AUGUST 2019

CURRENT PROJECTS

This report is a summary of current projects for the months May, June and July 2019
ACARP CONTACTS

PROGRAM MANAGEMENT
Australian Coal Research Limited
Level 5, Suite 18
Christie Centre
320 Adelaide Street
Brisbane Qld 4000
Phone: 07 3532 4077

Ian Neill
Executive Director
ian@acarp.com.au

Terry Reilly
Levy Administrator
terryr@acarp.com.au

PROJECT ADMINISTRATION
Australian Research Administration Pty Ltd
Level 12, 167 Eagle Street Brisbane Qld 4000
PO Box 7148 Riverside Centre Qld 4001
Phone: 07 3225 3600

Anne Mabardi
anne@acarp.com.au

Patrick Tyrrell
patrick@acarp.com.au

Nicole Youngman
nicole@acarp.com.au

RESEARCH COORDINATORS
Peter Bergin
Underground NSW
peter.bergin@optusnet.com.au

Cam Davidson
Open Cut – Mining
cam@cwrld.com.au

Ashley Conroy
Technical Market Support
ashley@ashleyconroy.com.au

Nerrida Scott
Coal Preparation
nscott@neluca.com

www.acarp.com.au

DISCLAIMER
No person, corporation or other organisation ("person") should rely on the contents of this report and each should obtain independent advice from a qualified person with respect to the information contained in this report. Australian Coal Research Limited, its directors, servants and agents (collectively "ACR") is not responsible for the consequences of any action taken by any person in reliance upon the information set out in this report, for the accuracy or veracity of any information contained in this report or for any error or omission in this report. ACR expressly disclaims any and all liability and responsibility to any person in respect of anything done or omitted to be done in respect of the information set out in this report, any inaccuracy in this report or the consequences of any action by any person in reliance, whether wholly or partly, upon the whole or any part of the contents of this report.
### 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:** August 2019
- **Industry Monitor/s:** Coal Burst Task Group
- **ACARP Contact:** Patrick Tyrrell

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

---

**C26006**

**Coal Burst Monitoring Technology Using Microseismicity**

*CSIRO*

Xun Luo

- **Value:** $230,500
- **Report Expected:** August 2019
- **Industry Monitor/s:** Coal Burst Task Group
- **ACARP Contact:** Peter Bergin

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

---

**C26053**

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

*CSIRO*

Baotang Shen

Ismet Canbulat

- **Value:** $275,520
- **Report Expected:** August 2019
- **Industry Monitor/s:** Coal Burst Task Group
  
  Patrycja Sheffield
  
  Sharif Burra

- **ACARP Contact:** Peter Bergin

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

---

**C26054**

**Modelling of Dynamic Fracture Mechanisms**

*University of Wollongong*

Gaetano Venticinque

Jan Nemcik

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

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

---

**C26060**

**Mechanics of Gas Related Coalbursts in Mining**

*SCT Operations*

Winton Gale

- **Value:** $273,750
- **Report Expected:** September 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.

Progress in the project has discussed with industry experts during a workshop meeting in November 2017. Work has been undertaken to understand the role of micro fabric in the burst process. The results to date indicate that the energy available form 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 and the results have been presented at the Ground Control Conference in Morgantown 2018.

A review of possible rapid gas desorption via networking of micro fabric has been undertaken. It is considered that the nature of the micro fabric within the coal is an important factor in the desorption rate under appropriate conditions. The project is in the early stages of reporting.
C26062
New Outburst Risk Determination Measures Along With Data Gathering and Analysis for Coalburst Assessment

Sigra
Jeff Wood

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

No report received.

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: September 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 seismic energy, strain energy, and gas expansion energy. The project seeks to identify the mechanics of the process and provide a better understanding of the risks, as well as to suggest means of predicting and preventing such coal burst events.

Quantification of energies within rock mass has been completed. An independent final report on the findings of SCT has been submitted to ACARP. UNSW will be submitting the final report within next 4 weeks.

C27020
Coal Bursts and Pillar Burst in Deep Mines

University of Adelaide
Murat Karakus

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

This project will provide new, fundamental knowledge on the damage evolution of coal material leading to coal burst. The Influence of confinement and deconfinement on the overall mechanical behavior of coal inducing coal burst have been investigated. The specific aims of the project are as follows:

- Develop an experimental methodology to investigate the deconfinement influence on coal burst;
- Develop qualitative and quantitative damage assessment processes to define pre-peak and post-peak mechanical behaviour of coal at high pressure by using acoustic emission;
- Develop a damage mechanics based plasticity model for coal accounting localization nature of failure and size effects in coal;
- Forecast coal burst by large scale mine layout simulation.

A total of 20 specimens were prepared for testing in the true-triaxial apparatus in China University of Mining and Technology Beijing. These were then carefully packaged and shipped to China for the start of coal burst testing at the end of May 2019. The first tests conducted were to determine the in-situ pressure required for the coal to burst shortly after excavation is made. Once the in-situ pressure was placed on the specimens by proportional loading, the free face platen was dropped and the principal and intermediate principal stresses were increased simultaneously at 0.25 MPa/sec. During these initial tests the in-situ pressure required to cause near instantaneous burst after platen unloading was found to be $\sigma_1 = 12$ MPa, $\sigma_2 = 9$ MPa and $\sigma_3 = 6$ MPa. Then using this in-situ stress level, specimens with different pre-conditioning holes drilled into the surface as shown in Fig. 1 were tested to see the effect of pre-conditioning magnitude and direction on the bursting behaviour of the coal.

![Fig. 1. Rectangular coal specimens with de-stressing holes and true-triaxial loading path](image-url)
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: October 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 rib side.

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 have been sourced for testing and sent to Curtin University. Initial results have been reported and more will be reported shortly. The results are very interesting and indicate the application of this testing approach to understand the full rock failure criteria.

C27041
Ground Support Requirements in Coal Burst Prone Mines

University of New South Wales
Ismet Canbulat

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

The objectives of this project are to:
• Review the international best-practice ground control systems in burst prone mines;
• Evaluate and characterise ground support principles and considerations;
• Assess yielding support technologies and determine the energy absorption requirements for the ground support systems for coal burst control;
• Identify engineering principals and failure mechanisms of yielding support; and
• Establish functional requirements of appropriate and effective ground support technologies for coal burst control that are in line with Australian experience, regulations, mine design, and operational practices.

Work undertaken since the last report includes:
• A review of the ground support systems that are used in rock and coal burst conditions;
• Energy absorption capacities of various yielding bolts have been collated;
• A risk-based approach has developed to identify the risk categories (ie risk zoning) in development and longwall faces;
• The framework for coal burst management plan, which was proposed as part of C25004, has been updated to reflect the new risk-based approach.

