to assess the factors contributing to the floor failures including, but not limited to, mining depth, horizontal stress, strata thickness and rock strength. The initial results showed that closely spaced bedding planes would increase the potential for high degree of deformation of floor. The simulation of failure of a thin stiff floor layer overlying weak floor units is exemplified in the figure below.

C27020
Coal Bursts and Pillar Burst in Deep Mines

University of Adelaide
Murat Karakus

Value: $257,240
Report Expected: 25/03/2020
Industry Monitor/s: Coal Burst Task Group
ACARP Contact: Peter Bergin

This project will provide new, fundamental knowledge concerning damage process of coal and coal measure rocks and how high-pressure influence the overall mechanical behavior of coal inducing coal burst phenomenon. Further, this project will allow the development of the new guidelines for governments, allowing better management policies to be developed so that future deep coal mining activities will be much safer. In short, the results from this project promise to greatly reduce the impact of coal burst and pillar burst, which will impact on sustainable coal production as well as the safety of people in the mines.

A literature review has been conducted on the subject of coal burst and coal testing methodologies focusing on the snapback behaviour to calculate excess stored strain energy in coal. This will allow us to identify the propensity of coal for coal bursts.
As planned in the project we expected to receive coal samples from Appin Mine by the end of June. However, due to some issues related to core bit availability at the mine site, we were told that the samples will be sent us by the end of July. We are still yet to receive coal samples. Meanwhile, we have focused on developing a new testing system which will enable us to acquire a better snap back behaviour than what we have currently as an alternative testing method.

C27039
True Triaxial Strength of Coal Measure Rocks and its Impact on Stability of the Roadways and Coal Burst Assessment

SCT Operations
Mahdi Zoorabadi
Winton Gale

Value: $187,000
Report Expected: 25/10/2019
Industry Monitor/s: Coal Burst Task Group
ACARP Contact: Peter Bergin

It has been found in previous studies and internal studies that the effect of intermediate stress can modify the strength of the rock. The stress anisotropy can lead to lower strength and modify the failure distribution about a roadway or ribside.

The aim of this project is to measure the strength of coal measure rocks under a range of true triaxial stress conditions. The rocks will be tested with variation in maximum, intermediate and minor stresses.

Samples are being sourced for testing. Testing has been organised for Curtin University. It is anticipated that testing will be underway in the next quarter.

C27040
Numerical Modelling Approach to Better Understand the Effect of Cable Bolt Performance on Roof Failure Mechanisms in Varying Rock Mass Conditions

University of New South Wales
Ali Mirzaghorbanail
Najdat Aziz
Paul Hagan

Value: $389,000
Report Expected: 25/07/2020
Industry Monitor/s: Paul O'Grady
                      Peter Corbett
ACARP Contact: Peter Bergin

The objective of this project is to provide the underground coal mining industry with an improved approach in modelling leading to enhanced mine safety, increased productivity and reduced costs through fit for purpose designs and more effective application of cable bolts in different ground conditions.

The project will focus on two important and interrelated aspects which are the function of pretensioning and shear displacement of cable bolts in ground support and, the influence that ground and stress conditions can have on performance of support systems and resultant roof behaviour, issues that still not fully understood in mining practice.

C27041
Ground Support Requirements in Coal Burst Prone Mines

University of New South Wales
Ismet Canbulat

Value: $150,000
Report Expected: 25/07/2019
Industry Monitor/s: Coal Burst Task Group
ACARP Contact: Peter Bergin

It has been found in previous studies and internal studies that the effect of intermediate stress can modify the strength of the rock. The stress anisotropy can lead to lower strength and modify the failure distribution about a roadway or ribside.
The aim of this project is to measure the strength of coal measure rocks under a range of true triaxial stress conditions. The rocks will be tested with variation in maximum, intermediate and minor stresses. Samples are being sourced for testing. Testing has been organised for Curtin University. It is anticipated that testing will be underway in the next quarter.

C27045
Assessment of Longwall Mining Induced Connective Fracturing: Stage 2

CSIRO
Deepak Adhikary

Value: $201,250
Report Expected: 25/12/2019
Industry Monitor/s: Paul Buddery, Peter Corbett
ACARP Contact: Peter Bergin

The objectives of the project are to:
- Further expand the science base and understanding of strata caving mechanics during longwall mining and specifically focus on the fracturing processes in coal measure rocks eg sandstone, siltstone, claystone, shale, coal etc;
- Extend and fine tune the technique developed in project C24020 of initiating and propagating fractures, estimating fracture aperture and connectedness and thereby calculating the mining induced permeability of strata from first principles; and
- Validate and quantify the height of connected fractures above longwall panels from studies of up to three additional participating mines with varying geology, and validate the proposed modelling method (in C24020 heights of connected fractures were quantified for Crinum North and Springvale mines only), and come up with simple to use charts that can be used to assess the height of mining induced connected fractures at other mine sites; and further refine with additional mine site data when available.

Geological, geotechnical and groundwater flow data has been requested from Ulan mine and available data from Grosvenor mine is being studied. Simultaneously, review of functionality of existing processes and software were being conducted.

C27060
Damage and Risk from Seismic Events

SCT Operations
Richard Lynch, Winton Gale

Value: $435,000
Report Expected: 25/05/2020
Industry Monitor/s: Coal Burst Task Group
ACARP Contact: Peter Bergin

The aims of this project are to:
- Develop and significantly improve the velocity models within the coal mine strata at 3 geological sites, nominally South Coast (Bulli / Wongawilli), Hunter Valley and Narrabri (Hoskisson seam);
- Review the seismic activity at the sites. This would be based on seismic monitoring data within a specific geological environment or computer modelling of caving and fracture modes about longwalls or roadways;
- Assess the wave propagation modes and pathway in stratified rocks from seismic events which occurs at various locations about a longwall or roadway;
- Simulate the effect of a range of events on potential damage about working areas. The range of events would relate to location, type of event (shear rupture / tensile fracture etc) and magnitude of the event; and
- Review the damage and risks for longwalls and roadways for seismic events in coal mines.

Work has been undertaken to scope up a monitoring network at Narrabri Mine and will be installed. Study of source mechanisms effects on wave patterns has been undertaken. The effect of different velocity models is currently being undertaken. The project is on schedule and budget.

C27071
Intrinsically Safe Digital Networked 3D Roof Bolt

Holville
Anne Wylie

Value: $140,000
Report Expected: 25/01/2020
Industry Monitor/s: Paul Buddery, Rae O'Brien, Roger Byrnes
ACARP Contact: Peter Bergin

The project objective is to develop an intrinsically safe instrumented digital roof bolt that will:
- Accurately measure axial strain and bending in three dimensions;
- Interface to the Holville handheld terminal (project C25060), the wireless network of geotechnical sensors (project C25059), and the IS certified (IECEx 12.0034X), Holville roofAlert™ communications and power backbone.
- Provide a cost effective alternative to the routine monitoring of existing analogue quarter bridge strain gauged roof bolts.

The main task for the first six months is to review alternative strain measurement technologies with the goal of increasing the percentage of the bolt being monitored. Literature is being gathered on parts and materials required to implement the bolt.

C27073
Roadway Stability Monitoring System

CSIRO
Chad Hargrave

Value: $239,565
Report Expected: 25/09/2019
Industry Monitor/s: Jim Sandford, Paul Buddery, Roger Byrnes
ACARP Contact: Patrick Tyrrell

This project is an extension to project C25062, which successfully demonstrated, in an underground field trial under realistic conditions, a new radar scanning technology that can detect millimetric changes in roadway structure. The project will take the next steps towards development of a practical
monitoring system for operational use by addressing three key issues:
- Spatial registration;
- Temporal coverage; and
- Practical deployment.

The objectives will be met by the achieving the following outcomes:
- Delivery of a new technology and method for both survey and continuous monitoring of underground structures;
- Clear indication of the capabilities and limitations of the technology for both the survey and monitoring applications;
- Development of a roadmap for the implementation of the technology as a product available to the industry.

The goal of the project is to fulfill 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.

The project focus has moved onto the continuous mode system for monitoring applications. Development of the monitoring-mode system configuration to perform mine site trials has therefore commenced, including:
- Experimental campaign with the existing radar system to detect movement and change while continuously monitoring;
- Modification to the existing radar system and software for a stationary configuration, including 1D change detection; and
- Engagement with radar manufacturer for design of the next-generation scanning radar sensor to produce 2D image maps.

Developments with the current radar system in a monitoring configuration are proceeding on track, and the basic monitoring solution is considered to be achievable with the current hardware. Initial experimental campaigns are therefore planned with the existing system, with a view to undertaking first mine site trials in Q4 this year. More scanning trials with a 3D laser system have also been carried out using the test tunnel at CSIRO QCAT, for ongoing comparison with the radar results.

Currently the project team is seeking to finalise a suitable target mine site for these initial trials, based on the following criteria:
- Non-IS system, would need to be registered as UPEE;
- Trial location should be in the NERZ, ideally a location with actual ground movement, rather than simulating change through manual changes to roof/rib features;
- Seeking to have the system installed and trialled over a period of at least a few days to ensure a good window for monitoring change.

### Ventilation, Gas Drainage and Monitoring

#### 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:** 25/08/2018  
**Industry Monitor(s):** Bharath Belle, Brad Elvy  
**ACARP Contact:** Peter Bergin

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

**Value:** $270,000  
**Report Expected:** 25/07/2018  
**Industry Monitor(s):** Bharath Belle, Brad Elvy, Jim Sandford, John Grieves, Peter Brisbane  
**ACARP Contact:** Patrick Tyrrell

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 are progressing with documentation of guidelines and reports.

#### 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, John Grieves, Paul O'Grady, Rae O'Brien  
**ACARP Contact:** Patrick Tyrrell

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.

The application of the newly developed SGE model for gas emission prediction at different mine sites has been demonstrated to the industry monitors, including detailed discussions on processes involved. Gas data from two boreholes of Grosvenor has been used in the demonstration studies, and the results were in good agreement with site experience. Based on the logging and gas content data from the borehole, the excel based tool could quickly predict SGE/gas emissions and its variations with longwall production rates. Based on the suggestions from industry monitors, further improvements have been made to the SGE prediction model, including incorporation of all the co-efficient parameters onto the front summary results-sheet. The latest enhancements enables mine engineers to change the mining parameters very easily in SGE model according to actual field conditions, which may vary significantly with time and location (eg cutting height, retreat rate). In the next quarter, the project team will focus on draft report preparation to present the details and results of all the investigations carried out during the course of the project.

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
John Grieves
Paul O’Grady
Patrick Tyrrell
ACARP Contact: Peter Bergin

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 roof falls, and an assessment of the risk of irrespirable atmosphere prevailing on the face through transient modelling analyses.

The results of all the gas drainage investigations under different mining conditions with different ventilation systems and field goaf gas drainage holes performance data are being analysed in detail to develop optimum goaf gas drainage management strategies and guidelines for highly gassy mines to support benchmark production rates. The results of all the risk simulation studies are being analysed in detail to develop appropriate risk mitigation strategies for different field site conditions to minimise the potential risk of high gas levels in the longwall returns due to fans/goaf plants failure, barometric pressure changes and major roof falls in the goaf area. These risk mitigation strategies also focus on an assessment of the risk of explosive range gas mixtures or irrespirable atmosphere prevailing on the longwall face. In the next quarter, the project team will focus on draft report preparation to present the details and results of all the investigations carried out during the course of the project.

C25072
New Approaches to Mine Gas Analysis and Ratios
Sintars
Fiona Clarkson

Value: $103,689
Report Expected: 25/08/2018
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.

All project work has been completed. The final report is being reviewed prior to submission to ACARP.

C26050
Floor Seam Gas Emission Characterisation and Optimal Drainage Strategies for Longwall Mining
CSIRO
Qingdong Qu

Value: $153,075
Report Expected: 25/12/2018
Industry Monitor/s: Bharath Belle
Rae O’Brien
ACARP Contact: Patrick Tyrrell

The project aims to characterise floor seam gas emissions in longwall mining and identify optimal gas drainage strategies. The expected objectives include:
a) Insights into mining induced floor strata, groundwater and gas behaviours;
b) An improved floor gas prediction model;
c) Floor seam gas emission patterns; and
d) Optimal floor gas drainage strategies.

To date, objectives (a) and (c) are achieved, and objectives (b) and (d) are nearly completed. The major work conducted in the
past quarter were extensive parametric studies (in-situ permeability, water saturation, gas drainage methods, coal seam position etc) and field gas drainage performance analysis. Gas emission profiles along goaf in different coal seams were obtained and a Tau-depth function is being developed towards a floor gas emission prediction. Gas drainage performance in three coal mines (Blakefield South, South32 Appin, and a Chinese coal mine) representing different interburden thicknesses and in-situ permeabilities were analysed. The results along with the 2-phase parametric modelling studies have led to the development of preliminary floor gas drainage strategies. It was found that the in-situ coal permeability, interburden thickness and strata composition are the three key factors that determine the selection of appropriate gas drainage methods and drainage performance. A visit to South32 was made and the project findings were presented and discussed. More detailed data from South32 are expected in the following quarter.

The remaining project work as well as the project report are targeted to be completed by end of November.

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 are to:
- 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; and
- 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.

During the quarter we finalised collection of gas data from Bulli seam mines for inclusion in the Bulli seam Benchmark assessment.

Testing was completed on coal samples to assess Protodyakanov index as part of initial work toward establishing a Coal Toughness Index.

We attended the 3rd International symposium for Dynamic hazards in underground coal mines and delivered presentation summarising the results of this research project.

C26058
Optimisation of the Coal Seam Gas Predrainage Process
Palaris Australia
Mark Blanch

Value: $293,220
Report Expected: 25/03/2019
Industry Monitor/s: David Webb, Russell Thomas, Sharif Burra
ACARP Contact: Peter Bergin

No report has been received from the researcher.

C27035
Automatic Leak Detection for Tube Bundle Systems
Simtars
Sean Muller
Snezana Bajic

Value: $220,000
Report Expected: 25/03/2019
Industry Monitor/s: Bharath Belle, John Grieves
ACARP Contact: Patrick Tyrrell

The objective of this project is to develop a fully automated integrity testing system prototype which is based on information on the flow rates and pressures on tubes from this research. This prototype will be able to be retrofitted to any tube bundle system, regardless of the supplier. The basis for the design of the automated system is Delta Automation’s manual integrity testing system. The project comprises of three phases. The first phase is the accumulation and evaluation of presently available information relating to flow rates, designs and pressures in tube bundle systems in underground coal mines. During the second phase the specifications for automatic system prototype will be developed. The final phase will be to retrofit the prototype to a tube bundle systems at the mines, which have existing tube bundle system supplied by three different manufacturers (Delta Automation, SICK and ADT). The information from this testing will then be used to compile the final report.

The survey related to current tube bundle systems and leak testing has been distributed to all mines. Half of the surveys have been returned. The information is being analysed at the present. The mine site visits and the visit to Deltamation were completed. Mine sites visited include Ensham mine Emerald (ADT Tube Bundle system), Wambo mine Singleton (Deltamation Tube Bundle system) and Broadmeadow underground mine, Moranbah (Sick Tube Bundle system). The information from the mine site visits are being processed and used to develop the prototype specifications.
C27037
Modelling of Strata Gas and Water Transport to the Mining Area

CSIRO
Zhejun Pan

Value: $89,900
Report Expected: 25/05/2019
Industry Monitor/s: Bharath Belle, David Webb
ACARP Contact: Peter Bergin

This project have very recently commenced.

C27048
Monitoring Stability of Roadway and the Longwall Face for Coal Burst Risk Management Using Distributed Fibre Optic Sensing Techniques

CSIRO
Xun Luo

Value: $195,000
Report Expected: 25/04/2020
Industry Monitor/s: Coal Burst Task Group
ACARP Contact: Peter Bergin

The objective of this project is to investigate a distributed fibre optic sensing technique for coal burst monitoring in Australian underground coal mines. The investigation will involve a comparison of seismic characteristics obtained from fibre optic cables and geophones, in a laboratory and possibly at a planned mine site or in a tunnel. The ultimate goal of this project is to develop a new and economic tool for Australian coal mines for coal burst risk management.

Theoretical investigation on acquiring laser light backscattering data for vibration sensing is in progress. Laboratory experiments on distributed fiber optic sensing for ground vibration have been discussed and the first experiment is to be conducted in November in CSIRO Brisbane Laboratory using both the IDAS instrument (fiber sensing interrogator) manufactured by Silixa and geophone instruments. Preparation for the experiment has been started.