The project is progressing within its anticipated timeframe.

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: April 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 (DOFS) 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.

A comprehensive field trial on DOFS will be conducted at a coal mine in New South Wales for three to four weeks, starting from July 25, using a conventional multi-core fiber cable with total sensing length of more than 5km. The sensing network is composed of two large aperture fiber antennas on the ground surface above a longwall panel being mined and one vertical antenna in a 300m deep borehole to record microseismic activities generated from longwall caving process. Four geophones will be installed in the borehole and on the ground surface next to the fiber cable for investigating the DOFS sensing sensitivity.
C27060
Damage and Risk from Seismic Events

SCT Operations
Richard Lynch
Winton Gale

Value: $435,000
Report Expected: May 2020
Industry Monitors: 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 three geological sites;
• 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. Site work has been initiated and the monitoring array is in the process of being installed and monitored.

Study of source mechanisms effects on wave patterns has been undertaken. The effect of different velocity models is currently being undertaken.

Work on the nature of seismic waveforms from different fracture surfaces has been undertaken to assess the effects of wave form on damage to ribsides. The effect of such waveforms on roadway stability is also planned for the next quarter in particular the effect of a seismic energy source close to a roadway.

A micro seismic monitoring site has been installed and data is being collected.

---

C28009
Advanced Fracture Propagation and Rupture Testing of Coal Measure Rocks Under Dynamic Condition to Replicate Coal Burst

Monash University
Amin Heidarpour

Value: $287,500
Report Expected: November 2021
Industry Monitors: Coal Burst Task Group
ACARP Contact: Peter Bergin

The objectives of the project include:
• Extensive literature review of all available experimental data and classification of them based on the associated mechanical properties;
• Characterisation of the supplied coal by conducting uniaxial and triaxial compressive tests; point load test; Brazilian test; fracture toughness test; cyclic test and slake durability test;
• Petrography analysis of coal including XRD and XRF;
• Advanced testing including true triaxial stress unloading and dynamic testing on the supplied coal;
• Examination of the water effects on coal samples; and
• Investigation of the size-dependent behaviour of coal under stress unloading and high energy impact testing condition.

To date, the work undertaken includes:
• The literature review on the fracture behaviour of coal under static and dynamic loading conditions has been commenced;
• Discussions have been conducted with senior industry consultants about the research approach and specifically on characterisation of testing program;
• One PhD student was appointed to the project who has commenced developing predictive models to simulate the fracture behaviour of coal. One more PhD student will join the team by the end of July 2019;
• The static testing program is progressing on coal samples sourced from Illawarra area while currently the team is working on coring as many samples as possible from the provided blocks;
• The team is communicating with other areas to obtain more coal blocks; and
• The team is conducting the essential initial study on the development of dynamic testing program and more importantly unloading testing condition under true triaxial testing regime.
C28012
Coal Micro Fabric as a Trigger for Coal Bursts

SCT Operations
Winton Gale

Value: $215,000
Report Expected: March 2021
Industry Monitor/s: Coal Burst Task Group
ACARP Contact: Peter Bergin

Under the appropriate stress and gas pressure microfractures can propagate to form closely spaced macrofractures commonly associated with bursts. Such fracture fabric has the potential to liberate large quantities of gas related energy stored in the coal. Similarly coal with high pore volume relating to igneous effects and fracture volume can liberate significant amounts of energy which can induce a coal burst. The aim of this project is to identify the nature of microfabric in coal around structures such as dykes and faults relative to ‘normal’ unstructured coal, 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.

The objectives of the project are to:
• Determine the nature of micro fracture formation in “normal coal” and that about the structures targeted in the study;
• Assess the effect of other aspects of the micro fabric such as coal pore structures and coal macerals / lithotypes;
• Simulate the effect of such micro fractures found with regard to burst mechanisms;
• Test the validity of the current research outcomes regarding the trigger mechanisms; and to
• Provide a much better understanding of the structural regimes which are likely to be burst prone in a mine.

Samples of coal adjacent to dykes and faults have been collected and will studied by an optical microscopy to determine the microfabric and porosity. Samples of areas of difficult drilling have also been tested in this manner. It is proposed to study these effects in two mines. CT scanning will also be used to study microfabric and compare with the results of microscopy.

Work has been undertaken to understand the role of micro fabric in the burst process. The results to date indicate that the energy available form 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 and the results have been presented at the Ground Control Conference in Morgantown 2018.

A review of possible rapid gas desorption via networking of micro fabric has been undertaken. It is considered that the nature of the micro fabric within the coal is an important factor in the desorption rate under appropriate conditions. The project is in the final stages of reporting.

Detection and Prevention of Fires and Explosions

C28013
Use of Compressed Air Foams (CAFs) to Alter Goaf Air Circuits and Mitigate Spontaneous Combustion Events

Mines Rescue
Clive Hanrahan
Matthew Fellowes

Value: $392,500
Report Expected: February 2020
Industry Monitor/s: Bharath Belle
David Webb
Paul Wild
Peter Baker
Rae O’Brien
Sharif Burra
ACARP Contact: Patrick Tyrrell

There have been some internal issues and delays with making the first 30% down payment for the CAF’s foam generator with payment now scheduled before the end of July. The equipment is on hand and is ready for despatch from Germany. Equipment is expected in Australia by October. Max Stottner is planning on attending the trials from Germany but is not available until after 3rd November.

Unfortunately we will miss the intended trial window at mine 1 which was originally targeted for the September LW relocation. In consultation with the mine 1 management, an alternate site now appears more favourable. In principal support has been given to hold the trials at an alternate underground mine. Mine 1 is still available as an option if needed.

Factors supporting this decision include:
• The significantly higher ventilation pressures and quantities around the mine 2 longwall circuit; and
• High natural CO2 goaf make that will allow more responsive gas monitoring for readily monitorable gases – namely O2 and CO2 and CO make. This will provide indication of influence and capability of altering goaf micro-circuits by strategic placement of high expansion foam plugs.
The monitoring trial program was discussed at an impromptu monitors meeting at the recent MMAA conference at Caves Beach. An opportunity was taken to discuss the project elements with Ting Ren and Jiangmin Wu (a Chinese spon com expert). In attendance during the discussions was David Webb, Rae O’Brien, Shane Pegg and Matthew Fellowes. Some of the discussion points included the use of tracer gas to monitor effects and the benefits of CFD modelling and the limitations of gas monitoring equipment. The mine 2 has natural high specific emissions and oxidation rates that will allow the tube bundle system to provide effective monitoring. This is proposed to be used with other more pragmatic and subtle monitoring methodologies – like the movement in exit path and change in discharge rate of goaf streams etc.

The base monitoring plan is still proposed but subtle variations and enhancements are likely to be made in the field – utilising the combined experience of the researchers and industry monitors.

In summary, the trials are likely between November and January dependent upon the availability of key research personnel and the host mine. The rest of the project plan would then follow as previously indicated.

Environment - Subsidence and Mine Water

C20038
Standardised Subsidence Information Management System

NSW Department of Industry
NSW Department of Planning & Environment

Gang Li

Value: $655,000
Report Expected: June 2019
Industry Monitor/s: Dan Payne, Phil Enright
ACARP Contact: Peter Bergin

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

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: August 2019
Industry Monitor/s: Bernie Kirsch, Gary Brassington
ACARP Contact: Patrick Tyrrell

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

Environment - Subsidence and Mine Water

C25056
Change Detection in Complex Vegetation Communities

Biosis
Andrew Fletcher
Richard Mather
Tony Cable

Value: $274,700
Report Expected: September 2019
Industry Monitor/s: Bernie Kirsch, Gary Brassington
ACARP Contact: Patrick Tyrrell

The requirement to pool data when using small UAVs is consistent across data capture, processing and classification. The complex nature of native vegetation targets create variable outputs however high accuracy and precision is possible when separate imagery sets are combined. Geolocated field photos with notes provide sufficient information to allow training of classification algorithms although fixed transect intercepts are also suitable. The interpretation of dense point clouds improves the determination of community boundary by several fold over traditional air photo interpretation reducing uncertainty to less than 2m. Bare ground and senescent vegetation are classified with near 100% accuracy using an ensemble of classification algorithms. Eucalyptus classification and detection is improved when multiple imagery sets are combined. We have developed a tool box that undertakes pre-processing, classification and full confusion matrix that provides consistent and transparent reporting of community condition and change. This approach has been demonstrated at sponsor sites.

The final sections of the final report are nearing completion. Draft versions have been reviewed by project monitors.

C27052
FO-RO Site Trial at Newstan Colliery

CSIRO
Ramesh Thiruvenkatachari

Value: $393,270
Report Expected: January 2020
Industry Monitor/s: David Randall, Jason Fittler, 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. 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). This 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 FO-RO prototype test unit has now been constructed. Control system and instrumentation programme have been developed. Project review meeting and test unit inspection was carried out on 14th June. Representatives from the mine inspected the test unit and the mechanical and electrical specifications. The constructed test unit was found to meet mine site requirements. Some minor modifications recommended have been carried out. Currently tests are being conducted to evaluate the membrane specifications. The pilot unit is planned to be transported and installed onsite in the next quarter. Major infrastructure required for on-site installation of the test unit are available.

C27059
Swamp Hydrology Modelling for Advancing Rehabilitation Planning and Management

University of Queensland
Mandana Shaygan
Neil McIntyre
Thomas Baumgartl

Value: $197,800
Report Expected: March 2020
Industry Monitor/s: Bernie Kirsch
Gary Brassington
Peter Corbett
Patrick Tyrrell

ACARP Contact: Patrick Tyrrell

This project aims to examine the resilience of Temperate Highland Peat Swamps on Sandstone (THPSS), in response to changes in soil moisture content induced by underground mining activities and climate variability. This study also aims to develop a hydrological model that can predict soil moisture variability under a range of swamp conditions.

A stepwise approach is being adopted for the monitoring and modelling of variations in the soil moisture content of swamps in mine sites one and two. For mine site one, soil moisture sensors are being (July) installed at five different soil depths (0.1, 0.25, 0.5, 0.75, up to 1.5 m) at four monitoring sites in two swamps. Soil samples are also being collected from the same locations and depths (up to 0.75 m) to determine soil hydrological characteristics. To investigate the response of plant species to the current moisture conditions of swamps, the leaf water potentials of plant species located around each monitoring station are being measured using a pressure chamber. At mine site two the project is relying on the soil moisture sensors that have been installed historically by the mine company. To supplement these data, in particular to allow calibration of a soil hydrology (HYDRUS) model, soil samples were collected from six locations (within four swamps) from mine site two up to a depth of 0.75 m. These samples were analysed for gravimetric water content, soil water retention characteristics, hydraulic conductivity, organic matter content and bulk density. Initial calibration of the HYDRUS model has been done for mine site two. The next steps are to advance the calibration and validation of the HYDRUS model for mine site two, and to analyse the soil hydrological characteristics of mine site one.

C28004
Monitoring Hydrological Status of Complex Upland Heath Communities Using Canopy Conductance and Thermal Imaging

Queensland University of Technology
Andrew Fletcher

Value: $200,264
Report Expected: August 2020
Industry Monitor/s: Bernie Kirsch
Gary Brassington

ACARP Contact: Patrick Tyrrell

This project is just beginning after some delays in processing contracts, but should now progress within the newly proposed and agreed timeline.

C28024
Optimisation of Water Management for Coal Mines - Water Tracer Tools

Deakin University
Wendy Timms

Value: $296,100
Report Expected: March 2021
Industry Monitor/s: Peter Corbett
Steve Downes

ACARP Contact: Patrick Tyrrell

The water tracer project is underway, with our efforts currently concentrating on reviewing tools that can optimise water management for coal mine operators, as well as preparing for site works. The project is in its first six months, with a new research fellow and a new PhD student having been successfully appointed. During June, the project leader and the new research fellow visited Sites A and B to discuss priorities with the mine operators to focus our water tracer work. In response to these discussions, our work at Site A will focus on establishing potential hydraulic connectivity between surface waters and wetlands, and that of the underlying shallow aquifers and deeper groundwater systems. Our work at Site B will be focus on potential hydraulic connectivity between deep groundwater systems and a locally important groundwater discharge area. Water sampling and tracer work at both sites will be leveraging regular water monitoring plans. Data compilation has
commenced and is currently awaiting additional water chemistry data from both sites. Meanwhile, review of available and suitable water tracers is continuing, along with meetings with ANSTO, to draft a tracer sampling plan for consideration by site personnel. In addition, work has commenced on a decision-making tool by which mine operators will be able to carry out selected tracer studies when needed to boost the confidence in water studies for regulators and the community. This project will demonstrate the application of suitable water tracers including stable isotope tracers that are not yet commercially available and that which complement physical water methods, empirical predictions and numerical modelling.