C27072
Intrinsically Safe Borehole Survey Tool

Holville
Anne Wylie

Value: $120,000
Report Expected: 25/06/2020
Industry Monitor/s: Paul Buddery, Rae O'Brien, Roger Byrnes
ACARP Contact: Peter Bergin

The project objectives are to develop an intrinsically safe borehole survey tool that will:
- Capture and store video and still images for later analysis.
- Record 3D spatial and temperature data linked to image capture;
- Provide a local display for reviewing data as it is captured, allowing features to be examined in greater detail;
- At the completion of the project it is expected to have a working prototype machine field tested and documentation submitted for Ex certification.

Information is being gathered on spatial information gathering technology including 3D magnetometers, 3D accelerometers, 3D gyroscopes, distance encoders and sensor fusion software. Imaging sensors suitable for a fixed focus, intrinsically safe use are being evaluated.

Alternative technologies for image and spatial data transmission are being considered with transmission distance, bandwidth and power consumption being the main parameters for comparison.
During this quarter, the project team has finished all the nominated objectives and the final report has been prepared and is under review. The project had two streams, laboratory and empirical streams which was carried out by UNSW and the numerical simulation stream which was conducted by UQ.

For laboratory and empirical stream, the project has investigated the influence of discontinuity in the laboratory scale (known as scale-effect) and in-situ scale (known as rock mass downgrading). The research outputs of this project have been condensed into six aspects which are further elaborated into six chapters in the final report. Firstly, the current state of art methodologies of scale-effect and rock mass downgrading have been reviewed. Following by a statically study of Australian coal measure rock intact properties, and an overview of the slope failure case collection from open cut coal mines. Then, the laboratory test of scale effect confirms that the ascending-descending also exist for extremely low strength rocks. Furthermore, the current GSI downgrading system has been improved based on back-analysis of slope failure cases, and the result is presented as the new GSIw downgrading system along with a step-by-step hand on tutorials.

For the numerical stream, Synthetic Rock Mass (SRM) model has demonstrated the potential to extend its use to coal measure rocks from the literature review and practices. A major concern of practical application of SRM is the model calibration and correlation of the established work-flow. To mitigate these issues, an automated microproperty calibration procedure has been established through a case study of Burton Widening highwall failure. The back-analysed rock mass properties from this study are compared against site investigation using limit-equilibrium models, and the results were analysed and discussed.

Damage to the tops of coal seams caused by incorrect blast stand-off distances is a serious issue to the Australian coal 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 borehole radar (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.

In the past quarter, a third field trial was conducted at Stanwell Corporation’s Meandu Mine from 19-23 May. Based on our review of the geophysical data from Meandu Mine for other project work, this mine has an average resistivity of ~140 ohm m, and is a suitable trial site for this project due to a much higher resistivity than the minimum required resistivity of 85 ohm m shown by modelling. Meandu Mine have kindly made this site available for this project.

The project team is currently analysing the acquired data sets from three different sites: Peak Downs, Boggabri and Meandu. The current results from these test data sets will be communicated to the mines and the project monitors in the coming project review meeting in August. The project is now nearing completion and the outcomes of the project will be documented in the final report in the coming quarter.

As part of dissemination of the results of this project, a paper entitled ‘Detection of Top Coal by Conductively-Guided Borehole Radar Waves: Results from Numerical Modelling’ was presented at the 17th International Conference on Ground Penetrating Radar held in Rapperswil, Switzerland, 18th to 21st June.
This project has the following objectives:

- A standard format for collection and use of data for drilling depth reconciliations;
- A free, public domain computer program validate and certify that a CoalLog data transfer format csv file complies to the CoalLog standard;
- A set of standard formats and field names for the transfer of coal analytical data;
- A set of graphic pattern ‘tiles’ to facilitate implementation of the standard CoalLog lithotype patterns by geological software suppliers;
- A standard for the downhole geophysics metadata stored in the header of LAS files and possibly some standardization of downhole geophysical variable names;
- A set of recommended colours for plotting lithotypes;
- A standard set of codes for:
  - Survey Company, Geological Logging Organisation and Geophysical Logging Company for borehole Header data,
  - Drilling Company, Rig Type and Hole Size Name (HQ, PQ, etc) for borehole Drilling data.

The following of the above objectives are currently being worked upon:

- New drilling data format and dictionary have been developed and peer reviewed;
- The CoalLog certification software has been produced and is being tested by the Queensland and New South Wales Geological Surveys. A User Guide has also been completed. The software will be available for free by mid-August from the AusIMM CoalLog website;
- A prototype for the transfer of coal analytical data has been produced and presented to the major laboratories and to meetings of coal industry geologists in Brisbane and Singleton.

Volunteers from industry are sort to assist on committees to review prototype standards for:

- Reviewing suggested improvements to the already established CoalLog standard;
- Transfer of coal analytical data;
- Downhole geophysics metadata and geophysical variable names;
- Recommended colours for plotting lithotypes;
- Codes for: Survey Company, Geological Logging Organization and Geophysical Logging Company, Drilling Company, Rig Type and Hole Size Name (HQ, PQ, etc).

If you can help please contact the project leader at brett@geocheck.com.au.

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This project aims 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 various mine sites and then to develop a methodology to detect the domains and the geological controls. Elements of the project that are being investigated include primary deposition; subsequent burial and deformation; intrusive processes; the influence of 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 primary fluorine bearing minerals, commonly fluorapatite, which occurs entrained within the cell lumens of semi-fusinite. Less commonly, the fluorine bearing minerals can occur within fractures or other macerals.

During this quarter samples were chosen from the Moranbah, Fort Cooper and Rangal coal measures to test for stratigraphic change. Samples of the Fort Cooper (Burngrove-Fairhill) coal measures were obtained from open file CSG core, and analysed for bulk P and F. Values for P and F in these samples showed a parabolic trend with higher values associated with the central seams associated with the Black Alley Shale, moreso than the abundance of tuffs. However, the mode of occurrence of fluorapatite tended to be atrital and show similar REE patterns to fluoapatite isolated from tuffs. The REE pattern of the tuffs associated apatites were significantly different to those occurring within the lumens of the semifusinite. This result was surprising and requires further work to confirm or refute the trends across all the coal measures. Samples analysis will continue using several micro-analysis techniques, including: infrared spectroscopy, cathodoluminescence, laser-ablation and electron-backscatter diffraction.

Based on delays outlined in the last report and after the team conducted a project review, a five month extension was granted at the July review meeting so the team may complete the research by May 2019.

The primary focus for next quarter, August to October will be to:

- Complete the data spatial analysis;
- Continue the isotope analysis; and
- Continue with microanalysis.
C26034
Storage and Time Effects on Coking Properties of Small Coal Samples

McMahon Coal Quality Resources
Chris McMahon

Value: $151,000
Report Expected: 25/08/2018
Industry Monitor/s: Angus McIntyre, Peter Chern, Richard Hingst, Richard Ruddock

ACARP Contact: Cam Davidson

The project’s objectives are to examine and quantify reduction in coking properties with time and conditions of storage on small samples that are commonly used in borecore and coal sampling generally. Four potential coal sources covering a range of rank and coal quality have been made available with three being undertaken initially and a fourth extra one just retrieved due to no samples being available with high fluidity for review.

The first sample in the lab was tested for the client’s original purpose (that includes relevant test work for this project) and testing of the final samples is due for completion in the next month. A second physical sample has been allocated to the project and processing of this sample via preliminary testing and two deterioration periods (of five) to date has been completed. A third physical sample has been allocated to the project and processing of this sample via preliminary testing to date has been completed. A fourth physical sample has been allocated to the project (the high fluidity sample), with the sample arriving at the lab earlier this week, instruction being issued to the lab and commencement of the testing being imminent.

All samples are due for completion by December 2018 with reporting to occur concurrently and issue made in January 2019.

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, Ewen Mills, Travis Zolnikov, Vishwa Bhushan, Cam Davidson

ACARP Contact: Keith Smith

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

At present, this project is on hold until an agreement between key researchers and Mining3 is reached in order to access background IP and continue the further development of the HP based technology and establish a commercialisation strategy.

Environment

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

Edith Cowan University
Mark Lund

Value: $362,714
Report Expected: 25/09/2018
Industry Monitor/s: Colm Harkin, Scott Diggles

ACARP Contact: Keith Smith

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

- Determine the downstream effects of pit-lake decant, with a particular focus on environmental and amenity values;
- Determine the effects river 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 to
- 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.

All data has been collected and is being analysed for inclusion in the final report which will be delivered soon.

C24030
Verification of the Vertical Distribution of Dust from Mining Activities

Advanced Environmental Dynamics
Darlene Heuff

Value: $361,140
Report Expected: 25/09/2018
Industry Monitor/s: John Watson, Kris Sheehan

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: 25/07/2018
Industry Monitor/s : John Watson
ACARP Contact: Keith Smith

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

C25039
Long Term Salt Generation from Coal Spoils

University of Queensland
Mansour Edraki
Neil McIntyre

Value: $239,150
Report Expected: 25/12/2018
Industry Monitor/s : Claire Cote
ACARP Contact: Keith Smith

The overall aim of the project 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.

During this quarter, work has continued on the laboratory scale and medium scale (>1 tonne) leaching experiments at UQ St Lucia and Pinjarra Hills. The timeline for final reporting of the project has been extended to December 2018.

C26019
Prediction of Long Term Erosion at Pit Walls

Henderson Geotech
Sue Henderson

Value: $90,000
Report Expected: 25/07/2018
Industry Monitor/s : Gavin Lowing
ACARP Contact: Keith Smith

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

C26027
Eco Toxicological Approach to Validate the DGT technique to measure Bioavailable Metal Concentrations and Deriving Water Quality Trigger Values for the ANZECC Guidelines

University of Queensland
Sue Vink
Trang Huynh

Value: $170,500
Report Expected: 25/08/2018
Industry Monitor/s : Andrew Lau
ACARP Contact: Keith Smith

We are awaiting updated statistical analysis of toxicity tests from the ecotoxicity laboratories. This was an addition statistical analysis as per request from the review process. We will complete the draft report as soon as the statistical analysis of the result is updated and submit it for review.

C27009
Tailings Revegetation through the Vegetative Water Pump

CSER Research
Carmen Castor
Mike Cole

Value: $447,000
Report Expected: 25/02/2021
Industry Monitor/s : Chris Urzaa
ACARP Contact: Keith Smith

The overall objectives of this project are to pump water from within, and under, the crust at tailings dams to greatly speed their drying and increase safety. This will be achieved using woody plant species that are able to penetrate the crust.

Safety of personnel is a primary concern for this project. To this end we have been measuring cone pressure resistance of the ‘surface crust’. At many locations the ‘crust’ is about 0.5m thick, but the ‘surface crust’ is less than 0.2m thick. We have been determining this using a hand-held cone pressure meter, also referred to as a compaction meter.

As noted in the previous report we intended to incorporate organic matter into the ‘surface crust’ to assist with speeding evaporation and root penetration. This was trialled using a small tiller weighing c.a. 11kg and with a 25cc 4-stroke engine.
The tiller only breached the surface by about 3cm. However, the vibration at the surface had an important effect on ‘surface crust’ resistance. The graph shows the difference in ‘surface crust’ pressure resistance between that before and after tilling trying two ways of holding the tiller. The left hand dotted line is when the tiller is more vertical to increase the effect of its mass. The solid line the average response.

![Graph showing pressure resistance differences before and after tilling.](image)

Interestingly, within 5cm there was between 350 and 650kPa lost to the surface crust resistance at about 3cm. Also, below about 10cm there was a lowering of about 100kPa which is believed to be due to water moving up into the surface crust due to the vibration of the tiller. We have, therefore, deferred tilling as a treatment and are concentrating now on the effect of surface variability and mulching. Experiments have begun at TD1 at Mangoola Mine to trial planting saplings into crust plates and into the cracks that form between them as the crust dries out. We are also trialling the effect of different levels of surface woody mulch and fertilizer to determine if we can promote softer surface conditions for root penetration and provide enough nutrients for sustained growth.

C27030
Examination of Past and Present Mine Rehabilitation to Grazing Land as a Guide to Future Research

New South Wales Department of Primary Industries
Neil Griffiths

Value: $166,203
Report Expected: 25/02/2019
Industry Monitor/s: Bill Baxter, Nigel Charnock, Stephen White
ACARP Contact: Keith Smith

This project has effectively just started.

C27038
Self Sustaining Ecological Mine Rehabilitation that Achieves Recognised Ecological Communities

Umwelt
Travis Peake

Value: $286,970
Report Expected: 25/08/2019
Industry Monitor/s: Bill Baxter, Nigel Charnock
ACARP Contact: Keith Smith

The project’s core objectives are to determine if mine rehabilitation can support recognisable and self-sustaining ecological communities and habitat for a range of threatened fauna species, in temperate woodland Australian environments.

The project aims to develop principles to inform industry in appropriate rehabilitation objectives, performance criteria and completion criteria, as well as provide guidance on benchmark successional stage criteria and monitoring of progressive ecological rehabilitation.

This project will provide guidance to industry and government on use of ecological mine rehabilitation as viable offsets, which will lead to improved ecological outcomes in mine rehabilitation. It has a national context, with a focus on the Hunter Valley. Comparison of existing mine rehabilitation will be made to Plant Community Types (PCTs), TECs and BioBanking benchmarks.

The project has three main stages, with the first two underway. Stage 1 comprises literature review of existing ecological mine rehabilitation reports and published articles, as well as legislation, policies and guidelines. Consultation with New South Wales OEH and DRG is ongoing regarding programs on mine rehabilitation. An information poster was presented at the Mined...
Land Rehabilitation Conference 2018 about this project, and we have been approved to present at the SERA Conference in Brisbane in September.

Stage 2 involves collection and collation of existing ecological mine rehabilitation data. Mining companies have been consulted regarding their existing ecological mine rehabilitation in the Hunter valley and selected interstate mines in Queensland and Western Australia; including Glencore, Peabody, Yancoal and Idemitsu, all of which are industry partners to this project.

Existing rehabilitation data is being amalgamated for analysis, and comprises BioBanking and monitoring data from mine sites at Mangoola, United, Bulga, Mount Owen, HVO and Mount Thorley Warkworth.

Stage 3, in late 2018, will comprise targeted survey for data collection and analysis, followed by final reporting in the second half of 2019.

C27042 Adaptation of Design Tools to Better Design Rehabilitation and Capping Over Highly Mobile Mine Waste

University of Newcastle
Garry Willgoose

Value: $439,000
Report Expected: 25/06/2020
Industry Monitor/s : Alicia Hooper, Chris Quinn
ACARP Contact: Keith Smith

The main objective of this project is to develop a set of mine rehabilitation design tools that can predict the performance of a rehabilitated mine with and without a capping layer. The specific application is in the containment of highly mobile mine wastes (e.g. dispersive, reactive shales, tailings). The tool will be developed by merging an existing mine rehabilitation design tool, EAMS-SIBERIA, with a new computer code, SSSPAM. SSSPAM models the sediment characteristics (eg full particle size distribution of sediment) of a landscape surface (in this case a post-mining landscape) that are currently not modelled by SIBERIA. A secondary objective is to be able to predict the mobility of sediment (primarily a factor of the particle size distribution) so that assessments can be made of that portion of the erosion that can be captured on site in sedimentation structures, and that material that will move off-site (and is either captured on floodplains or is transported to the coast by the rivers).

The first three months of the project were scheduled to be contacting the project field sites, identifying potential sampling locations, and coordinating the field data collection at a mutually convenient time. We have been in discussion with site staff at Rixs Creek and Alicia Hooper (BHP) re Goonyella. We are currently working through the data provided by Alicia Hooper for Goonyella to identify potential field locations so we can plan the Qld field campaign. Rixs Creek environmental staff have been busy so while we have talked with staff there we have prioritised Goonyella. This field data collection is not on the critical path so the delay in starting this work will not delay other parts of the project.

The main task in July was to appoint the post-doctoral fellow to work on the computer modelling. That appointment has occurred and he is familiarising himself with the Goonyella field data collected during the 1990s “Post-mining landscapes” project (and the analysis we carried out at the time using these data), as this will be the basis for the first stage of his work at Goonyella.

C27044 Testing the Resilience of Mine Site Rehabilitation with Fire

University of Queensland
Phill McKenna

Value: $239,537
Report Expected: 25/03/2021
Industry Monitor/s : Craig Lockhart, Pieter Swart
ACARP Contact: Keith Smith

The aim of this project is to apply controlled fire at a range of mine sites in Queensland and New South Wales and to use a combination of ground monitoring transects and remote sensing technologies derived from UAV and LiDAR products to assess the post-fire recovery dynamics and measure resilience.

CMLR visited the Coronado Curragh Mine from 16-20th July 2018 to complete the three year, post-fire monitoring of the rehabilitated sites that were burnt in the 2015 experimental fire program. The next scheduled field work for Curragh will be in 2020 and will provide the project with long-term recovery data to be used in the analysis.

The Glencore Newlands Mine site have the first controlled burn for the project scheduled for Monday 13th August with a 40 ha block in the Banrock area earmarked for the experimental fire. The site emergency response team is conducting the burn and will be attended by fire behaviour experts from the Queensland Fire and Emergency Services (QFES) as well as researchers from CMLR to characterise ground fuels and fire behaviour. CMLR teams will arrive on site the week of August 5th to begin pre-fire monitoring.

Other sites that have expressed interest in the project, and may be part of the future burning program include the Commodore Mine and Blair Athol.

Figure 1. Eremophila maculata (Spotted Emu Bush) flowering for the first time in three years since the fire at the Curragh Mine site. Image: P.McKenna
The specific objectives of the project are to:

- unlikely to promote low wall spoil pile geotechnical instability.
- they do not substantially degrade on wetting-up, and hence are materials that do not require removal prior to spoiling because

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.

- Geologically identify and sample selected fresh and degraded spoil and floor materials to assess their potential for water-softening, complete;
- Carry out appropriate in situ shear strength assessment of water-softened in-pit spoil and floor materials that can safely be accessed, complete;
- Characterise physically and chemically in the laboratory the representative spoil materials sampled, including testing for slake durability, complete;
- Carry out laboratory shear strength testing on fresh, moistened and water-softened specimens of the spoil and floor materials sampled, complete;
- Relate the laboratory shear strength of the spoil and floor materials tested to their physical and chemical characteristics, complete;
- 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, incomplete;
- 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, complete;
- Disseminate the results of the project to the industry via quarterly progress reports, project review meetings, industry seminars, a timely final report, and conference and journal papers, in progress.

All laboratory testing has been completed, including an added large slurry consolidation test, and direct shear of degraded spoil formed via accelerated weathering. Key results from the research were presented at the BOHOGS/BBBUGS ACARP Meeting held in Moranbah on 21 June. Three conference papers have been published and presented, one at T&MW 2016 and two at MWT 2018. The project report is being finalised and reviewed by the project team, with submission to ACARP expected in late August.

The project objective is to evaluate a UAV-LIDAR system's suitability for mapping structural characteristics of pit walls compared to Terrestrial Laser Scanning (TLS) and UAV-photogrammetry. During this quarter, the final structural analysis was performed with UAV-LIDAR, TLS and UAV-photogrammetry datasets.

Two spoil and mud sampling and testing campaigns were undertaken, and representative samples from BMA's Goonyella-Riverside, Peak Downs and Cavil Ridge mines were subjected to physical, chemical and mineralogical characterisation testing, as well as geotechnical parameter testing, including consolidation and direct shear testing.

The primary objective was to assess the compatibility of the generated datasets in widely used structural mapping software and address corresponding challenges. The traditional structural mapping workflow includes conversion of the collected discrete point cloud returns into a meshed surface (or complex surface modelling), which is an essential process for further analysis such as calculation of slope, aspect, detection of joints and features on highwalls. The process is computationally extensive and is designed to suit traditional data sources, such as from TLS. However, the backend software operating protocols for the complex surface modelling was found to currently limit seamless adoption of high resolution/density datasets. Multi-core CPU/GPU based and tilled processing was therefore recommended to make the backend software operation more efficient and suitable to handle high resolution/density datasets. Nevertheless, a medium resolution reconstructed point cloud model was found to suit the processing overhead for complex surface model construction. An octree based downsampling operation on UAV-LIDAR datasets was found to best suit the required data characteristics (size and point spacing) and undergo proper complex surface model computation without process stagnation. It is worth noting that the mobile nature of the operation for UAV-LIDAR systems introduces noise in the geotechnical structural mapping stage, that could be reduced with improved hardware, planned acquisition paths and robust noise filtering algorithms. In summary, UAV-LIDAR is a rapidly developing technology and is found promising for highwall structural mapping applications after few modifications at both, hardware and software, levels.
Autonomous Sensors for Evaluation of Groundwater in Spoil Dumps and Tailings Dams

University of Queensland
Enver Bajram
Fernando Vieira

Value: $349,760
Report Expected: 25/09/2018
Industry Monitor/s: Kim Peckett, Martyn Robotham
ACARP Contact: Cam Davidson

This project aims at starting the research and development of a sensing solution that can monitor and convey ground water measurements and movement from within the internal structure of a spoil dump or tailings dam wall. The aim of this system is to provide essential data to mine operators as to the structural integrity of the spoil pile of tailing dam to predict and prevent future failure or identify areas with high levels of ground water movement or structural movement.

Current focus of the research is researching, testing and developing a magnetic communication method capable of transmitting and receiving data over a distance within a highly saturated material such as that found within a spoil pile or tailings dam. Currently developing a magnetic transmitter that can generate an alternating magnetic field at a known carrier frequency and a highly sensitive receiver that would be capable of extracting the carrier wave from the noise floor and then measuring the frequency and intensity of the received field. Research into highly sensitive magnetic field measuring concepts is ongoing with investigations into fluxgate magnetometers, fibre optic magnetometers and SERF magnetometers currently being conducted. Development of a control system board is completed and we are currently developing the operating system that will control and operate the sensor network. Investigation into sensor types to take physical ground water measurements is completed.

Predicting the Impact of Complex Joint Structures on Mine Operations

University of Newcastle
Anna Giacomini
Marc Elmouttie

Value: $273,711
Report Expected: 25/05/2020
Industry Monitor/s: Gift Makusha, Leonie Bradfield, Walter Keilich
ACARP Contact: Cam Davidson

Accurate prediction of geological and structural 3D spatial variation in planned highwall strips can lead to increased optimisation of slope designs and drill and blast operations. Although vast amounts of data are currently collected (face mapped structural and lithological data from laser and photogrammetry, both terrestrial and aerial/drone, borehole data from ATV/OTV), a method to reliably use this data to predict conditions at the next strip is lacking.

This project will develop a method for improved prediction of the 3D spatial distribution of rock mass defects and their properties (including orientation, persistence, fracture frequency and intensity) ahead of mining. A second project objective is to demonstrate the relationship between rock mass structure and the frequency of highwall incidents and their subsequent contribution to production delays and overburden removal rates for a given blast pattern.

The start meeting with industry monitors has provided valuable input and recommendations on industry guidelines for structural characterisation using photogrammetric and laser scanners.

Meetings with one of the supporting sites, Meandu mine, has identified significant amounts of production data that the mine has generously agreed to provide for the project.

The project team has identified a young engineer who will be starting soon to work on the first data series from Meandu mine and a master student that will support the data analysis.

True Vector from Slope Radar Monitoring

CSIRO
Marc Elmouttie

Value: $163,036
Report Expected: 25/10/2019
Industry Monitor/s: Adrienna Robotham
ACARP Contact: Patrick Tyrrell

A well recognised problem with slope stability radar monitors is that they only measure deformation directed towards the detector (line of sight bias). This bias can lead to misinterpretation of deformation size, rate and failure mechanism, and therefore miscalculation of failure volume, which can significantly impact safety and productivity. This project will field test integration of high precision computer vision technology with slope stability radars to address this problem.
Work done in this quarter includes:

- Meetings with supporting companies GroundProbe and IDS GeoRadar to discuss project details and technical requirements;
- Visit to Meandu Mine (who are offering significant support for the field testing component) to scope out potential sites and discuss technical requirements;
- Contact with Macraes Mine, NZ, to initiate sourcing of a valuable multiple radar data set that will be used for validation.

Work to be done in the next quarter:

- Benchtop analysis to begin of previously acquired radar and imagery for algorithm refinement prior to fieldwork phase.

**Maintenance and Equipment**

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<tr>
<th>Code</th>
<th>Description</th>
<th>University</th>
<th>Principal Investigator(s)</th>
<th>Value</th>
<th>Report Expected</th>
<th>Industry Monitor(s)</th>
<th>ACARP Contact</th>
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<tr>
<td>C25041</td>
<td>Dynacut Fundamental Development and Scalability Testing</td>
<td>University of Queensland</td>
<td>Brad Neilson, Dihon Tadic, Joji Quidim</td>
<td>$540,000</td>
<td>25/07/2018</td>
<td>Andrew Lau, Ivan Heron</td>
<td>Cam Davidson</td>
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A draft report is with the industry monitor(s) for review.

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<tr>
<td>C26021</td>
<td>Verification of Interoperability - Collision Awareness and Avoidance Systems</td>
<td>CSIRO</td>
<td>Jeremy Thompson</td>
<td>$105,844</td>
<td>25/08/2018</td>
<td>Iain Curran, Matt Clements, Paul Forsaith, Tim Gray, Tony Egan</td>
<td>Cam Davidson</td>
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A draft report is with the industry monitor(s) for review.

**Health and Safety**

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<tr>
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<th>Value</th>
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<th>Industry Monitor(s)</th>
<th>ACARP Contact</th>
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<tr>
<td>C25026</td>
<td>Reducing Risk Taking Among Australian Coal Miners</td>
<td>University of Newcastle</td>
<td>Anna Giacomini, Mark Rubin</td>
<td>$302,235</td>
<td>25/04/2019</td>
<td>Bharath Belle, Doug Kennedy, Simon Coleman</td>
<td>Patrick Tyrrell</td>
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This project aims to identify the causes of dangerous risk-taking among Australian coal mine workers. The longitudinal research will include both open-cut and underground coal mine workers from a number of Australian mine sites. The project also aims to develop a practical intervention that will result in a significant reduction in risk-taking behaviour and its associated accidents, injuries, and fatalities. The project will test the effectiveness of the intervention and develop a tool to enable industry users to assess the long-term effectiveness of the intervention.

The research is currently focused on completing the data collection for Survey 2. To date, we have recruited 672 participants for Survey 2: 135 responses to the online survey and 537 paper responses.
In June we completed a second site visit to Oaky North underground mine. We had an excellent response from this mine, receiving 302 completed surveys during the site visit. Data collection (small group sessions) continues at Liddell Coal Operations in the Hunter Valley which will make an important contribution from the open cut sector.

We continue to focus our recruitment efforts on revisiting the mines and mines rescue stations that participated in Survey 1 as well as direct contact with Survey 1 participants who provided their contact details for follow-up in future stages of the project. We also continue our broad online/social media recruitment campaign to further increase participation numbers for the second survey.

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: 25/08/2018
Industry Monitor/s: Occupational Health and Safety Task Group
Tony Egan

ACARP Contact: Patrick Tyrrell

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.

Progress
The Health-e Mines website has now been launched. We are continuing to visit mine sites to promote the website and to provide feedback to participants of the initial survey on how they helped shape the development of Health-e mines.

Over the last quarter, there have been 1,133 hits (page views) on the website. Of these, 20% have been new visitors to the website, and 80% have been returning visitors. This has translated into 227 sessions by people visiting the website, who have viewed, on average, five pages per session. HealthMines has 162 unique users visit the site during May-July. After the home page (landing page), the most frequently visited page on the site is the section that contains fact sheets and tips for maintaining mental health and wellbeing. The next most popular activity on the site is registering for access to the evidence-based programs that address depression, alcohol/other drug use, and healthy living.

If you would like to find out more about how Health-e mines can be offered at your site, please contact Frances Kay-Lambkin, frances.kaylambkin@newcastle.edu.au

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

University of Queensland
Robin Burgess-Limerick

Value: $328,704
Report Expected: 25/01/2021
Industry Monitor/s: Ellen Roots
Ross Di Corleto
Shane Apps
Troy O'Reilly

ACARP Contact: Keith Smith

The objectives of the project 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.

An iOS application was written to allow iPhones to be installed in haul-trucks at Millennium mine, and accelerometer and GPS data was received from the phones by the UQ server software. However, regular breaks in transmission occurred as a consequence of the phone overheating, and this issue could not be overcome. Alternate hardware involving a miniature accelerometer located in the seat and utilizing a Raspberry Pi microcomputer has been designed and software coded to replace the iPhone. A change of site to Peabody Moorvale mine was also required. A visit was undertaken to Moorvale on 10th July to test the RPi hardware and software connectivity to the Peabody truck hubs. This was successful and five complete sets of hardware (Figure 1) were delivered to site, including seat mounted accelerometers. However, installation was delayed by drivers’ objections to seat warmers being removed. Two accelerometers have now been located into seat cushions which also include seat warmers and data from two trucks are now being transmitted.

Figure 1: Accelerometer ready for mounting in seats and the Raspberry Pi based transmitting module.
C26028
Proximity Detection System Performance Testing Framework
University of Queensland
Joel Kok
Joji Quidim
Susan Grandone

Value: $268,000
Report Expected: 25/08/2018
Industry Monitor/s : Matt Clements
Tim Gray
Tony Egan

ACARP Contact: Cam Davidson

This project aims to align and build upon the EMESRT PR5A body of work to develop a set of standardised functional and performance requirements with an associated testing regime for validating PDS technology capability relative to control levels 7, 8, and 9 in open cut mining.

Stage 2 is currently drawing to a conclusion. All main findings and recommendations for this project have been communicated to the monitors. During this quarter two workshops with the industry monitors were held (9th May and 18th July). Tier 1 test methodology was presented in the May workshop, while the body of work for Tier 2 was presented in the July session. The final report is currently being written while a few actions (from the last workshop) are being followed up on. A draft final report is expected to be tabled in mid-August.

C26036
Earthmover Rim and Wheel Safety: An Investigation
Simtars
Mark Petrie
Tilman Rasche

Value: $511,681
Report Expected: 25/08/2018
Industry Monitor/s : Nathan Clements
Tim Gray
Tony Egan

ACARP Contact: Cam Davidson

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

C27005
Interface Design for Haul Truck Proximity Advisory Systems
University of Queensland
Robin Burgess-Limerick

Value: $199,296
Report Expected: 25/04/2019
Industry Monitor/s : Tony Egan

ACARP Contact: Cam Davidson

The project extends on completed project C24028 by utilising a similar experimental paradigm to examine two of the issues identified as requiring further investigation:
- The relative benefits of proximity information based on distance only vs collision prediction information; and
- The relative benefits of auditory tones vs speech.

Preparatory work required for the experiment is completed. This work included replacement of the haul truck simulator computers and programming of the revised proximity advisory interfaces. Data collection commenced from March. As of 25th July, 45% of the data collection has been completed. The data collection is on track to be completed in 2018.

C27013
Evaluating Risk Control Performance
University of Queensland
Maureen Hassall

Value: $135,000
Report Expected: 25/03/2019
Industry Monitor/s : Kevin Rowe
Kylie ah Wong
Stephen Broad
Tony Egan

ACARP Contact: Cam Davidson

This project seeks to identify, develop and assess leading-edge, evidence-based approaches for measuring the effectiveness of implemented risk controls. The objectives of this project are as follows:
- Collect and review current work being conducted by a diverse range of coal mining companies and others on the measurement of control effectiveness;
- Identify and specify potential practical methods for measuring control effectiveness;
- Develop worked examples that illustrate how the range of control effectiveness measurement options might be applied to a selection of common high priority controls;
- Evaluate and critique options for measuring control effectiveness.

The project will capture and evaluate options for measuring control effectiveness trialled, in use and conceptualised in the coal industry and by others. The findings will be written in a report that describes, provides worked examples and critiques the range of ways control effectiveness can be measured for industry practitioners and others to use as a reference.

The project has just begun. The review of literature on defining control effectiveness has been completed so has preliminary work done on collecting information on how others measure control performance. An ethics application has been submitted to formally collect people’s views on current status and future directions. A workshop for industry leaders is being planned to bring lead thinkers into the room to review findings to date and discuss how control effectiveness is or could be measured.
Overburden Removal

C25038
Dragline Excavation Sequencing: Phase 2

University of Queensland
Andrew Jessett
Ross McAree

Value: $1,129,000
Report Expected: 25/08/2018
Industry Monitor/s: Andrew Denman, Hans Hayes, Win Klass

ACARP Contact: Cam Davidson

This project will address the tactical planning problem for dragline excavation – the computation of excavation sequences and their use to guide on-board operation. The project objectives are to develop the algorithmic framework capable of optimising the excavation decisions for machine positioning and material movement, and to evaluate the potential operation benefit of the excavation sequences when used as an operator assist. The targeted production benefits are more consistent production, faster lineal advances rates down the strip, and continuous assurance that future material movement tasks remain feasible relative to a plan.

The project completed a field trial of the operator assist, on dragline DRE35 at BMA’s Caval Ridge Mine, across three weeks in May to June. The trial was conducted on a blocks-pass to final spoil and included two main sections of work: system shakedown and testing during operation, without providing guidance; and dragline excavation with operators being provided guidance on machine positioning and the dig and spoil task at each position. This exercise brought clarity to gaps in the problem formulation and solution implementation that need to be addressed in order to realize value from the technology.