**C28028**  
Inclusion of High Interest Native Plants in Mine Site Restoration Programs: Propagation, Translocation and Field Reintroduction  
Royal Botanic Gardens and Domains Trust, Sydney  
Cathy Offord

| Value: | $318,500 |
| Report Expected: | April 2022 |
| Industry Monitor/s: | Bernie Kirsch, Gary Bragginton |
| ACARP Contact: | Patrick Tyrrell |

This project continues the extensive research on restoration of *Persoonia hindii* and *Persoonia hirsuta* carried out in project C24013. Both plant species are listed as Endangered and occur on mining lease. The overarching objective of the project is to successfully translocate and monitor multiple populations of both species in offset and rehabilitation areas. Research will be conducted in parallel with the translocation work, with a strong focus on understanding the seed biology and reproductive system of both species.

Following preliminary translocation trials of 128 *P. hirsuta* and 280 *P. hindii* plants in May, post-planting monitoring has been conducted over winter with no plant deaths recorded. These translocations will be monitored throughout the project. Work has commenced to propagate more *P. hindii* plants from cuttings for subsequent translocations with 842 cuttings processed in the nursery. Vegetative cuttings were collected from eight populations spread throughout the known distribution in attempt to capture greater genetic diversity. We have conducted a number of trials aimed at improving the strike rate of cuttings of both species, with results still to come. Field sampling for genetic analysis of *P. hirsuta* has been completed with leaf sample processing underway. The next major steps of the project are to collect fruits over spring and summer for further seed biology studies, conduct pollinator observations, and investigate the susceptibility of *P. hindii* to *Phytophthora cinnamomi*.

**C28030**  
Reducing Brine Volume through Membrane Distillation Crystallizer  
CSIRO  
Ramesh Thiruvenkatachari

| Value: | $214,350 |
| Report Expected: | December 2020 |
| Industry Monitor/s: | David Randall, Jason Fittler, Paul O'Grady |
| ACARP Contact: | Patrick Tyrrell |

This project aims to investigate the proof-of-concept in applying membrane distillation (MD) process coupled with a crystallizer to concentrate hypersaline brine to reduce the brine volume for disposal and increase water recovery. The optimum operating parameters for the membrane distillation crystallizer, including the extent of brine concentration are to be identified. A preliminary economic evaluation will also be carried out.

The design information for the crystallizer is being collected. Sample water required for testing was received from the mine. The brine characteristics are being analysed.

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

| Value: | $374,000 |
| Report Expected: | March 2020 |
| Industry Monitor/s: | Cheryl Miffin, Heather Schijns, Paul O'Grady |
| ACARP Contact: | Patrick Tyrrell |

This is an extension project that builds on the recently completed stage 1 which focused on an evaluation of the algorithms developed in C22016 for the detection of small faults. It demonstrated that about half of the small faults (< 1m) mapped from mining that were not detected by reflection seismic data analysis, could be associated with extracted diffractions. This clearly illustrates that diffraction imaging adds value to the reflections and warrants the further development of the diffraction imaging technique to make it applicable to a complex geological environment. This extension project aims to improve the current algorithms to work with dipping or gently folded coal seams; to expand the algorithms to work with 3D seismic surveys; and to develop validated interpretation workflows that add
confidence to the interpretation of small structures and avoid false positive fault interpretations.

After the development and demonstration of the new diffraction extraction algorithm for 2D seismic data in complex geological environments, the project team has completed basic implementation of the new algorithm for 3D seismic data in the last quarter. The new 3D algorithm will be refined and tested on the 3D seismic datasets from the supporting companies of this project in the next a few of months.

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: | May 2020 |
| Industry Monitor/s: | John Terrill, Roger Byrnes |
| ACARP Contact: | Peter Bergin |

The main objective of this project is to use the sonic logging to extract the poro-mechanical responses of the coal seam at in situ condition and predict stress redistribution as a result of degassing. As part of the project, the effective stress law of coal was redefined using non-equilibrium thermodynamic concept and Biot coefficient of coal with sorbing gas (so-called Pseudo-Biot coefficient) was derived. It was also shown that the bulk modulus obtained from sonic measurements is relatively insensitive to type of gas and therefore the percolation theory was used to identify the solid bulk modulus to predict the Biot coefficient of the coal at field scale. We are currently investigating the effect of single fracture on acoustic responses of the rock to study the cleat anisotropy from wave propagation point of view (Fig 1). The preliminary results showed that wave velocity is the fastest when the fracture is horizontal (parallel to the direction of wave propagation) followed by 45 degree and then vertical fracture. This is a promising trend emphasising that the cleat major direction might be identifiable from sonic data when the compressional and polarised shear wave are recorded.

Figure 1. Wave propagation in elastic solid with a fracture filled with gas a) no fracture, b) horizontal fracture, c) fracture at 45 degree and d) vertical fracture

C27057
Automated Structural Mapping using a Mobile Laser Scanner

University of New South Wales
Simit Raval

| Value: | $108,146 |
| Report Expected: | January 2020 |
| Industry Monitor/s: | Brian Vorster, Roger Byrnes |
| ACARP Contact: | Patrick Tyrrell |

The main objective of this project is to evaluate a mobile laser scanner for routine mapping of underground mine environments and embedded structural features. Large-scale 3D point cloud data collected using a mobile laser scanner in an underground coal mine environment begins to drift from actual locations due to errors incurred in inertial sensor measurements while scanning and also due to the lack of discriminative features in underground coal environment. We are now addressing this drift problem by changing the scan environment and improving the point cloud processing algorithms. These measures will help in correcting the generated 3D map and aligning multi-temporal datasets (known as data co-registration) in a common reference frame for change detection.

During this quarter, the second set of data collection was completed from the mine site. A total of three pair of datasets were collected strategically to cover various geometrical and operational possibilities at the mine site. The length of the scan varied from 700 m to 3 km with larger scan captured in vehicle mounted mode and shorter scan in handheld mode. A large amount of drift was observed for a longer distance scan. The post processing technique and data collection strategy were amended and enhanced for vehicle mounted mode. The results obtained after applying our improved processing technique is promising and helps in reducing the mapping error (See Fig)

Fig. Reducing mapping error by improving data acquisition and processing
C28031
Longwall Geological Risk Minimisation using Advanced Electromagnetic and Sonic Technologies

CoalBed Energy Consultants
Scott Thomson

Value: $178,750
Report Expected: February 2020
Industry Monitor/s: Eric Battig, Owen Salisbury
ACARP Contact: Patrick Tyrrell

This project aims to integrate geophysical exploration data provided by both electromagnetic and sonic technologies (the Radio Imaging Method (RIM), v6 and In Seam Seismic (ISS) Summit II System respectively). These technologies should provide a unique evaluation of geological integrity within a longwall panel prior to mining. Integrating the latest versions of these technologies has never been tried before. Both proposed methods have been used only sporadically and in isolation in Australian coal mining and for disparate reasons, are underutilised and poorly understood by most operators.