Analysis of the production trial and compilation of the project report are almost complete. Optimising the positioning and material movement tasks of dragline excavation has the potential to deliver 10% improvement to productive output. The project report, to be submitted to ACARP soon, addresses the achievements of the project and the challenges to realizing as much of the potential of dragline excavation sequencing as possible.

C26035
Dynacut Fundamental Development: Phase 2

University of Queensland
Dihon Tadic

Value: $1,333,000
Report Expected: 25/12/2018
Industry Monitor/s: Andrew Lau, Hans Hayes, Ivan Heron

ACARP Contact: Cam Davidson

This project follows directly from project C25041 – “Dynacut fundamental development and scalability testing for high capacity mining of coal overburden”. There are three project elements: the first aims to examine the effect of key operating variables on cutting performance via further cutting trials; the second aims to extend cutter design work and test more advanced cutter designs; and the third will use the findings of the first two elements, combined with potential mining system concepts, to produce a design for an up-scaled test machine. This phase aligns with the overarching objective of completing core R&D to demonstrate the performance and scalability of the DynaCut technology, to ultimately justify a commitment by Komatsu and/or an industry consortium to develop a full-scale prototype system for coal mining applications.

Preparation and planning for cutting trials at Komatsu’s test facility in New South Wales continues, however, these trials first require that specific modifications are made to the DynaCut test machine. Options for these modifications/enhancements are being explored and reviewed, in order to ensure that key operating parameters can be adequately investigated to ultimately inform a new and superior machine design. New cutter design concepts have also advanced, aiming to further push cutting rate performance beyond that demonstrated during the previous quarry cutting trials.

Some organisational restructuring has affected project resourcing, and a revised completion plan is currently being prepared to understand the impacts on project delivery.
COAL PREPARATION

Major Projects

C20052
Full Scale Gravity-Desliming Using Cascading Reflux Classifiers

University of Newcastle
Kevin Galvin

Value: $215,480
Report Expected: 25/09/2018
Industry Monitor/s: Kevin Rowe, Tom Wilson
ACARP Contact: Nerrida Scott

The project objective is to investigate 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 ACARP project, C20052, were completed and commissioned in December allowing some initial experiments to be done. A number of other circuit adjustments was then undertaken and completed. Samples from over 20 runs have now been collected, covering a range of circuit feed rates (eg 52, 100, 162 m³/h in the RC1400 gravity unit). The effects of varying fluidisation rate (4.9, 6.0, 8.0 m³/h) in the deslime unit were also examined, achieving classification in line with expectations.

The work program was finalised during the previous quarter and an interim report prepared and submitted to ACARP. The purpose of the report is to permit the committee to identify any further work needing to be done before dismantling the facility. A review of the work to date showed the circuit successfully produced clean coal product over a broad range of conditions, at feed rates of 52 to 162 m³/h (18 to 53 t/h solids), feed ashes of 30 to 52 wt.%, achieving product ashes of 3.4 to 9.3 wt.%, and combustible recoveries of 40 to 86 wt.%. Work also demonstrated the consequences of operating the first stage gravity separator at too-high a set point. This condition causes mineral matter to report to the desliming unit, resulting in the mineral matter forming a lower bed in the desliming unit, and forcing the coal to overflow. The work has identified a robust design that permits a low set point separation. The reject would then be sent to a second gravity stage from which a deslimed thermal product would be produced. A coking coal product would emerge from the first-stage gravity product following desliming. The project has reached completion, and the final draft report is being prepared.

C22046
Reflux Classifier to 4mm Top Size - Full Scale Trial (Construction of Test Rig)

University of Newcastle
Kevin Galvin

Value: $131,874
Report Expected: 25/08/2018
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 worked 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 has been completed and the industry monitors have accepted the interim summary. Plans are underway for the removal of the facility this year, for use in another ACARP project.
Dewatering

C24040
Improving the Dewatering Efficiency of Fine Flotation Concentrates by De-Aerating Froth Products

University of Queensland
Yongjun Peng

Value: $383,468
Report Expected: 25/10/2019
Industry Monitor/s : Alvaro Diaz Lema
ACARP Contact: Nerrida Scott

This project extends on a previous project C24040 and focuses on direct plant tests of the deaeration techniques developed in the laboratory. The main objectives of this project are to:

- Scale up the effective deaerating techniques developed in the laboratory (including deaeration devices and chemicals) and then directly test and optimise them in the plant;
- Study, define and optimise parameters that cannot be properly studied at a laboratory scale;
- Identify the most cost-effective froth deaerating strategy depending on the plant flowsheet;
- Evaluate the effects of different deaerating methods on upstream and downstream performance in the plant; and to
- Demonstrate economic benefits by implementing a deaeration technique in plants.

The designs of physical deaeration system have been completed. It includes a froth-slurry separation system to separate froth from slurry before deaeration, a spinning basket deaeration device for the first stage deaeration and a vacuum deaeration system for the second stage deaeration. The devices are being fabricated by the workshops, which will take approximately three months.

Two coal preparation plants were visited in June. Both plants have overly stable froth problem in the dewatering circuit. The designs of the deaeration system, the connection of the system to the plant operation, and the testing program were discussed with plant engineers. 400 L coal samples were collected for initial pilot testing in the laboratory.

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

QCC Resources
Andrew Swanson
Bob Drummond

Value: $437,393
Report Expected: 25/10/2018
Industry Monitor/s : Mario Salazar, Rod Fox
ACARP Contact: Nerrida Scott

The use of high pressure steam to supplement pressure filtration has been used in various mineral and niche chemical applications where the final cake moisture specification is significantly less than what alternative, conventional dewatering technologies can achieve.

The initial pilot testing phase of the project was completed in 2017. A summary of the pilot testing headline filter cake discharge moistures from site moisture testing is provided below.

The objective of this phase is to confirm the scalability of hyperbaric filtration technology by comparing the batch-wise laboratory (or bench scale) data relative to the continuous pilot testing data (collected as part of the initial project work). Once the scalability of the technology is confirmed a detailed laboratory assessment of ten flotation concentrate samples provided to Bokela will determine the effect of filter feed (coal quality) characteristics, such as: coal rank; particle size distribution; and clay content; on filtration rate, final product moistures and air and steam consumption rates.

The evaluation of a wide range of flotation concentrate samples coupled with the deployment of the Bokela in-house coal processing data to expand the dataset (provided as part of Bokela’s in kind support for the project) will establish the operating limits of the pressure filter technology and provide the industry with nomograms and derived empirical relationships, relating the feed coal quality parameters to the filter throughput, air and steam consumption rates and moistures outcomes.

Initial internal assessment has identified ten sites that have agreed to contribute a sample towards the research. Sample collection is currently being undertaken with three samples delivered to Bokela in Germany and a further three awaiting collection at various New South Wales and Queensland sites. QCC are targeting for the remaining four samples to be taken and collected, such that by the end of August all samples will be delivered to Bokela to undertake the laboratory scale testing.

It is anticipated with three months of laboratory testing and allowing two months to analyse the data and prepare the report, that the research will be completed by the end of 2018.

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

University of Queensland
Anh Nguyen

Value: $220,000
Report Expected: 25/08/2018
Industry Monitor/s : Penny Walker, Rahul Patel, Steve Vaughan
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
- Compare pilot-scale findings to full-scale results.

Last two series of the pilot-scale centrifugal dewatering experiments on coal tailings thickener underflow with high solid concentration were completed at QCAT. Trials on tailings thickener underflow with 13% solids were conducted. Minimum cake moisture of 29.5% with 96% solid recovery was obtained at 2000 g-force and 20 differential rate. Total dissolved solids (TDS) of the effluent water was 0.52%. Applied anionic flocculant improved solid recovery to 98% with 0.35% TDS of the effluent water, but the cake moisture increased to 32.1%. The cationic surfactant also improved solid recovery to 98% with generating 0.41% TDS effluent water. The cationic surfactant showed a minor effect on the moisture increment.

The extension of the project for more eight months was approved in June, with the objectives of the extended part being:
- To design optimum operational condition for samples with different dewatering difficulty; and
- To provide solid recovery by size analysis for each type of the samples.

The pilot-scale centrifuge was moved from QCAT to our pilot-scale lab at University of Queensland, Pinjarra Hills Facility. The centrifuge installation and commissioning were completed. IBCs were dispatched to two coal preparation plants in the Bowen Basin for sampling. Samples from tailings thickener underflow with different dewatering difficulties will be collected and delivered to the pilot-scale lab in UQ Pinjarra Hills Facility.

C25018
Improving Solids Recovery and Moisture Reduction in Ultrafine Coal Dewatering

University of Queensland
Liguang Wang

- Value: $184,000
- Report Expected: 25/09/2018
- 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 to
- Conduct a cost-benefit analysis to compare the cost of the chemicals to the increase in solids recovery.

The installed pilot-scale SBC at University of Queensland has been subjected to extensive testing. An operating issue has been identified when the SBC is operating at the target rotation speed, and attempts are being made to fix the problem. Alternative plans are also being explored to test the new concept developed from the laboratory-scale work.

C26015
Characterisation of Coal Petrography for Improving the Dewatering of Fine Coals Using Chemicals

University of Queensland
Anh Nguyen
Graham O’Brien

- Value: $199,436
- Report Expected: 25/12/2018
- Industry Monitor(s): Luke Dimech, Naomi Pritchard, Rahul Patel
- ACARP Contact: Nerrida Scott

The objectives of the project are to:
- Apply microfocus XCT facility to image fine coal grains and develop the specialist software to reconstruct 3D density maps of fine coal grains;
- Apply the facility for the coal grain analysis by optical petrography to obtain detailed information on maceral constituents (vitrinite, inertinite, liptinite) and minerals on individual grains for calibrating and validating the XCT results of 3D density maps;
- Conduct the float-and-sink analysis of coal grains to determine maceral density (three different coal ranks of mean vitrinite reflectance of 0.6%, 1.35% and 1.8%) for calibrating and validating the XCT results of 3D density maps (jointly with Objective 2);
- Apply the coal grain composition information obtained in Objectives 1-3, develop matrices of dewatering chemical aids for the coal grain compositions, and conduct the corresponding dewatering experiments to gain an understanding of the response to dewatering of different grain types and predict the process performance under centrifugation conditions;
- Apply the XCT calibrated procedure (Objective 1) and the procedure of matching the dewatering chemical aids with coal grain composition (Objective 4) to develop a reliable method for determining the composition characteristics of fine coals for dewatering.

Progress to date
Pure individual coarse (~1mm) vitrinite and inertinite samples were prepared from two different coal mine sites, samples A and B, using an optical microscope, then the grains were ground to get particles size of 53-106 microns for float-sink tests. Based on the density difference of the macerals, pure vitrinite and inertinite samples were prepared using the float-sink method. The purity of the prepared vitrinite and inertinite samples were confirmed by Coal Grain Analysis (CGA). These samples were applied successfully to calibrate microfocus XCT. The XCT 3D macerals maps of the samples A and B showed that sample A contains 90% vitrinite, 8% inertinite and 2% minerals, while sample B comprises 84% vitrinite, 14% inertinite and 2% minerals. As there was not a significant difference on the macerals compositions of the samples A and B for dewatering experiments, it was decided to split sample A from cut-point density of 1.30 g/cm3 to prepare two 1.30 g/cm3 float fraction, representing vitrinite-rich sample, and 1.30 g/cm3 sink fraction, representing inertinite-rich sample. XCT and CGA results showed that vitrinite-rich sample encompasses 95% vitrinite, 3% inertinite and 2% minerals, and for an inertinite-rich fraction, there were 65% vitrinite, 24% inertinite and 11% minerals. These two fractions will be used for dewatering experiments.
A wide range of flocculants with different structures, and surfactants using the Hydrophilic-Lipophilic Balance number were prepared to study the effect of the dewatering aids on coal samples dewatering with different macerals compositions. A Single Leaf Filtration Test (SLFT) rig was modified for the dewatering experiments. The SLFT tests are underway.

**C27016**
**Eriez HydroFloat in Plant Evaluation**

**Eriez Magnetics**
Darren Mathewson
Liam Davis

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The Eriez HydroFloat is a small footprint, high capacity coarse flotation technology capable of recovering coal from a fine (-2.0x0.3-mm) material stream using both density and surface chemistry properties of the feed. This technology potentially delivers higher efficiency and reliability than existing technologies as shown by independent USA testing. It is a hybrid ‘teeter-bed separator’ that augments a density separation by simultaneously employing flotation techniques.

The USA test results using the HydroFloat show a product of 6.6% ash (dry) was obtained with a combustible recovery of 94% for a -2.0 +0.15 mm feed (top:bottom size ratio 13.3). Further, it was shown that superior performance would be expected at the recommended maximum design top:bottom size ratio of 6:1 while treating the coarser end of the particle size distribution (ie +2.0 +0.30 mm).

The frother requirements for the HydroFloat are minimal (1-3 ppm) as this separator does not operate with a deep and stable froth. Also, the frother dose is only related to the teeter water flowrate, as such, the low surfactant addition rate will not negatively affect the performance of the plant.

There are currently no Eriez HydroFloat units installed in the Australian coal industry and no pilot plant test work has been performed. Plant trials will allow the coal industry to properly assess the benefits of Eriez HydroFloat across a range of site specific conditions, without requiring each site to individually assess the technology. It is planned that the HydroFloat will be tested at one site in New South Wales and two in Queensland.

**C27064**
**Dry Beneficiation Using FGX and X-Ray Sorters**

**A&B Mylec**
Kevin Boddeus

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The main objective of the project is to determine the performance of single and combined dry-processing technologies, treating a coal sample sourced from a local coal resource. In addition, the project will undertake order of magnitude estimates for the impacts upon resource value for such processes.

The overall outcome is to assess the merits of this unique combination of technologies as a processing option for those Australian coal mines where either wet processing is an unpalatable option or an in-pit processing option improves the overall resource economics through reduced haulage of rejects. Dry processing, at a suitable throughput and metallurgical efficiency may also assist some projects in cold climate areas or remote locations which are being considered by Australian mining houses overseas. The low capital cost profile and quick site establishment of an FGX plus XSS-T operation is likely to be a better capital fit for junior to mid-tier mining houses seeking to establish a cash flow from their resource.

The following lists some of the key project milestones and status to date:
- FGX and XSS-T equipment locations and equipment operation service providers ability to conduct test work has been confirmed;
- Initial coal sample from Peak Downs was investigated but found to be significantly more expensive to transport than a sample from New Acland;
- A source of 6 tonnes of ROM coal has been confirmed with New Acland;
- A coal transport provider has been sourced who is site-qualified and approved to pick up the sample;
- A quotation has been requested and received from the coal transport provider;
- A source of 6 tonnes of ROM coal has been confirmed with New Acland;
- A coal transport provider has been sourced who is site-qualified and approved to pick up the sample;
- A quotation has been requested and received from the coal transport provider;
- A detailed test work plan has been developed and sent to ALS for quotation;
- The quotation from ALS has been received;
- A detailed test work plan has been sent to Steinert for quotation and comment with regards to XSS-T tests; and
- A literature search has been started and the initial stages of report development have begun.
The objectives for this project are to:
- Study mineralogy, surface chemistry and rheological properties of coal tailings clays (eg smectite and kaolinite; two main clay minerals in coal tailings);
- Design experiments and test work and examine the effect of chemicals (floculants and surfacants) on the coal tailings concerning the dual functionality of capturing fine clay particles and reducing the final moisture of dewatered tailings;
- Provide detailed information on the impact of the chemicals on the laboratory-scale dewatering performance of Australian fine coal tailings; and to
- Monitor the effect of chemicals on coal tailings dewatering at a pilot-scale solid bowl centrifuge, which operate in a continuous flow mode.

Ten samples from different coal seams were collected from a mine site in the Bowen Basin. All the samples were crushed and prepared on glass slides for X-ray Diffraction (XRD) analysis of clay minerals. In order to identify swelling clay mineral (eg smectite), ethylene glycol treatment was applied to all samples. XRD results revealed that dominant clay minerals vary for different coal seams samples. Smectite, a swelling clay mineral, and kaolinite with illite, non-swelling clay minerals, were identified as the main minerals in the samples. Surface characterisation of the samples is underway.