Geological surprises that halt or slow longwall production are still relatively common in Australian coal mining and may have severe financial consequences for an operation. This is despite the benefit of development driveage from both sides and, in many cases, extensive inseam drilling. There is a need to apply modern scientific technologies and analytical techniques to the problem and provide operators with an accurate assessment of geological risk prior to the commencement of the longwall.

Surveys are planned to be undertaken at a New South Wales underground mine in August/September, with preliminary results available by end September. A suitable site has been selected which has a range of geological features that will provide an excellent test for the equipment and should provide valuable information to the participating site. DMT of Germany will be undertaking the ISS survey, and are currently preparing equipment for shipping to Australia. CoalBed Energy Consultants will be conducting the RIM survey. Project development meetings with the site are ongoing in preparation for the imminent start of the surveys.

Health and Safety

C24009
Establish ‘At Risk’ Distance from Hydraulics

University of New South Wales
Gary Nauer

Value: $26,908
Report Expected: September 2019
Industry Monitor/s: Paul Gill
ACARP Contact: Patrick Tyrrell

Awaiting availability of lab time and input from UNSW.

C24010
Proximity Detection Systems Specification for Underground Coal Mining Machines

Simtars
Andre De Kock

Value: $565,988
Report Expected: November 2019
Industry Monitor/s: Brad Lucke, Glenn Owens, Peter Nelson
ACARP Contact: Patrick Tyrrell

The objectives of the project are:
- Develop a proximity detection system specification and minimum acceptance criteria for the underground coal mining industry;
- Determine the gap between the specification from the coal mining industry and the performance of systems offered to the industry by proximity detection system manufacturers; and
- Determine if future developments by the proximity detection manufacturers will address the specification from the coal mining industry.

At the project start meeting it was decided to add a literature (state of the art) review to the project. The aim of the literature review was to document:
- The status of suppliers, and their systems involved in the original stage of the project; and
- Identify any new entries into the underground coal mining proximity detection arena.

The base data collected during the workshop on the 16th and 17th April were processed. The data were grouped into the major areas of equipment, organisational factors, processes and additional information. Each of the major areas were subdivided into a number of focus areas. Similar or equivalent information in the focus groups were weeded out. The remaining information was transferred to a mind map. The mind map forms the basis for the interview questions being developed. During the next phase of the project the interview questions will be completed and the initial interviews conducted with mine personnel and proximity detection equipment suppliers.
C26047
Real Time Dust Monitor

University of New South Wales
Charles Harb
Duncan Chalmers

Value: $184,300
Report Expected: September 2019
Industry Monitor/s: Bharath Belle, Brad Lucke
ACARP Contact: Peter Bergin

Some anomalies in the data have arisen in writing the final report and with the concurrence of the industry monitors the initial draft report is hoped to be written in August.

C26048
Improving Respirable Coal Dust Exposure Monitoring and Control

University of Queensland
David Cliff
Mark Shepherd
Nikky La Branche

Value: $250,000
Report Expected: September 2019
Industry Monitor/s: Bharath Belle, Peter Smith
ACARP Contact: Patrick Tyrrell

The project objective is to improve the Australian coal mining industry 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 to all ACARP contributing coal mines;
- Evaluation of current dust control techniques;
- CFD analysis - firstly, of air/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;
- Measurement of dust concentrations after the implementation of the new systems and comparison with previous dust levels.

There has been a delay in part 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. The problems with one of the respirable dust sampling heads has led to the need to re-evaluate the monitoring data to see what adjustment to the dataset is required. It was agreed by the industry monitors that the report needed to be comprehensive and a slight delay was in order if this could be achieved. In addition there has been an additional workshop occurred in November 2018 in conjunction with DNRME to discuss the future research needs and planning is well in hand to take particulates research forward. Contact: David Cliff: d.cliff@mishc.uq.edu.au

In the next quarter the final report will be submitted in draft form including:
- The literature review;
- Analysis of the exposure data collected from DNRM and Coal Services including comparison of different sample flows on cyclone elutriator and potential impact of proposed changes to exposure standards for coal and silica;
- Results from exploratory particle size and chemical analysis will be completed; and
- Results of exploratory study looking at a range of monitoring devices.

C26065
Dustless Longwall and Development Face

University of Wollongong
Peter Wypych

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

The objective of this project is the development of ‘dustless’ mining operations in two key areas - longwall and development face. For both areas 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/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;
- Measurement of dust concentrations after the implementation of the new systems and comparison with previous dust levels.

Work in the past quarter has included:
- Discussions with OEMs and two mines – to gain support for miner dust suppression trials;
- Mine 1 showed interest in modifying a new miner but then declined due to possible delays;
- Mine 2 showed interest with one miner but then changed to another miner due to revised overhaul schedules – work is being scheduled currently (in liaison with OEM);
- Continuation of 3D-CAD/CFD modelling of development phase of project; and
• Preliminary design of system to suit miner for specific mine.

In the next quarter it is aimed to:
• Finalise proposed system for continuous miner dust suppression;
• Testing of new high pressure booster pump (underground compliant) for application on continuous miners;
• Install system on miner and conduct above ground trials (by October, as advised by Mine 2);
• Based on discussions with Mine 2, the proposed miner that the system will be installed on is likely to be in operation by December at which point testing will be conducted.

C27007
Assessment of Pyritic Coal Dust Induced Pneumoconiosis

B3 Mining Services
Basil Beamish
Graeme Zosky

Value: $93,000
Report Expected: October 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 additional laboratory testing has been completed and the project leaders met in Hobart in early July to formalise the reporting structure of the project. The draft report for the project will be submitted to the industry monitors at the beginning of September.

C27010
Occupational Assessment and Centralised Repository for Coal Mine Dust Lung Disease

Uniting Care Medical Imaging
Bob Edwards, Katrina Newbigin, Rhiannon McBean

Value: $294,090
Report Expected: January 2021
Industry Monitor/s: Bharath Belle
Brad Lucke
Sharif Burra

ACARP Contact: Patrick Tyrrell

The original stage of this project focused on reviewing the medical details of coal workers diagnosed with a coal mine dust lung disease (CMDLD) and was completed in May 2019.

This project aims to translate the research questionnaire developed in the first stage of the project into a streamlined clinical questionnaire that highlights risks for diagnosis of CMDLD. A new researcher will need to be hired for this second stage, and this has not yet occurred. At the present time the research team is focusing on dissemination of results from the original research work.

C27015
Coal Characteristics and Pneumoconiosis

University of New South Wales
David Cliff
David Waite

Value: $348,800
Report Expected: February 2020
Industry Monitor/s: Bharath Belle
Brad Lucke
Sharif Burra

ACARP Contact: Patrick Tyrrell

Coal workers’ pneumoconiosis (CWP) has been proposed to be related to the presence of reactive iron minerals such as pyrite in US coals, but little information on factors contributing to reactive oxygen species (ROS) generation by Australian coal dusts is available. Key objectives of this project are to:
• Quantify the toxicity of Australian coal dust to human lung epithelial cells and to determine whether any relationship exists between the toxicity and elemental composition;
• Quantify ROS production and determine whether a relationship exists between the oxidant generating capacity and the elemental composition;
• Develop a screening protocol for particles with regard to potential toxicity and recommend management approaches; and to
• Develop guidelines relating to best practice dust management for Australian coals considered particularly problematic with regard to CWP risk.
During the last three months our research has focussed on measuring intracellular ROS production and cell viability in human lung cell models and comparing the relative impacts between silica- and iron-bearing coal samples as well as pure mineral phases. Recently obtained X-ray fluorescence results identified that the samples being tested on our lung cell models had wide variations in iron (0.1 - 46%), silicon (1 - 37%), carbon (11 - 76%) and other components, indicating an ideal subset for assessing the impact of geochemical variation. Unsurprisingly, the presence of any dust (coal or pure mineral) significantly reduced the growth rate or even caused cell death for our lung cell model (A549 cell line). Our results also indicated that the enhanced ROS produced in the presence of silica was < 30% of the ROS produced in the presence of iron mineral bearing coal samples, highlighting the importance of iron in intracellular ROS production. In terms of the cell viability, in the presence of the lung cell component H₂O₂, reactive iron sulfide (FeS) is more cytotoxic than pyrite, which in turn, is more cytotoxic than nano-sized silica (when surface area corrected). Additional experiments using a second human lung cell model (Calu-3 in an Air-Liquid-Interface) showed different rates of cytotoxicity between different iron-mineral containing coals. These complementary techniques will enable a robust interpretation of the impact on human lung cells occurring from a range of Australian coal dusts potentially being inhaled.

In the next quarter we will focus in more detail on the coal dust related cell viability, aiming to provide recommendations into screening of coals based on geochemical composition.

**C27049**

**Mine Rescue Vehicle Radar Sensing Integration**

CSIRO
Gareth Kennedy
Lance Munday

**Value:** $254,405  
**Report Expected:** September 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 to
- 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.

During the Quarter the new, smaller radar unit underwent further testing. This new radar (which operates at 77GHz) has the advantage of being approximately one-quarter the size of the original unit, so it can fit in the "transparent flameproof" enclosure developed by CSIRO. This enclosure is relatively small and weighs only 8 kilograms, which facilitates mounting the radar system on mine passenger vehicles and other mobile equipment.

**C28001**

**Fit for Purpose "Self Aware Unmanned Aerial Vehicle (UAV)" for Remote Underground Deployment: Stages 1 and 2**

Mines Rescue
Paul Martin
Steve Tonegato

**Value:** $228,500  
**Report Expected:** September 2019  
**Industry Monitor/s:** Brad Lucke, Sharif Burra  
**ACARP Contact:** Patrick Tyrrell

The objective of this project is the development of a ‘Self Aware Unmanned Aerial Vehicle (UAV)’ for remote underground deployment. This will enable Mines Rescue to readily deploy UAV’s in an underground coal mine post a major incident to gather critical data, including atmospheric explosibility, toxicity, and personnel status. Following delivery of a customised UAV from a Canadian company in April the UAV has now been significantly modified to meet the project objectives with achievements as follows.

**Protective exoskeleton**

Has been designed and installed with effective bump protection offered from contacting roadway sides and roof. It works extremely well, being rigid but with some ‘rubber like’ impact absorption provided by the LED light strip. A great feature is that it is modular, easily dismantled, with spare parts being 3D printable.

**Improved lighting**

From OEM supplied craft additional light systems installed have increased the light produced by approximately 3000%. Extra lights installed include 360 degree lights, vertically down lights and two additional forward facing lights.
Improved power management
Rationalised all power systems to operate from one battery by condensing all auxiliary (lighting, video transmitter, video camera, optical and acoustic sensors) power systems which were on varying voltages and replaced with one system supplying all components with 12 volts. Flight time varies depending on battery used. Currently preferred battery has shown increased flight time by up to 250%.

Improved on board camera system
Replaced supplied camera with low light camera in a customised housing. The new camera provides better definition of objects in little to no light whilst being lighter with a wider field of view and a better dynamic range.

Tested and proved OEM supplied driver interface
The driver interface as supplied by OEM is adequate but a Digital Link upgrade has been added that amplifies control signal up to 7km when in line of sight.

Tested capabilities of the UAV in smoke and dust demonstrated that whilst particles in the air reflect light back to visual sensors thereby confusing the collision avoidance system, the optical sensors still allow the UAV to safely hold position.

The craft was flown through very heavy water droppers and was not affected by them in any way.

A presentation and demonstration of the UAV took place on 23rd of July at Southern Mines Rescue. It successfully demonstrated its capabilities to:
- Self-hover in a safe location in an underground roadway with bump protection and high powered LED lighting for navigation;
- Be piloted via simple driver interface by a novice pilot that enables simple control of a UAV – in terms of up/down, left/right, forward/back.

It is planned to finalise the project with work planned to:
- Prove its actual underground travel range by conducting underground testing (2 mines are keen to have testing conducted at their site);
- Improve the protrusion protection of the rotors;
- Test and determine its power to ratio.

C28014
Optimum Air Velocity for Management of Both Dust and Gas on Longwall Faces
CSIRO
Rao Balusu

Value: $275,250
Report Expected: January 2022
Industry Monitor/s: Andrew Lewis, Bharath Belle, Ken Singer, Russell Thomas
ACARP Contact: Patrick Tyrrell

The objective of this project is to investigate the effect of various mining and ventilation parameters and determine optimum air velocities for management of both dust and gas concentration levels on longwall faces under high production scenarios with different cutting heights. The project work will involve both field studies and modelling investigations. The project aims to obtain fundamental understanding of the effect of air velocities on dust entrainment from various dust sources with different dust characteristics. The project also aims to investigate dust entrainment vs dust dilution at different velocities and investigate the influence of air velocity on effectiveness of various dust control technologies and strategies. The project studies also provide greater insights into the effects of air velocities on gas and dust distribution patterns at different locations along the longwall face.

This project has very recently commenced.