Environmental Improvement

C26009
Improved Precision for the Determination of Coal in Urban Dust Samples by Combining a Reliable Analysis of Soluble Particulates with CGA

CSIRO
Graham O’Brien
Michael Campbell

Value: $175,622
Report Expected: 25/08/2018
Industry Monitor/s : John Watson
Kevin Rowe
ACARP Contact: Nerrida Scott

The objectives for this project are to:
- Establish a rigorous method for the collection and analysis of urban dust samples that accurately incorporates the contribution that water soluble particles make to urban dust in the entire sample (TSP) and respirable (PM10) fraction.
- Investigate if the current optical dust marker method developed using samples from Mackay, Gladstone and Newcastle can accurately identify the coal and non-coal particles in dust samples collected from Wollongong and Brisbane;
- Investigate whether this method is able to differentiate between dust generated during open cut mining operations and windborne dust from non-mining activities; and
- Undertake a statistical analysis of the results generated that provides detail of the method’s accuracy.

All samples have been collected and analysed and the final report is being written. The Newcastle sampling program, which commenced in July 2017 was completed in January 2018. Over this time two TSP samples and a PM10 were collected on two different sampling days each month. In total 14 sets of samples were collected. For selected TSP and PM10 samples, the CGA method was used to determine the proportion of coal and other particulates in the water insoluble fraction. Samples of the overburden rock types, from a Hunter Valley open cut mine, a sample of the surface dirt collected off lease and a PM10 sample were collected in a nearby township, have also been analysed. Key project findings are:
- The proportion of water soluble particulates in the TSP and PM10 samples collected in the Newcastle region varied from 10% and 90%. In general terms samples collected in winter had a lesser proportion of water soluble particulates and samples collected in summer contained a greater proportion of water soluble particulates;
- For PM10 samples collected in the Newcastle region, CGA analyses determined that a significant proportion of the insoluble particulates (in excess of 50%) were greater than 10 microns in size; and
- The CGA method successfully identified the coal particulates in a sample collected in the Wollongong region.

In the next quarter we plan to complete and submit the draft final report to ACARP for review.

C27067
Tailings Management - Dewatering of Slurry Tailings at Disposal Site

University of Newcastle
Craig Wheeler

Value: $150,000
Report Expected: 25/10/2019
Industry Monitor/s : Kevin Rowe
Tom Wilson
ACARP Contact: Nerrida Scott

The objective of this project is to investigate the feasibility of dewatering slurries at the disposal site via an open declined gravity chute, or simply, a flume. The project aims to develop a flume system that can suitably dewater a coal slurry that is pumped as a lean phase slurry. The goal is to increase the solids content of the tailings entering the tailings dam and recover water before it is deposited in the tailings dam. The recovered water would be recycled back to the CHPP as process water, thus limiting the volume of water stored in the tailings dam and reduce, or eliminate, the use of secondary flocculant in the tailings dam.

The research will focus on determining the optimum length and angle of declination of the flume that would allow the maximum dewatering of slurry at the rated flowrate of the CHPP slurry pumping system. A secondary objective is to develop a model...
that would accurately predict the operation of the flume at different flowrates, percentage solids and flume angles.

Bench top settlement tests are currently being undertaken on tailings samples acquired from site, in addition to Computational Fluid Dynamics (CFD) analysis of the settlement process. This initial work will help inform the design parameters of the pilot scale test facility and key input parameters for the numerical models. The next stage will involve the design, construction and operation of a pilot plant size dewatering flume, in addition to a flume model using CFD.

### Fine Coal

**C23045**  
Full Scale Trial of the Reflux Flotation Cell

University of Newcastle  
Kevin Galvin

- **Value:** $294,820  
- **Report Expected:** 25/07/2019  
- **Industry Monitor(s):** Clinton Vanderkruk, Kevin Rowe, Penny Walker  
- **ACARP Contact:** Nerrida Scott

The objective of this project is to investigate the performance of the Reflux Flotation Cell (RFC) at full scale. This will be a two-stage study investigated at a volumetric throughput of up to 1000 m³/h. A key focus of the study is on the physics that underpin the scale-up performance of the technology, in terms of delivering “Fast Flotation”, and “Desliming Flotation”. The existence of a system of inclined channels increases the segregation rate of the bubbles from the downwards tailing flow. This mechanism produces a significant gas-hold-up, a concentrated bubbly zone, ideal for counter current washing to achieve clean product. A further objective is to assess the potential for process control of the technology, and hence assess the reliability over extended campaigns.

A number of laboratory experiments have been conducted in order to inform the project on what is possible. These experiments involve a two-stage system, each with a 0.1mx0.1m cross-section, and vessel 2.0 m high. The initial experiments were focused on two-stage operation under conditions below the target processing rate. The feed rate used was equivalent to 700 m³/h through a 2.0 m diameter unit, very high compared to the rate supplied to conventional systems. The rougher product was then cleaned in a second stage. In general, the final product ash values were about 5%, and always high compared to the rate supplied to conventional systems. 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.

There have been significant changes to this project since the last quarterly project. The project has been moved to a new site in order to take advantage of the existing flotation infrastructure, including feed delivery, frother supply, collector addition, and screen bowl centrifuges for product dewatering. This change greatly reduces the cost of establishing a facility for the trial. The project will also utilize the existing facility deployed for a recent full-scale trial of related technologies. The preparations for the new facility are underway, with assessments of the location (geotech) completed, MCC requirements completed, and about 80% of the overall process design complete. The RFC units are now being manufactured for the project. Five organisations are involved in establishing the facility to trial the technology at full scale, and a strong financial contribution from the Federal government has been secured.

The plant seeks to process up to 1000 m³/h of cyclone overflow, using two 2.0 m diameter RFC units operated in series, to achieve high recovery, throughput, and low product ash.

**C24049**  
Performance Enhanced Diesel Collector for Coal Flotation

CSIRO  
Shenggen Hu

- **Value:** $148,013  
- **Report Expected:** 25/10/2018  
- **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; and
- Improving collector addition methods with enhanced dispersion of collector.

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

Additional plant-based trials were conducted in June at another CHPP having a coal which is difficult to be floated. The combustibles recovery obtained with the performance-enhanced diesel collector in the primary Jameson cell can be up to 2 to 6% higher than that with the same dosage of normal diesel collector. Due to the slow dissolution of Nalflote 9840 which was used as frother at the site with Jameson cell, the combustibles recovery for all cases were less than 27%. In the ACARP reviewing meeting held in March 2018, it was suggested by the ACARP committee that one more plant-based test should be done on Jameson cells with MIBC as frother and the final report should include the useful results from an additional test. The additional test will be carried out at Coppabella mine site. To be cost effective, the field trials of this project will be carried out in September together with other two ACARP projects. The report will be submitted in October.
The objectives of this study is to establish 2m³/h and 20m³/h can also be washed over a screen. Low density product that floats to the surface. The final product embedded within the 3D matrix of the binder, producing a very attached to a novel binder. The coal particles then become project is concerned with 3D Flotation in which the fines are have not changed significantly in the past 100 years. This new Conventional 2D Flotation involves the agglomeration of fine feed rate was also increased to 120 L/min, achieving acceptable further experiments were conducted using 40 L/min, through to 60 L/min. There was a loss in yield at the higher feed rate, however the pressure drop through the orifice plate was further regulation of the system scale-up, and assessment of economic potential.

We have established that these agglomerates are buoyant hence they tend to rise naturally to the water. We previously constructed a system to promote the buoyant separation of the agglomerates to achieve continuous steady state separation. We have since commenced work to trial the new Reflux Flotation Cell, and have found it necessary to build an understanding on how best to use the system. At this stage we have only conducted about six experiments. We have succeeded with multiple runs, each with a different bias flux. In the end, the Reflux Flotation Cell was found to be highly restrictive in processing deformable agglomerates.

Therefore, a new 280 Litre trough based system was constructed. The system was designed to process feed at 20 L/min, while also permitting operation at much higher rates approaching 100 L/min. The trough arrangement has been completed, and commissioned. The system performed very well on a genuine continuous steady state basis, with a clear tailings stream, and distinct and complete product. When operated at 20 L/min on a feed consisting of a plant tailings material (head ash of 61.6%), a combustible recovery of 67.6% at a product ash (directly from trough) of 10.7% was achieved.

Further experiments were conducted using 40 L/min, through to 60 L/min. There was a loss in yield at the higher feed rate, however the pressure drop through the orifice plate was significantly higher. So the work was repeated at a lower pressure drop of 160 kPa. Again there was a loss in yield. However, the air rate introduced with the agglomerates was very low compared to those used in flotation. Therefore, new experiments were conducted at higher air rates. The volumetric feed rate was also increased to 120 L/min, achieving acceptable product ashes and combustible recoveries, demonstrating initial scale-up of the system.

The draft final report has been submitted.
To implement this project and quantify approaches to mitigate excessive frothing, a rapid, robust and portable sensor/device to determine very low frother concentrations in process streams is required, presenting significant sensitivity challenges when using currently available sensors. The project team sourced components for building breathalyser-type systems using the latest advanced alcohol detection systems for use in this study. The components were assembled into frother sensor systems.

Frother concentrations in the range of interest (0-20 ppm) in water were presented to the breathalyser-type sensor systems. Measurements were also performed on dilute fine coal slurries to determine the effect on sensor output. A sensor system has been assembled that is able to detect frother concentrations in the range of interest with reasonably high sensitivity and has been optimised for detection of low concentrations of MIBC frother. The architecture of the sensing system was modified to maintain temperature of the sensing element within a narrow band to eliminate measurement drift that was initially observed.

Frother partitioning experiments were performed in a batch flotation system to study the kinetics of residual frother removal with and without solids present. Two-stage flotation tests have been performed to examine the impact of solids and coal types on frother partitioning and the effectiveness of second-stage flotation in reducing residual frother. Experiments have also being completed in a pilot-scale air stripping column to determine the effectiveness of this process in the removal of frother from aqueous streams. All laboratory and pilot-scale experiments have been completed. A plant audit has been performed to determine residual frother levels in selected process streams for comparison with the pilot scale data. Report preparation is progressing and expected to be completed by end of August 2018.

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

CSIRO
Philip Ofori

Value: $165,582
Report Expected: 25/09/2018
Industry Monitor/s: Alvaro Diaz Lema
Justin O’Neill
ACARP Contact: Nerrida Scott

The objectives of the project are to develop the best implementation methodology and confirm the effectiveness and safety of aerosol frother addition at plant scale in:
- Improving flotation performance;
- Reducing frother usage; and
- Minimising residual frother in process water.

The project involves a large-scale investigation of the effectiveness of aerosol frother addition at a selected CHPP. The project team visited the selected mine site to determine the retrofitting position of the frother atomising systems in consultation with site personnel. Design and fabrication of frother dosing systems, atomising nozzle sizing and positioning and connections to existing systems were completed. Dosing pumps and atomising nozzles were procured and aerosol generation and delivery systems fabrication were completed.

The complete aerosol generation system was assembled and tested in our pilot plant and minor modifications required were implemented before site installation and commissioning Plant installation. The selected CHPP for the investigations had the ideal set-up for the planned experiments with separate feed pump and frother dosing system for each cell. This made it possible for one cell to be isolated for the aerosol frother experiments to be performed without impacting the other cells operating in parallel. However this CHPP uses a proprietary frother. The viscosity of this frother is an order of magnitude higher than MIBC. ACARP Coal Preparation Committee members expressed preference for the tests to be performed at a site that uses MIBC at the Project Review meeting. MIBC is the most widely used frother in the industry.

No other site was identified with MIBC dosing setup that allow the experiments to be performed as described. The ACARP Committee members agreed for the tests to be conducted on a large pilot-scale Jameson Cell at a Bowen Basin mine site using MIBC frother. The required modifications to the pilot-scale Jameson cell for set-up at the mine site are being made. The experimental investigations are planned to take place in September to be followed by report preparation.

C25019
Adaptation of Coal Grain Analysis to Improve Yield Estimation

QCC 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 provide a more accurate basis for modelling flotation yield. The information is generated in a form is able to be directly utilised in the likes of LIMN process models.

An earlier project (C24045) involved 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. The C24045 report demonstrates the variety of modelling approaches which may be undertaken using CGA data.

A total of six sites have been sampled for this extension project, C25019. Due to a laboratory error in sample handling, one of those sites is awaiting re-sampling so that the sampling phase of the project may be completed. It is expected that the one remaining site will be sampled by August 2018, and that the draft report will be able to be submitted by early 2019.
C26001
Impact of Sub Optimal Operation: Stage 2
CSIRO
Mike O’Brien

Value: $41,500
Report Expected: 25/04/2018
Industry Monitor/s: Mario Salazar
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. 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 some activities in the plant operation, and in all cases, a successful description of the situation was obtained consistently. 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.

The new spreadsheet has been populated, and new macros are currently being written to ‘drive’ the data base. Completion of this part of the work will be in the next two months, and the final report will be completed within the next four months.

C27033
Comprehensive Flotation Model using CGA Particle Surface Composition
Basacon Services
Bruce Atkinson

Value: $74,527
Report Expected: 25/04/2019
Industry Monitor/s: Chris Urzaza
ACARP Contact: Nerrida Scott

This project involves the adaptation of an existing particle-based flotation circuit simulation architecture, developed by the Julius Kruttschnitt Mineral Research Centre (SMI-JKMRC) for metalliferous flotation circuits, as a tool that can be applied in fine coal flotation to forecast the likely impact changes in the feed particle characteristics will have on the yield and quality of the flotation product. This architecture is envisaged to make extensive use of the Coal Grain Analysis (CGA) methodology and its relation to flotation.

The objectives of the project are to:
- Employ CGA particle surface composition data for coal (surface CGA methodology developed under current project C25017), to apply the SMI-JKMRC flotation model that has been developed for metalliferous ores (which use surface CGA methodology developed under current project C25017), to apply the SMI-JKMRC flotation model that has been developed for metalliferous ores (which use surface CGA methodology developed under current project C25017); and
- Recommend future work that may be required to validate the impact that changes to upstream coal processing stages may have on flotation product yield and quality.

The project has recently commenced.

Gravity Separation

C24050
Options for the Addition and Control of Non Magnetic Material in Correct Medium
CSIRO
Mike O’Brien

Value: $205,490
Report Expected: 25/08/2018
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. During the quarter work has been on preparation the draft final report. The report is being internally reviewed and will be submitted shortly.

C24051
Effect of Particle Crowding at the Vortex Finder and Spigot on Cyclone Operation
CSIRO
Mike O’Brien

Value: $145,255
Report Expected: 25/08/2018
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.

Figure 1 shows the relationship from data found in the literature between the feed volumetric medium to coal ratio (M:C) and the Ep. It can be seen that when the feed M:C ratio is less than 3, the variation in the Ep greater than higher M:C ratios. Figure 2 shows the data for all of the pilot plant vortex finder crowding experiments for this project. While only one data point was obtained below a M:C ratio of 3 the data is consistent with that found in the literature shown in Figure 1.
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. One site was found not suitable for this project due to the slow dissolution of Nalflote 9840 which is used as frother at this site. Approval for site access has been obtained from one preferred mine site. The test rig has been tested using water only at QCAT for verifying all control means. Preparation work for the safe installation of test rig which weighs 2.5t has been carried out since last October. As there is no ground space for the test rig, the rig has to be installed at the second floor of the plant. The approval of structure soundness of the plant floor has been obtained. Currently safe measures for holding the rig are being finalized. The rig will be installed in the plant in August, and the test will be carried out in the later August and the report can be submitted in October.

C25016
G Force Reduction and Failure Monitoring of Multi Sloped Screens

CSIRO
Mike O’Brien

Value: $190,282
Report Expected: 25/09/2018
Industry Monitor/s: Clinton Vanderkruk
ACARP Contact: Nerrida Scott

This project has two objectives, designed to address the priorities of optimising maintenance practices and equipment designs to deliver improved process efficiency at lower cost. The project 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.

One of the screens has suffered a failure since the last report however it was unusual in that it was a longitudinal support that failed the mechanism of failure is currently being investigated by the site. The longitudinal supports hold the screen panels in place and are mounted on the main cross beams. No failures have been recorded of the main beams since the g forces were reduced. Failure monitoring continued for a three month period on the desliming screen. The correlation function at this plant has been found to be conditional on the feed rate, (see the figure below) and therefore needs to have an algorithm in place that will take into account the feed rate prior to correlation. The displacement or stroke will is inversely proportional to the feed rate and therefore may be used in an algorithm to ‘normalise’ the correlation function to the feed rate.

Figure 1.  Histogram of the correlation function over a day of operation
Process Control

C22033
Advanced Control and Optimisation of DMC Operation
CSIRO
Shenggen Hu

Value: $246,685
Report Expected: 25/09/2018
Industry Monitor/s: Rahul Patel
ACARP Contact: Patrick Tyrrell

This project has successfully developed and demonstrated a system that can optimise DMC operating conditions under which a target product ash and/or a given incremental ash can be achieved. The following project tasks have been successfully completed:

- Developed methods for on-line estimation of product ash and increment ash;
- Improved an approach for online estimating plant coal feed washability;
- Developed mathematical representations for all types of instantaneous ash versus density curves;
- Developed methods for predicting instantaneous ash curve for known or unknown coal source;
- Carried out coal sampling and analysis to establish the relationship between ash value and density for 6 seams;
- Developed and implemented on-line measurement system and method for on-line monitoring medium densities and DMC product yield;
- Carried out plant-based experiments for the on-line estimation of the plant feed washability from medium densities and product yield;
- Carried out plant-based experiments for the on-line estimation of product ash and incremental ash for coal feeds sourced from mixed seams or single seam;
- Carried out plant-based experiments to evaluate the method for the on-line determination of instantaneous ash curve through rapid ash analysis;
- Carried out plant-based experiments to evaluate the method for determining the DMC cut-point for given product ash levels and/or a given incremental ash.

The final report has been completed and will be submitted after finishing internal review.

C26007
Revised Dustiness and Dust Extinction Moisture Testing Method (Update of AS 4156.6): Part 2 Preparation
University of Newcastle
Dusan Ilic

Value: $80,000
Report Expected: 25/07/2018
Industry Monitor/s: Kevin Rowe
ACARP Contact: Nerrida Scott

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

C26008
Oxidation Monitoring Tools and New Reagents in Plants to Improve the Flotation of Oxidised Coals
University of Queensland
Yongjun Peng

Value: $116,600
Report Expected: 25/08/2018
Industry Monitor/s: Alvaro Diaz Lema, Justin O'Neill
ACARP Contact: Nerrida Scott

This project is a continuation of previous project C23039 through plant tests and technology transfer. The objectives of this project are to:

- Implement the oxidation measurement tools in coal preparation plants and train plant engineers how to use these tools;
- Measure the degree of coal oxidation at different feeds and stockpiles on sites, correlate the oxidation with coal flotation performance;
Develop an oxidation database to guide the plants to manage oxidised coals through blending and adjusting operation conditions; and

Trial the new reagents identified for floating oxidised coals from the previous project (C23039) in the plant to improve the flotation of oxidised coals.

The first three objectives have been achieved. Oxidation measurement tools have been developed and implemented in two plants processing oxidized coals. Several plant surveys have been conducted to measure the degree of coal oxidation in flotation feed on a large number of different samples, and the oxidation degree was well correlated with plant flotation performance. The results showed a general trend that flotation combustible recovery decreased sharply with the increase of the degree of coal oxidation, and a critical oxidation degree was identified, below which the flotation recovery became nearly zero. These results will help the plants to predict their plant flotation performance based on the oxidation degree.

New reagent system which is suitable for oxidised coal flotation has been identified and tested through both batch flotation tests and pilot scale Jameson cell tests. The results have shown that mixing a polar collector with diesel at an optimum ratio can significantly improve the flotation performance of oxidised coals. In addition, the replacement of MIBC with a slightly stronger frother has shown an improvement in flotation kinetics without a significant decrease of selectivity. The reagents for plant trials, including 1 IBC of polar collector and 1 IBC of frother, have been delivered to the plant. The plant trial plan, including the setup of the reagent dosing systems, dosing points and experimental design, has been discussed with plant engineers. The plant trial has been scheduled in September.

C26010 Multi-sloped Screening Efficiency with Changing Strokes, Frequencies, Feed Solids and Feed Rates - Pilot Plant Study

CSIRO
Mike O’Brien

Value: $140,025
Report Expected: 25/08/2018
Industry Monitor/s: Clinton Vanderkruk, Rod Fox
ACARP Contact: Nerrida Scott

This project aims to provide the coal industry with usable data from a pilot scale multi-sloped screen that can be used to maximise screening efficiency while providing the lowest possible forces on the screen, screen components and screen structures. The project targets the ACARP priority of ‘optimising maintenance practices and equipment designs to deliver improved process efficiency at lower costs’.

The coal collected for this test work was a low rank coal and as such was not suitable for the test work as it all broke down to minus 1.4 mm within a short period of time. The program will now use a crushed volcanic rock with apparent densities ranging from 1.2 RD to 2.2 RD for the plus 1.4 mm material. Pump issues required the pump to be rebuilt which also resulted in a delay for this project. The system is now working and the testing underway.

C26011 CSIRO Instruments at Multiple Plants

CSIRO
Mike O’Brien

Value: $427,798
Report Expected: 25/01/2019
Industry Monitor/s: Naomi Pritchard, Rebecca Fleming
ACARP Contact: Nerrida Scott

To maintain the momentum of industry access to the CSIRO technology, the project will manufacture and install CSIRO density monitors into DMC circuits at approximately six plants covering a range of mining companies, plant designs and coal types so that operating conditions from each plant and the dense medium conditions can be monitored by the plant operators to optimize the DMC circuit providing immediate benefits to the plant. This information will also be used to further CSIRO research and knowledge on improving the efficiency of DMC circuits. The exact number of participating plants will obviously be subject to industry pressures influencing the feasibility of their committing to the project.

The objects of this project are as follows:

- Determine the effect of changes in plant conditions on the operation of the dense medium cyclone circuit with the use of CSIRO instruments over a range of mining companies, plant designs and product coal types;
- Provide data over a broad range of coal types and plant designs that will identify costs of inefficient DMC operation, ways for operators to increase efficiency and point to directions for future research;
- Communicate the benefits of the technology to the broader industry; and
- Identify and engage with potential commercialisation partners to build a sustainable commercially available source of instrumentation systems.

The new smaller low priced electrical impedance spectrometer has been produced and tested as a prototype. Boards have been printed and are currently being populated to make up the instruments required for the field work. Figure 1 shows the screen output for the testing of the prototype in the pilot plant. It is important to note that the measurement time which previously was in the order of 30 seconds is now just 1.73 seconds, this is important when determining the cut point and for models that predict the washability and partition curves.

The design and manufacturing of these new instruments, while not in the scope of this project, has been a critical step in the manufacturing of a commercial instrument. Eight sensors have been manufactured and tested ready for installation. A second Boon Basin Plant has indicated that they are interested in taking part in this project.
Figure 1. Pilot plant testing of the new instrument showing density steps up to the density of 1.194 and the time taken for the measurement 1.73 seconds which is one-tenth of the time for the previous instrument.

**C26012**  
**Improved Flotation Recovery Via Controlling Froth Behaviour - Stage 2**  
University of Queensland  
Liguang Wang  

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ACARP Contact: Nerrida Scott  

The objectives of this project are to:  
- Demonstrate and evaluate a real time froth control system for maximising and maintaining the separation efficiency of coal flotation;  
- Demonstrate and evaluate a simple and fast tool for measuring the concentration of frother in flotation cells and water circuits.

Data collected from the first round of site work for the froth monitoring system were analysed. There was a strong correlation between the combustible recovery and the output of monitoring system A, with the coefficient of determination R2 being 0.79.

We also identified the main cause of the defect of froth monitoring system B observed during the site-work. The design of the sensor B was modified to improve robustness and sensitivity. The modified sensor will be tested in the follow up site visit.

The prototype of the frother concentration measurement system is still under construction. Once the prototype is built and assessed at UQ, it will be taken to a participating site for onsite evaluation.

**C26014**  
**Low Cost Online Measurement of Particle Size and Density for Diagnostics Across the Fine Coal Circuit**  
University of Newcastle  
Peter Stepien  
Rohan Stanger  

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ACARP Contact: Nerrida Scott  

The objective of this project is to develop a prototype analyser for determining particle size and density in a slurry using an image-based system. It was found that for the proposed fine circuit particle size -2.0+0.125mm, a vertical gravity based system could provide adequate particle velocities and the spiral-based track was shelved for lower particle sizes. The work over the May-July 2018 period has involved recording a range of coal particle trajectories sized at 106-212um, 212-355um and 355-425um and subsets that have been density separated using tight density cuts 1.25-1.26 SG and 1.35-1.36 SG. These prepared samples will form the basis of the calibration data.

Across the same period, Restech have been developing the ‘Beta-program’ that can take recorded videos and convert them into particle size/shape and trajectory data. Initial programming was found to be capable of discerning particles and trajectories over each frame but showed the need to compile this data as averaging. Our expectation is that this will be completed by the end of July, allowing full demonstration of the system in August-September.
ACARP Current Projects Report August 2018

Particle identification using image analysis

Particle size (right, top) and trajectory data (left, bottom) will be used to calculate apparent particle density.

C26016
Benefits of Online Thickener Underflow Rheology Measurements
Clean Process Technologies
Noel Lambert

Value: $251,000
Report Expected: 25/09/2018
Industry Monitor/s : Mario Salazar, Naomi Pritchard
ACARP Contact: Nerrida Scott

No report has been received from the researcher.

C27004
Improving Coal Flotation with Oscillatory Air Supply
University of Queensland
Liguang Wang

Value: $217,000
Report Expected: 25/07/2019
Industry Monitor/s : Diego Dal’Molin, Kevin Rowe
ACARP Contact: Nerrida Scott

The objectives of this project are to:
- Demonstrate and evaluate coal flotation with oscillatory air supply at pilot scale;
- Evaluate energy and reagent savings of oscillatory air flotation.

The construction of the pilot-scale flotation column has been completed. The auxiliary parts are ready for use. The entire pilot scale test unit will be evaluated at UQ prior to on-site trials.

A comparative study of bubble size between conventional steady air supply and oscillatory air supply was conducted. The study identified the optimum ranges of key operating variables and examined the relation between flotation performance and bubble size.

C27028
Lab Froth Flotation Testing Guide with Coal Quality
McMahon Coal Quality Resources
Chris McMahon

Value: $29,820
Report Expected: 25/05/2019
Industry Monitor/s : Angus McIntyre, John Kelly
ACARP Contact: Nerrida Scott

This project aims to examine data attained by MCQR in froth flotation across several deposits to define effective reagent dosages for effective froth flotation outcomes and to produce a guide for use with Australian Standards.

Three sample sets are due for review.

MCQR has approval for anonymous review and reporting of the databases held by MCQR and initiated paperwork with one information supplier that is outside the ACARP program to ensure the client remains clandestine as is their wish.
Additional requirement for conditions of emplacement and physical conditions that can occur in coal seams that will affect froth flotation outcomes was stipulated and noted at that meeting.

C27032
Methodologies for Applications of CGA: Handbook

Basacon Services
Bruce Atkinson
Graham O’Brien

Value: $51,422
Report Expected: 25/04/2019
Industry Monitor/s: Angus McIntyre
Chris Urzaa
Morgan Blake
Pam White
Richard Ruddock

ACARP Contact: Nerrida Scott

This project involves formulation of a Handbook that will detail current methodologies for applying coal grain analysis (CGA). It is a follow-on from the series of Industry Workshops held during 2017.

The project involves formal documentation of the methodologies that are used to apply CGA. The outcome will be a Handbook of applications. The Handbook will provide a sound basis for possible future publication as an Australian Standard Handbook for applications of CGA.

The Handbook will also document the methodology for determination of fine coal washability using CGA, and it is anticipated that this method may be able to be incorporated as a new Standard: Washability Determination of Fine Coal (minus 1 mm) under Australian Standard 4156.1. The project has recently commenced.
TECHNICAL MARKET SUPPORT

Major Projects

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

The project includes research to investigate issues identified in relation to the accuracy, repeatability and reliability of the IMSBC Code corrosivity test. ACARP work is closely linked with a Global Industry Alliance addressing similar issues from an international perspective for other cargoes. Research is now complete for coal and other cargoes and has been peer reviewed. Findings and recommendations will be reported to the IMO in September 2018.

The second aspect of the project relates to similar issues of accuracy, repeatability and reliability when testing coal cargoes for self-heating potential as required under the IMSBC Code.

Outcomes and recommendations have been prepared and will be reported to the IMO in September 2018. Peer review of the work has commenced. In the interim, experimental work is continuing.

Metallurgical Coal

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: 25/08/2018
Industry Monitor/s: Kim Hockings, Nick Andriopoulos, Oliver Scholes
ACARP Contact: Dave Osborne

The objective of this project is 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, the analysis of 3D microstructure of coke from Computed Tomography scanning and the analysis of fracture surfaces using fractographic techniques.

All of the analyses are complete and preparation of the draft report is underway. The extension project to analyse a further two coals grind series is also underway.

In the next quarter we plan submit the draft report.

C25042
Mechanistic Model for the Understanding of the Sole Heated Oven

CSIRO
Joan Boulanger
Merrick Mahoney
Richard Sakurovs

Value: $159,105
Report Expected: 25/07/2018
Industry Monitor/s: Graeme Harris, Kim Hockings, Oliver Scholes
ACARP Contact: Dave Osborne

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

C25045
In Situ High Temperature Strength of Low CSR Cokes

University of New South Wales
Pramod Koshy

Value: $190,000
Report Expected: 25/06/2019
Industry Monitor/s: Kim Hockings, Nick Andriopoulos
ACARP Contact: Dave Osborne

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

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: 25/12/2018
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 following has been completed:
- 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;
- Task4 Imaging and image analysis;

The following are being performed in parallel:
- Task 5 Data processing and analysis;
- Task 6 Final reporting and technology transfer.

Calculated data for all cokes were transferred from Excel files to Minitab and combined with data supplied by industry. All the major correlation and statistics parameters have been calculated. In particular, correlations of measured coke characteristics (amount of vitrinite in parent coal blend, MMR, coke strength indices, CSR, MCS etc) with parameters obtained from optical image analysis connected to structural and textural coke characterization were obtained. Inter-correlations of optical image analysis parameters were also studied. Preparation of the final report is under way.

### C25049

**Fusibility of Coal Blends and Behaviours of Minerals in Coking**

**CSIRO**
Merrick Mahoney
Priyanthi Hapugoda

**Value:** $193,020  
**Report Expected:** 25/08/2018  
**Industry Monitor/s:** Kim Hockings, Stephen Brant  
**ACARP Contact:** Dave Osborne

The main objectives of this project are to:
- Understand the fusible reflectance range for major Australian coking coal basins, via the method demonstrated previously. This requires an extension of the number of coals in the database of results;
- Test the fusible range of the coals in a binary blend and investigate the interactions between the components of a blend that change the fusibility characteristics of the individual coals; and to
- Identify the major minerals in the different basins and the way they transform during coking without the need for coal and coke ashing.

To date all the analysis is completed and report writing in progress.

During the next quarter report writing will continue with the draft report to be submitted around end of August.

### 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:** 25/08/2018  
**Industry Monitor/s:** Nick Andriopoulos, Oliver Scholes  
**ACARP Contact:** Dave Osborne

The project is an extension of project C23048, investigation of the links between microstructure development in softening coal and the characteristics controlling coke quality. This project extends the successful outcomes of that previous project.

We will address the questions of how coke structure is formed within the plastic layer during coking and how these structures control strength of the final coke. We will also address 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; and
- Develop some understanding of how different inertinite types can influence structure development by modifying processes in the plastic layer.

The draft report is about 60% complete. It is expected that the submission of the draft report will occur in August.

### C25052

**Concentrating Coke Oven Sized Inertinite Particles: Behaviour in Targeted Coking Blends**

**University of Newcastle**
Wei Xie

**Value:** $91,690  
**Report Expected:** 25/08/2018  
**Industry Monitor/s:** Shaun Booth, 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 Petrographic analysis for fused carbon of coke. The coke oven size
inertinite particles (1.6-2.0 mm) have been obtained by using an upgraded Reflux Classifier.

In previous quarter report, we mentioned that the draft report of this project has been delayed because ALS who was doing fused carbon analysis damaged our coke samples. We re-prepared coke samples with the blends of maceral concentrates and the raw coals, and the coke samples were sent to Pearson in Canada for fused carbon analysis, we have just received the images this week. We are expecting to submit the draft report in early August.

C26039
Nanoporosity in Cokes: Their Origin and Influence on CO2 Reactivity
CSIRO
Mihaela Grigore

Value: $149,756
Report Expected: 25/02/2019
Industry Monitor/s: Kim Hockings, Nick Andriopoulos, Oliver Scholes
ACARP Contact: Dave Osborne

Recent project C24060 found that closed nanoporosity occur in large proportions in cokes, and almost all pores less than 5 nm are closed. The amount of closed porosity in cokes was influenced by the maceral composition of the parent coals. In addition, the study on two cokes and their parent coals suggested that many of the closed nanopores are inherent to the parent coal, even down to nanometer-sized pores.

The aims of this project are to determine the role of nanoporosity in cokes on the gasification rate, establish to what extent nanopores are inherited from the original coal or formed during coking and determine association of closed nanoporosity with macerals in coals.