C28023
Developing Suitable Gas Separation Membrane for Breathing Apparatus
Monash University
Victor Wei-Chung Chang

Value: $196,500
Report Expected: April 2021
Industry Monitor/s: Ken Singer, Paul Wild, Shane Apps
ACARP Contact: Patrick Tyrrell

The main objective of the project is to develop a new prototype for breathing apparatus in underground coal mines using a new membrane.

The literature review on available gas mixtures profiles is progressing mainly on Australian underground mines including both coal and hard rocks. One visit to the coal mines in Illawarra area has been completed and the aim and research methodology of the project has been directly communicated with the site ventilation officers to ensure the robustness of the planned methodology. The construction of test chamber is progressing and
most of it has been completed yet the safety of the chamber is under further examination. The development of baseline membrane cells is progressing through extensive trial and error process. The search for recruiting the suitable PhD candidate is continuing and is expecting to be finalised by September.

C28029
Personal Real Time Dust/Particulate Monitor (Direct Mass Based Measurement)

Lear Siegler Australasia
Peter Phaedonos

Value: $500,000
Report Expected: April 2020
Industry Monitor/s: Bharath Belle, Brad Lucke
ACARP Contact: Patrick Tyrrell

The project is progressing well and on target to this stage. This Real time monitor at any point in the shift will display what exposure levels you will have and allow the operator to make decisions and withdraw to a safe area. Standards exist for limiting exposure to the respirable fraction of coal dust in most industrial settings. It will have a very low detection limit that will meet or exceed current and anticipated exposure limits, and AS2985-2009 requirements for such continuous testing.

Status:
• Intrinsically safe electrical architecture complete and reviewed by 3rd party consultant -
  o for an intrinsically safe product this is fundamental to achieving product compliance. It is a detailed exercise to calculate electrical safety circuits, power dissipation, temperature rises;
• Product physical and aesthetic concept design complete (pending final flow path testing) -
  o internal component layout prepared in preliminary 3D,
  o size, shape, physical features,
  o product aesthetic concept renders produced;
• Detailed electronics design commenced -
  o focus on critical Intrinsically safe sub-circuits. Will be working closely with Compliance partner to ensure design aligns with regulations;
• Mechanical System Design nearing completion;
• Firmware development and testing ongoing;
• Electrical architecture and early system design reviews undertaken by IS Consultant and IS Compliance Lab to minimise risk of issues in compliance testing -
  o significant effort sourcing critical components including pump and internal heater elements to comply with functional requirement and meet intrinsic safety,
  o intrinsically safe battery pack (with PCB) designed,
  o intrinsically safe battery tested and report prepared by IS Lab;

• Control Circuit Boards Internal to the PDM nearing completion;
• Connectivity and external communications being developed and prepared for inhouse testing;
• Intrinsically Safe Certification houses being vetted for compliance partner.

C25063
Photocatalytic Destruction of Diesel Particulate Matter

CSIRO
Yonggang Jin

Value: $527,192
Report Expected: February 2021
Industry Monitor/s: Brad Lucke, Greg Briggs
ACARP Contact: Patrick Tyrrell

The second stage of the project is focused on developing 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.

The design of photocatalytic reactor has been investigated for the porotype unit with a focus on the types of flat plate and monolith. Both types are immobilised photocatalytic reactors with photocatalyst attached to a quartz plate or the pore surface of a ceramic monolithic foam, suitable for the DPM application. Over the last quarter, a significant amount of experimental work has been carried out in preparing photocatalyst film onto a quartz plate using various methods including cast coating, spray coating, screen printing, hydrothermal growth, etc. The co-catalyst loaded TiO2 nanoparticle material that was identified as the best performed photocatalyst for DPM oxidation in the stage one project has been used in the current experimental study of photocatalyst film fabrication. The methodology has been developed for photocatalyst loading to fabricate photocatalyst film onto the quartz plate. The fabricated photocatalyst thin film exhibits excellent binding strength with the quartz substrate. The optimisation of fabrication parameters such as the thickness of TiO2 film, the amount of co-catalysts is being conducted by testing DPM oxidation performance after disposition of simulated DPM nanoparticles onto the photocatalyst film. Configuration of LED light source according to the design of prototype photocatalytic reactor is being carried out and several suppliers have been approached to obtain specifications and pricing of a LED unit with control and cooling system.
**C26056**

Optimisation of Low and High Pressure Longwall Hydraulic Systems

Quantise Consulting Engineers
Russell Smith

Value: $80,000
Report Expected: September 2019
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.

Analysis and modelling has been further delayed. Resource allocations have been set for completion in August.

**C26057**

Electrically Safe Variable Speed Drive for Underground

University of Newcastle
Galina Mirzaeva, Peter Stepien

Value: $158,202
Report Expected: August 2019
Industry Monitor/s: Barrie Alley, Brad Lucke
ACARP Contact: Peter Bergin

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

**C27006**

Lightweight/Compact IS 12VDC UPS Portable or Fixed Supply

KRS Technologies (KRS Drive Systems)
Kurt Schober

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

This project aims to produce a Light Weight and Compact I.S. 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.

- Battery Cell Testing still being carried out by the TestSafe Lab in Londonderry.
- The short circuit test is applied to simulate a possible internal short circuit within the cell during a failure.
- Initial testing indicated that the temperature during short circuit was too high and small amounts of electrolytes along with gas vented from the cell.
- We had to come up with a new way of encasing the cells so to protect the electronics and environmental possibility of the cell venting gas as well as lowering the temperature during the applied short circuit.
- The new method is proving to be successful by reducing the cell temperature during short circuit from 150 Deg C to 130 Deg C.
- We had to supply 10 more cells for the further testing and expecting the result in the positive over the next couple of weeks.

Once the cell testing has been carried out and resolved, the electronics will be tested to conform with the requirements.

**C27019**

Underground Compressed Air Vehicle

AMM Project Development
Michael Christian

Value: $120,000
Report Expected: November 2019
Industry Monitor/s: Greg Briggs, Rick Chugg
ACARP Contact: Patrick Tyrrell

The current program has been extended to November due to having to redesign and manufacture of a lighter and more robust braking system. The manufacturer has a long lead time due to work pressures, it is expected that the rebuild will be complete by the end of August with site trials proceeding in September.
C27069
Reduce Time Required for Certification of Equipment for Use in IS Zones

Jandar Consulting Services
John Rose

Value: $100,000
Report Expected: May 2020
Industry Monitor/s: Barrie Alley, Brad Lucke
ACARP Contact: Patrick Tyrrell

The objective of this project is to reduce the time required to obtain certification for explosion protected electrical equipment. Intrinsically Safe equipment certification is being utilised as a selective sample for the first part of this project.