The neutron scattering analyses of the unreacted and reacted cokes with carbon dioxide to different carbon conversion levels show a significant decrease in the fraction of closed pores less than 100 nm radius at the initial stages of reaction (25% burn-out) (Figures 1 and 2). The fraction of closed porosity (<100 nm) in cokes either decreased or was not significantly affected as the cokes were further reacted to 50 and 75% carbon conversion levels. The fraction of closed porosity greater than 300 nm radius was less affected by coke gasification. This indicates that closed porosity, less than 100 nm in particular, become accessible by CO2 to a different extent between cokes during gasification.

The neutron scattering analyses are still underway. Additional beam time was awarded by ANSTO in September and October this year.

C26040
Fusible Content of Individual Coal Grains and its Application in Cokemaking
CSIRO
Karryn Warren, Merrick Mahoney

Value: $161,640
Report Expected: 25/12/2018
Industry Monitor/s: Kim Hockings, Nick Andriopoulos, Oliver Scholes
ACARP Contact: Dave Osborne

The objectives of this project are to:
- Understand the link between coke oven coal grain composition and coke structure and strength and improve our ability to explain/predict anomalous strength results;
- Help to confirm new insights obtained from C24057 into the links between the size distribution of fusible and infusible macerals and minerals, associations of macerals structures in coke oven feed coal and resultant coke structure and strength;
- Further understand the mechanisms behind why coals from the Rangal Coal Measures have unexpected coking behaviour.
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.

Progress to date:
- Tribological and scratch tests, followed by analysis using a 3D laser scanning microscope, were completed in the last quarter using instrumentation at Zhengyi Jiang’s research laboratories at the University of Wollongong;
- CGA is underway for each of the size fractions for each of the four remaining grinds for coals D and E and size information for each of the fusible and infusible structures will be extracted;
- The CT images of three cokes from each grind of each coal were collected from the IMBL at the Australian Synchrotron. These images have been reconstructed into slices for use in the 3D analysis of the cokes.

In the next quarter we expect to start the 3D image analysis of the microstructure of the cokes and complete the CGA of both coals. Further fractographic analysis will involve the use of an SEM to identify the mechanisms of degradation or damage to the coke, followed by linkage of the findings to the specific coke microtextures and their interfaces. This information will then be linked to the coal grind characteristics.

C26041
Australian PCI Coals Under Industry Scale Conditions of Ironmaking Blast Furnace using 3D Computer Modelling

University of New South Wales
Yansong Shen

Value: $200,000
Report Expected: 25/05/2019
Industry Monitor/s: Chris Urzaa, Morgan Blake, Stephen Brant

ACARP Contact: Dave Osborne

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

C26042
Coal Swelling in PCI Lance Conditions

University of Newcastle
Liza Elliot

Value: $179,500
Report Expected: 25/10/2018
Industry Monitor/s: Chris Urzaa, Jason Nunn

ACARP Contact: Dave Osborne

Swelling of coals in the tuyere lance during pulverised coal injection is expected to occur rapidly and is associated with the sudden exposure to heat emanating from the tuyere / raceway and the heated gas in the blowpipe. This swelling potentially risks the formation of blockages in the PCI lance that could result in a reduction or loss of PCI rate to the furnace. Lance blockage risk increases with increasing PCI rate. Therefore, as blast furnace operators attempt to increase productivity by increasing PCI rates, they will become more concerned with ensuring the selected coals used in PCI do not block the lances of their furnace(s). Many operators use CSN to assess if the selected coal is expected to cause blockages, however CSN is determined at significantly different conditions to those inside the lance. The project aims to investigate the swelling performance of coals in PCI before combustion and determine key parameters for judging the likely blockage caused by swelling of coals within the lance before entering the blowpipe.

Deposition of coal within a tube heated to 1200°C as coal is conveyed under pneumatic transport, as in PCI, is being measured. Calculations and experiments completed without heat have shown that particle flow is consistent and above the saltation velocity. When the tube is heated to 1200°C, significant deposition within the tube occurs for all except one of the coals considered to date. Examples of the experimental data for coals tested are shown in Figure 1.

![Figure 1: Experimental data.](image)

The pressure drop along the tube is a direct measurement of the build-up occurring within the tube. The initial slope of the curve is used as a measure of the deposition for each coal and has been compared with the coals’ crucible swell number (CSN), shown in Figure 2. It is clear from the figure that, on its own, CSN is not a legitimate tool for determining a coals propensity for blocking the PCI lance.

![Figure 2: The slope of pressure drop along the tube with time compared to each coals CSN.](image)

The results are also being compared with CATA (Computer aided thermal analysis) of the coals and indices used to assess coals for transport.

These experiments are presently almost complete. Imaging and assessment of the deposition within the tube using SEM is still to be completed. Delays associated with setting up the experimental rig, mill failures and CATA experimental technique have caused the project to fall behind it proposed project schedule. An additional six months has been requested to allow the project to be completed concurrently with another project.
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: $362,620
Report Expected: 25/09/2019
Industry Monitor/s: Stephen Brant, Tim Manton
ACARP Contact: Dave Osborne

The key objective of this collaborative project is developing further understanding of the degradation of cokes under blast furnace (BF) conditions and methodologies for the characterisation of cokes under simulated BF conditions. The project will study the degradation of cokes made from blends of Australian coals. The methods currently under development in the project will be advanced further by the addition of water vapour to the gas atmosphere in a study of coke gasification and the introduction of CO and H2 to the gas atmosphere in a study of coke annealing.

Progress to date
- Pilot scale coking of the commercial coal blend were completed;
- Conventional characterisations of the commercial battery coke and its matched pilot oven coke were completed;
- Experimental setups for the study of coke gasification with included water vapour in the gaseous atmosphere and annealing with CO-H2-N2 atmosphere were completed;
- Gasification and annealing for commercial battery coke and its matched pilot oven coke were completed; and
- The macro strength, micro strength and crystallinity of two cokes were determined using tensile testing, ultra-micro indentation, XRD and Raman spectroscopy.

Preliminary results indicated that the coke produced in the pilot coke oven showed similar properties compared with its matched commercial battery in the conventional coke testings. Upon gasification and annealing under the simulated BF conditions, the two cokes also showed similar level of crystallinity development and degradation in both macro and micro strength. These results further verified the reproducibility of pilot coke oven to the commercial coke battery.

Next quarter the pilot scale coking of four compartment charge and conventional characterisation of the cokes will be completed. The gasification and annealing of four-compartment charge cokes will be finished in August. Macro strength of cokes after gasification and annealing will be determined using tensile testing in September.

C26044
Physical and Chemical Interactions Occurring Between Macerals During Cokemaking and their Influence on Coke Strength

University of Queensland
Karen Steel
Wei Xie

Value: $149,750
Report Expected: 25/11/2018
Industry Monitor/s: Ashley Conroy, Nick Andriopoulos, Oliver Scholes
ACARP Contact: Dave Osborne

In this project we are attempting to confirm our hypotheses. In particular, we are doing ‘cross-fertilisation’ studies where we mix the inertinite from one coal with the vitrinite from another. To produce maceral concentrates we are attempting to handpick macerals from large chunks. We are using the same analytical techniques of rheometry, DETA and TGA, however, the TGA analysis will be conducted on larger sample sizes to allow better mass transfer to occur within the sample.

This project is a follow on from project C24055 of the same name. In project C24055 we observed interactions occurring and proposed that inertinite plays an important role in volatile release behaviour, and consequently liquid phase behaviour, which has a variety of impacts on behaviour in the coke oven.

We have completed the rheometry tests on all three samples and most of the DETA tests, including the cross fertilisation studies. We have found consistent behaviour in all the systems, whereby the measured viscosity is lower than predicted with the reduction appearing to peak at particular blend ratios. The DETA results also show less volatile release than predicted. It is proposed that inertinite presents a barrier to the flow of volatile matter and therefore traps liquid matter. We are interested in how the properties of the inertinite may influence this, in particular the porous properties, and are now studying the use of 2 additives - graphite powder which contains no porosity and a charcoal containing mesopores. Both powders have a similar particle size of <150 \( \mu \text{m} \). TGA test work is ongoing.

C26045
Mineralogy Effects on the 3D Porosity of Coke

University of Wollongong
Brian Monaghan
Richard Sakurovs

Value: $189,140
Report Expected: 25/08/2018
Industry Monitor/s: Kim Hockings, Oliver Scholes, Tim Manton
ACARP Contact: Dave Osborne

The specific focus of the project 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;
- 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:
- UOW Dr Dong focus is on the 3D modelling;
- All micro CT data have been analysed;
- UOW Ms Jayasekara primary focus is on the experimental work;
- All laboratory work has been completed;
- Currently the report is being finalised and is almost complete. It will be shared with other research partners for comment prior to submission to ACARP.

C26046
Relevance of Maceral Concentrates to Whole Coal Coking Predictions

University of Newcastle
Wei Xie

Value: $69,500
Report Expected: 25/08/2018
Industry Monitor/s: Graeme Harris, Kim Hockings, Oliver Scholes, Dave Osborne
ACARP Contact: 

The first goal of this project is to clarify how to concentrate maceral components from coke oven feed particles combining the reflux classifier and Coal Grain Analysis. The second goal is to examine what maceral concentrates represent in whole coal and the extent of the concentrates and the blends modify industrial fluidity of whole coal. The third goal is to establish the relevance of coal maceral concentrates on whole coal coking prediction. To achieve these goals, this project uses Coal Grain Analysis (CGA) for analysing coal maceral populations and compositions of whole coal, Reflux Classifier feed and products; Reflux Classifier for concentrating coal maceral concentrates; and Gieseler plastometer for evaluating the fluidity of the concentrates in bulk. We completed coal maceral separation for the first two coals in March and April, two cuts of separation for each coal based on CGA results of the raw coals. The first bunch of macerals for CGA analysis was then sent out to CSIRO last quarter. Vitrinite and inertinite concentrates and their blends will be selected and blended for fluidity tests on the basis of the CGA results. Next quarter, we are expecting to get CGA and fluidity tests done in CSIRO and ALS for the macerals from the first two coals, based on these results, we will determine which size of macerals should be tested for the third coal.

C27014
Plastic Layer Formation during Blending of Australian Coking Coals with Weakly Coking and Non-Coking Coals using the UoN 4kg Lab Scale Coke Oven

University of Newcastle
Jianglong Yu

Value: $135,500
Report Expected: 25/10/2019
Industry Monitor/s: Morgan Blake, Sean Flanagan
ACARP Contact: Dave Osborne

The objective of this project is to achieve fundamental understanding of the plastic formation in coal blends during coking, in particular to investigate the interaction of coal particles/grains in the blend from different types of coals during coking and its impact on coke formation and coke quality. The project extends the previous project C24054 which was focused on in-situ investigations of the plastic layers formed from single Australian coking coals. This project will utilise the 4kg lab scale dual-heated-wall coke oven testing rig at the NIER site of the University of Newcastle and try to gain insights into blending strategies in coke plants at steelworks and provide suggestions to blending options in order to reduce the cost of cokemaking using coal blends.

Currently, coking coal sample selection is to be completed and will be submitted to ACARP coal bank through industry monitors. Using coals left from previous project, some preliminary experiments have been carried out and plastic samples have been produced based on a few blending ratios of two coking coals. Synchrotron Micro-CT, ATR-FTIR and NMR are being used for analysis of the plastic layer samples. Currently the data are being processed and we are also awaiting further results from NMR analysis. Once new coals have arrived, project experiments will be carried systematically.

C27017
Influence of Evaluated Temperature on Interface Properties in Blast Furnace and Pilot Oven Cokes

University of Newcastle
Hannah Lomas, Richard Sakurovs

Value: $159,849
Report Expected: 25/10/2019
Industry Monitor/s: Kim Hockings, Morgan Blake
ACARP Contact: Dave Osborne

We have previously demonstrated that techniques used in tribology, ie the science and engineering of interacting surfaces in motion, can be applied to metallurgical coke to better understand the abrasion resistance of their different microtextures, and the strength and properties of the interfaces between these different components. In this current project we aim to apply tribological testing techniques to coke samples at temperatures of up to 950°C in both inert and carbon dioxide atmospheres, in order to determine the abrasion resistance of the different microtextures and the strength of their interfaces at temperatures similar to the top of the cohesive zone in a blast
furnace. We will then use this information to identify steps to help improve coke strength prediction and its resistance to abrasion.

In the last quarter we conducted trial tribological tests using instrumentation housed at Prof Zhengyi Jiang’s laboratories at the University of Wollongong. These tests demonstrated our successful development of a suitable sample preparation method to allow tribological testing of coke samples at elevated temperatures. Moreover, the coke samples were able to be tested at elevated temperatures in the absence of a mounting medium, allowing the results of the tribological tests to be related exclusively to the properties of the coke, and thus the properties of the parent coal(s).

The sample preparation approach included preparation of polished samples of coke mounted in epoxy resin which were thus able to be imaged at high resolution using an optical microscope. This allowed linkage of the coke wear and damage mechanisms that took place during tribological testing to the specific coke microtextures and their interfaces. The next step was to remove the epoxy resin via heat treatment. Two pilot oven cokes with different parent coal properties were tested in this trial, each of which gave different tribological test results. This demonstrated that thetribological test technique used in combination with adapted experimental conditions for testing of the ‘raw’ coke was able to distinguish between cokes, for example, the coefficient of friction value and the severity of the ‘damage’ to the coke surface.

C27031
Evolution of the Pore Structure in Coke and Implications on Coke Strength

University of Queensland
Karen Steel
Merrick Mahoney

Value: $108,050
Report Expected: 25/04/2019
Industry Monitor/s: Kim Hockings, Sean Flanagan
ACARP Contact: Dave Osborne

We are interested in finding the factors controlling pore contraction because the densification of coke plays a key role in strength development. This project follows on from project C23048 and C25051. In the previous projects we found that pore coalescence is not the sole reason for densification. In this project we will determine the extent that applied load plays a role by examining quenched samples subjected to different applied loads. We will use micro-CT to examine samples up to 1000°C to follow pore contraction and densification. We are also examining the extent that the pore structure has preferential pathways.

After establishing methods to study porosity and permeability for coke samples using micro-CT and GEODICT software we have been working on task 1 – test work to study the impact of applied load, viscoelasticity, volatile matter, and inertinite on the process of pore contraction. While this is being completed we will be starting task 2 (search for preferential pathways) in the next quarter and will be getting in touch with industry monitors regarding acquisition of coke samples from box charge tests.

C27036
Understanding of Coke Quality using 3D Immersive Visualisation and Statistical Characterisation of Microstructure Properties

University of Newcastle
Keith Nesbitt
Merrick Mahoney

Value: $92,880
Report Expected: 25/06/2019
Industry Monitor/s: Kim Hockings, Tim Manton
ACARP Contact: Dave Osborne

The project addresses:
• Fundamental and applied understanding to relate properties of cokes to those of the coals from which they are made.
• Effective and consistent characterisation techniques for thermal coals, metallurgical coals and cokes to enable rational market valuation.

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.

The project began in June. A software engineer to support the project has been selected and contract is being processed – it is for two days a week, starting in August and running over the course of the project. Additional high-end graphics hardware has been specified and ordered to support software development and demonstration of outcome. After meeting with monitors it was agreed to focus the project on six specific coals covering a range of vitrinite and rank and coal basins. This data is available from previous ACARP projects.

C27053
Method to Compare Chemistry vs Structure Effects of Fusible Inertinite in Coke Making

CSIRO
Karryn Warren
Merrick Mahoney

Value: $173,196
Report Expected: 25/10/2019
Industry Monitor/s: Chris Urzaa, Tim Manton
ACARP Contact: Dave Osborne

The objective of this project is to demystify coking behaviour of some coals that have similar ranks and maceral composition, but behave differently during coke making. We aim to determine the relationship between reflectance, chemistry, size and fusibility for the different macerals and try to answer the following questions:
• Is there a link between the fusibility of inertinite and its chemistry/reflectance?
--Is there a chemical difference between vitrinite and inertinite structures with the same reflectance?
--Are there differences in aliphatic/aromatic ratios and oxygen functional groups of maceral structures with a range of reflectance values?
--Do these ratios determine the level of reactivity/fusibility of the maceral? Or
--Does the size of the internal component structures within grains, and/or the association of the macerals and minerals within grains, play a role in determining the coking attributes?
--And finally, can these be correlated with the coking attributes?

Progress to date:
--An application for time at the Australian Synchrotron using the Fourier Transformed Infra-Red (FTIR) beam line has been submitted for the FTIR analysis of the different macerals.

In the next quarter we will need to clarify the remaining coals to be included in the project. We will also hopefully have gained access to the Australian Synchrotron for the FTIR analysis of the coals and be able to collect the IR spectra and start analysis. We also plan to start the CGA of the coals.

C27056
Imaging Gas Penetration Inside Coals and Cokes at Nanoscale and Determining its Influence on Coke Reactivity

CSIRO
Merrick Mahoney
Sherry Mayo

Value: $100,935
Report Expected: 25/05/2019
Industry Monitor/s: Graeme Harris, Steve Lempereur
ACARP Contact: Dave Osborne

The aim of this project is to use Xenon gas K-edge subtraction in synchrotron micro-CT imaging for probing the fine scale porosity and gas transport behaviour in coking coals and cokes. This includes investigating the differences in open and closed pore structure at fine scales for a range of coals and cokes and how this varies within coal and coke particles. After characterising the fine pore structure of inerts in coal lumps and IMDC in coke lumps we are relating this pore structure to specific reaction behaviour of inerts by observing changes following reaction in a furnace.

So far we have selected samples and completed the experimental component of the project. Samples of 6 types of coke and one coal have been selected. Initial synchrotron characterisation of the structure of the samples and the transport of xenon gas into these structures has been completed. Following this we reacted the samples in a 100% CO2 atmosphere at 1100°C with the aim of reducing mass by ~20% (actual mass loss varied between specimens). This was followed up by a second round of synchrotron characterisation to observe changes in structure and the xenon gas transport behaviour following reaction. Tomographic reconstruction (the conversion of raw synchrotron data into 3D images) has been completed for around half the synchrotron data collected so far and is ongoing.

The next phase of the project will be to complete 3D image data preparation and then move on to 3D image analysis to compare the structure and gas transport in samples before and after reaction. Currently the project is slightly ahead of schedule due to the fortuitous timing of synchrotron beam-time, however the image analysis is a very substantial component of the project and will be the focus of a major effort in the coming months.

Thermal Coal

C27003
Review of ACARP Research to Support Marketing of Australian Thermal Coal

University of Newcastle
Terry Wall

Value: $102,200
Report Expected: 25/09/2018
Industry Monitor/s: Chris Spero, Kay Palmer, Kerry Atkins
ACARP Contact: Dave Osborne

This project will conduct and coordinate a process to establish issues in the use of Australian thermal coals, and identify relevant previous research and Australian capabilities for thermal coal marketers. The project objectives are to cover the relation of Australian thermal coal quality to performance and operational issues to:
--Assist in defining the 2018 ACARP TMS research priorities to include more specific directions for coal research and technology assessment opportunities for marketing of Australian thermal coal;
--Provide a review of ACARP and other relevant Australian research as a reference document for thermal coal marketers;
--Report relevant Australian thermal coal research capabilities; and
--Suggest priorities and a roadmap for a five-year research program on thermal coal for the TMS.

Drafts of report sections for objectives b and c are being prepared. Discussions on the roadmap have been initiated.

C27029
High Tech Testing Facility for Evaluating Combustion Performance of Thermal Coals and Establishment of Testing Methodology

University of Newcastle
Jianglong Yu

Value: $236,750
Report Expected: 25/12/2019
Industry Monitor/s: Chris Spero, Greg Wickman
ACARP Contact: Dave Osborne

The objective of this project is to develop a high-tech combustion testing facility at the University of Newcastle and to establish a comprehensive testing methodology for evaluating the combustion performance of Australian thermal coals, in particular under HELE coal combustion conditions. Given the increasing needs for Australian thermal coal producers to have
convenient access to such an advanced high-tech combustion testing facility and expertise inside Australia to provide fundamental support to marketing sectors, the construction of such a lab-scale high-tech combustion testing facility at UON will greatly enhance the existing capability to assess combustion performance of Australian thermal coals and provides strong support to the Australian thermal coal industry.

Currently, the research team at UON is undertaking the preliminary design of the combustion rig based on the information of the technical survey on the current R&D status of HELE combustion technologies worldwide, in particular in the countries where Australian thermal coals are sold. CFD modelling of the combustion furnace has been carried out using the CFD modelling to assist the combustion rig design. Once the design has been completed, we will commence the manufacture of the furnace. We have also started the purchase of some analytical instruments including Micro-GC. The site is being evacuated to allow sufficient space for the combustion rig.

C27047
Combustion Characteristics of Australian Export Thermal Coals using Advanced Imaging Techniques
CSIRO
Ed Lester
Silvie Koval

The project objective is to benchmark the combustion characteristics of Australian export thermal coals by:

- Establishing a focused research collaboration between CSIRO and The University of Nottingham researchers based on their complementary imaging capabilities of coal and combustion char and their world expertise in this field. This framework might be expanded in future collaborations between the current partners and Asian research organisations.
- Linking CGA information for coal particles to information acquired by using image analysis methods for char particles to quantify the transformation of different coal grain types (ie pure components and composite particles) to specific char types to gain a better understanding of combustion performance. For selected samples these analysis will also include the identification of the major minerals in the parent coal particles and in the daughter char particles (by incorporating the mineral marker capability developed in C23050). The analysis should compare chars generated in drop tube furnace with real samples from power plants via pyrolysis and refire tests at comparable temperatures and residences times.
- Comparing the results obtained for 5 Australian thermal coals of different ranks with 3 non-Australian thermal coals which are imported into the UK to determine combustion properties.

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

C25044
Trace Elements in Coal: Status of Test Methods in use and Applicability to Industry Needs
QCC Resources
Ian Anderberg

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

C25050
Overview of ACARP and NERDDC Outcomes
CSIRO
Richard Sakurovs

A draft report is with the industry monitor(s) for review.
C25053
Coal Sample Bank

CSIRO
Lukas Koval

Value: $279,329
Report Expected: 25/10/2021
Industry Monitor/s: Graeme Harris, Kim Hockings
ACARP Contact: Dave Osborne

The main objective of this project is to operate the ACARP Sample Bank to make coal and coke samples available to researchers and to enhance the systematic provision of the samples for research projects funded by ACARP.

This project started on 1st March 2017. To date, 33 coal samples were delivered and stored at -18°C and their details updated to the database. Out of 33 stored coals 26 were fully analysed and analysis results provided by the coal producers.

Coal samples missing the samples analysis:

<table>
<thead>
<tr>
<th>Coking coal:</th>
<th>PCI coal:</th>
<th>Thermal coal:</th>
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ACARP Sample Bank coal testing form was updated to follow the standard reporting formats within the industry which are covered by standards. ACARP Sample Bank database was updated to accommodate the changes in the formatting. To accommodate the expanding collection of samples, new refrigerated container will be purchased and installed within July (currently in progress).

Coal and coke samples were provided to the following projects in 2018 were C27017, C26046, C26043 and C27047.

C26037
Australian Participation in Development of ISO Methods for Sampling, Analysis and Coal Preparation and National Technical Committee Support: 2017/2018

Standards Australia Limited
Ahshanur Rashid

Value: $77,500
Report Expected: 25/11/2018
Industry Monitor/s: Kevin Rowe, Kim Hockings
ACARP Contact: Anne Mabardi

SA support for Australian Mirror Committee—Schedule of meetings:

- MN-001 (Coal and Coke)—Mirror Committee for ISO/TC27. Chairman is Barry Isherwood. The next meeting is 26th July, in Sydney.
- MN-001-01 (Coal analysis) – Mirror Committee for ISO/TC27/SC3 and SC5. Chairman is Barry Isherwood. Last meeting was 22nd March in Brisbane, the next meeting is 26th July in Sydney. Meeting objective is 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. The Chairman is Dave Osborne. The last meeting was 12th July at QCAT in Brisbane. The next meeting will be 22nd November, at NIER, Newcastle. The meeting objective is review of ISO/TC27/SC1 and SC4 documents including systematic reviews and finalise Australian mirror Committee position on ISO ballot (and comments). Review update on national Standards and projects.

MN-001-02 Subcommittee has active projects to develop Australian Standards:

- SA HB 102 Guide for Sampling in Coal Preparation Plants, Drafting Leader is Jim Docherty.
- AS 5213 Density tracer testing for measuring performance of coal density separators, Drafting Leader is Chris Wood.
- AS 4156.1.1 Coal preparation, Part 1.1: Higher rank coal-Float and sink testing, Drafting Leader is Michael Campbell.
- MN-001-05 (Coal Mining and Geology), Chairman is Walter Pickel. No meeting planned; Subcommittee has no work program.
- MN-001-06 (Determination of Gas Content). No Chair and no meeting planned; Subcommittee has no work program since publication of AS 3980-2016.

C26003
Management of SA and ISO Coal Technical Committees Work Programs

Carbon Connections
Barry Isherwood

Value: $104,750
Report Expected: 25/10/2018
Industry Monitor/s: Graeme Harris, Kim Hockings
ACARP Contact: Dave Osborne

There has been very little activity in this past quarter regarding SA or ISO activities. A number of SA meetings are scheduled for end of July, including the annual MN/1 meeting. The next quarterly report will include reports from these meetings.
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: Patrick Tyrrell

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 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 CO2 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 the primary aims of:
- Design, construction, commissioning and field trials of a 200 m3/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.

Safety procedures, including hazardous area classification assessment, hazard and operability (HAZOP) studies, risk assessments and internal safety reviews and approvals have commenced. Site specific construction work and the extension of services to the location of the pilot-plant have commenced in preparation for the delivery of the pilot-plant to The University of Newcastle. The project is on track to complete the necessary field trials within the project timeframe.

C26004
CFD Modelling of Reverse Thermal Oxidisers for VAM Abatement

University of Newcastle
Behdad Moghtaderi

Value: $361,520
Report Expected: 25/04/2019
Industry Monitor/s: Donna Dryden
Jim Sandford

ACARP Contact: Patrick Tyrrell

The project outlined in this submission is part of a larger multi-phase program of study aimed at Computational Fluid Dynamics (CFD) modelling of Reverse Thermal Oxidizer (RTO) devices for mitigation of Ventilation Air Methane (VAM). The emphasis however, is not to model the operation of the RTO devices. The aim is rather to determine whether in the event of an explosion within or upstream of the RTO device, the device could reflect the pressure wave and the reaction front sending them back down the mine ventilation shaft, in turn, causing an explosion in the mine itself. Therefore, the principal vision here is to numerically assess the detonation and/or flame arresting properties of RTO devices. In doing so the simulations should create an explosion wave and model its progress as it travels into the RTO to investigate what happens to the pressure wave and reaction front. The relevant research work will be conducted in two phases, namely:
- Phase-I; CFD modelling of ceramic-brick RTO devices;
- Phase-II; CFD modelling of fixed-bed RTO devices.

Phase-I project was completed in early 2018 and a final report was sent to ACARP on 17 April. The emphasis in Phase-II is on fixed-bed RTOs due to the dominance of this configuration in the global supply chain for VAM abatement hardware with several US and European companies marketing their fixed-bed type products to the mining sector. The key outcome of Phase-II will be a versatile and validated CFD model capable of assessing the detonation and/or flame arrestor properties of fixed-bed type RTO devices.

The progress so far has been on track and on budget. The milestone activities undertaken in Q2 of Phase-II project are:
- Milestone Task II – Modify the base-model of an explosion and run this case for the capture duct with no downstream device. This will provide a benchmark giving pressure developed when the explosion vents to atmosphere, completed;
- Milestone Task III – Add a CFD model of the fixed-bed RTO to the base-model and run this case for a variety of upstream and downstream conditions, 60% completed.

The focus of research activities in Q3 will be on completion of milestone task III as well as milestone tasks V and VI (please refer to the long version of the project proposal for details):
- Milestone Task V – Upon approval, perform simulations using the same fuel load as in milestone task IV, completed Q1; and
- Milestone Task VI – Provide a write-up of these cases for peer review and independent assessment.
C27008
Selective Adsorption of Methane by Ionic Liquids

University of Newcastle
Andrew Maddocks
Behdad Moghtaderi

Value: $147,320
Report Expected: 25/02/2019
Industry Monitor/s: Alex Neels, Jim Sandford
ACARP Contact: Patrick Tyrrell

The selective absorption of ventilation air methane (VAM) in ionic liquids has the potential to be a step-change in VAM abatement technology. The absorption process would occur at temperatures less than 200 °C, which is several hundred degrees Celsius less than the autoignition temperature of lean methane/air mixtures. Operating at temperatures less than the autoignition temperature of VAM completely eliminates the safety concerns related to a mine fire or explosion caused by connecting a ventilation shaft to a VAM abatement plant.

The principal vision of this project was to carry out fundamental investigations into the chemistry of ionic liquids and low-concentration methane mixtures and develop a proof-of-concept process for the absorption and desorption of methane using ionic liquids.

To fulfill the above vision, the following objectives were defined:
- Determine the effect of temperature on methane solubility and selectivity;
- Determine the effect of pressure on methane solubility and selectivity;
- Determine the optimal ionic liquid properties for the absorption of methane from low-concentration methane-air mixtures;
- Determine the effect of temperature and pressure on the desorption rate of methane from ionic liquids;
- Evaluate the performance of ionic liquids and undertake a preliminary feasibility assessment; and
- Report the key findings and provide recommendations for advancing the next phases of the program of work.

Tasks to achieve the project objectives and progress to date are as follows.

Task 1. Screening ionic liquids using high pressure thermogravimetric analysis (TGA). This task was completed in Q1 2018 and the results were outlined in the Q1 quarterly report.

Task 2. Selectivity experiments in stirred-tank reactor. Selectivity experiments for single component gases (ie nitrogen, methane, oxygen and carbon dioxide) have been completed at pressures of 1, 4, 6 and 8 bar, and at temperatures of 30 °C, 50 °C and 70 °C. The data obtained from these experiments will be used to compare the ideal selectivity of methane to nitrogen, oxygen and carbon dioxide to the selectivity from a multi-component gas mixture. The experiments for the multi-component gas mixtures are ongoing.

Task 3. Desorption experiments in stirred-tank reactor. Desorption experiments were commenced in Q2 2018. The initial experiments were conducted with 80% methane/20% nitrogen mixtures and focused on refining the experimental procedure to obtain the data necessary to evaluate the desorption rate. These experiments are ongoing.

Task 4. Evaluation of the performance of ionic liquids and project reporting. This task has not commenced.

C27054
Optimisation of a Thermal Flow Reversal Reactor for VAM Mitigation

CSIRO
Jon Yin

Value: $190,173
Report Expected: 25/01/2020
Industry Monitor/s: Alex Neels, Ben Klaassen, Trevor Stay
ACARP Contact: Patrick Tyrrell

Ventilation air methane (VAM) capture, mitigation and utilisation are on-going challenges faced by the Australian coal industry. Throughout the previous ACARP project C19055, CSIRO has developed and demonstrated a novel pilot-scale VAM Mitigator (VAMMIT) with a newly-structured regenerative bed consisting of honeycomb monolith ceramic blocks. This bed also incorporates an innovatively-designed flow diverting section located at the bed centre with connections to a gas burner for easy start-up and a bursting disc for safety management. The technology has been fully proven feasible through pilot-scale prototype unit development, experiments at CSIRO laboratories, and site trials with actual VAM at an Australian coal mine. The VAMMIT unit is the first of its kind in the world, possessing significant advantages (ie less dust deposition, less footprint and lower energy consumption) over other packed bed mitigators.

This project aims to optimise the VAMMIT thermal oxidiser through design calculations and CFD simulations to achieve lower pressure drop, higher methane oxidation efficiency, and stronger dust deposition and corrosion resistance. The project will also investigate the feasibility of a catalytic VAM mitigator to operate at much lower temperatures (~450-700 oC) to completely avoid stone dust decomposition and at lower methane concentrations (≥0.2%). The specific objectives are:
- Optimisation of the honeycomb bed structure of VAMMIT;
- Optimisation of operating parameters of VAMMIT;
- Feasibility study of a new catalytic version VAMMIT; and
- Investigation of safety management associated with VAMMIT.

Preparation is underway to develop a 3-D CFD model for optimisation of the honeycomb bed structure of the VAMMIT unit.
Ventilation air methane (VAM) is one of the major greenhouse contributors associated with mining. In order to decrease the environmental impact, it would be advantageous to convert the methane to carbon dioxide (decreasing the green house potential by a factor of 13), however the methane concentration is well below the flammability range preventing flaring. It has been shown previously that catalysts can be used to convert more than 90% of the low concentration methane. To examine the potential for a continuous catalytic VAM abatement system, a lab-scale reactor has been designed and constructed to measure the performance of catalysts for the oxidation of methane in very low concentrations in air, with the reactor was commissioned and tested under typical conditions. Catalysts with the potential for VAM mitigation which have been previously identified have been sourced, with 1.2 wt% palladium loaded onto an alumina. Initial experiments utilising 100 mg of catalyst loaded into the reactor have shown that initial performance can be achieved after partial deactivation when the catalyst is exposed to a dry air stream.