The initial objective is to conduct a scoping study to define the problem more clearly and determine if there are practical measures that could be implemented in the next five years.

To date:
• A review of ACARP projects was undertaken and suitable projects were selected to take part in the project; and
• Initial contact was made with the personnel involved in each of the projects.

Initial interviews are currently underway with personnel involved in the Queensland based projects.

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

University of Queensland
Paul Wilson

Value: $271,200
Report Expected: September 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 500 mm 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 intention 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.

Because of the paucity of reliable training data, and because clustering is the only effective approach in those circumstances, the clustering-based machine learning approach was used for the exploratory phase of work. With the vast amount of data acquired from field testing, new information about the conveyor system has been discovered and is statistically repeatable. This phase of work has been completed.

The feasibility study phase is essentially complete with the conversion of the exploratory clustering discoveries into workable algorithms. Two algorithms have now passed the proof of concept stage and these are:
• A self-adaptive method of compensating for laser pulse power losses along the length of the fibre;
• A self-tuning method of measuring the true conveyor speed and the different diameters of the carry and return idlers.

The algorithms that have emerged from the research are expected to be converted to operational program code in the near future for testing in the commercial product.

A contract was signed in December with Future Fibre Technologies, a Melbourne company owned by the AVA Group which is an international electronic security company. From January until the last working day of March 2019, the entire team plus a contractor was fully committed to converting the experimental program code developed up to the end of phase 2 of the project into operational program code written in the C language. The commercialisation work is continuing and includes assisting the commercial partners with preparing marketing material for the mining industry.

The draft of the final report has been completed and is being circulated within Mining3 for review before being released to ACARP. It is expected to be released in the very near future, depending on the workload of the reviewers.
C28003
Lithium Traction Battery for Underground Coal Project: Stage 2 Build, Test and Certify a Heavy Duty Lithium Battery Module Capable of Powering Underground Coal Plant

3ME Technology
Justin Bain
Phil Coop
Richard Eveleigh

Value: $739,750
Report Expected: September 2019
Industry Monitor/s: Brad Lucke, Greg Briggs, Paul Wyatt, Peter Liston, Rick Chugg, Sharif Burra

ACARP Contact: Patrick Tyrrell

The objective of the project is to design, build and certify a high-performance Battery for use in an Electric Vehicle (BEV) system that meets Australian compliance requirements. In the previous project (Stage 1), 3ME Technology conducted a successful design verification of its heavy-duty lithium battery modules design to meet IEC60079 Standards for operating in an explosive atmosphere within a coal mine. At the end of this project (Stage 2), certified heavy-duty lithium battery modules would be powering an underground coal vehicle.

The following key activities have been conducted to date:
• The Mark One (MK1) Battery designed was manufactured, load tested and assessed against all applicable standards by an independent contractor;
• Several design opportunities were identified to solve the challenges encountered on the Mark Two (MK2) design. This further design work has seen a delay to the project by three months but will result in a superior solution;
• The engagement has continued with a Certification Authority for both testing assistance and to review the learnings from the MK1 design;
• Accelerating Commercialisation funding (matching ACARP) continues to support the development and establishment of 3ME’s battery assembly, testing and quality assurance implementation;
• A Life Cycle Management Plan has been developed with information relevant to the battery modules and for use in Hazardous area environments;
• Risk register, Safety standards, Design Risk Assessments, FMECA, Legislation and regulations continue to guide design outcomes; and
• The MK2 Battery design has been finalised, and manufacturing is underway.

Integration with Underground Plant (Man Transporter):
• The integration planning and preparations have continued to progress with 3ME’s mechanical integration partner;
• The electrical system and mechanical integration drawings have been drafted; and
• The electric flameproof motor and custom onboard charger plans are being concurrently executed.

Key Tasks to be conducted include:
• Final Assembly and testing of MK2 prototype;
• Certification of relevant components;
• Battery Management System (BMS) configuration;
• Integrating of the certified battery modules and complete the electric vehicle (EV) system into the proof of concept vehicle;
• Charger Prototype testing and final certification;
• Field trialling of the proof of concept EV in an underground coal mine; and
• 3ME Technology is aiming to achieve the above tasks by the end of this calendar year (2019).

C28005
Low cost, wireless, intrinsically safe sensors for underground coal mines

Vayeron
Mark Walter
Ryan Norris

Value: $170,000
Report Expected: February 2020
Industry Monitor/s: Brad Lucke, Dave Young

ACARP Contact: Patrick Tyrrell

Radio performance and conceptual form factor considerations tested on an pre-assembled Longwall in a workshop facility located in Mackay.

Three prototypes were designed and assembled for the purposes of the following tests. The total weight of the prototypes was 300g. The total pull force of the magnet mount was 16kg which was more than sufficient to hold the weight of the inclinometer on a metal surface, at all tested angles.

Components of Inclinometer Prototype
Three Inclinometers were distributed along the head chain component of the Longwall at various distances and the following results were recorded:

<table>
<thead>
<tr>
<th>Distance (Meters)</th>
<th>RSSI (dBM)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>60 to 70</td>
<td>Good</td>
</tr>
<tr>
<td>20</td>
<td>80 to 85</td>
<td>Acceptable</td>
</tr>
<tr>
<td>30</td>
<td>90+</td>
<td>Weak</td>
</tr>
</tbody>
</table>

Measured Radio Signal Strength at Head Chain

Three Inclinometers where distributed along the pan line at various distances and the following results were recorded:

<table>
<thead>
<tr>
<th>Distance (Meters)</th>
<th>RSSI (dBM)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-15</td>
<td>-60 to 70</td>
<td>Good radio</td>
</tr>
<tr>
<td>20</td>
<td>-80 to -85</td>
<td>Acceptable</td>
</tr>
<tr>
<td>30</td>
<td>-90+</td>
<td>Weak</td>
</tr>
</tbody>
</table>

Measured Radio Signal Strength on Roof Supports

One Inclinometer was placed at different points on the roof support to test the effects of the metal structure and the orientation of the device on radio performance, relative to the Gateway.

Although the radio range in all tests is within acceptable limits to establish a reliable mesh network for a Longwall application, alternate antenna structures will be investigated to optimize and improve the radio range as best as possible. This may involve designing a custom antenna to suit our desired profile whilst being optimized for this particular application.
Towards Better, Safer Mines - Optical Technologies for Software Defined Instrumentation

University of New South Wales
Francois Ladouceur

Value: $334,200
Report Expected: March 2021
Industry Monitor/s: Ben McCamley, Brad Lucke, Dave Young, Greg Briggs

ACARP Contact: Peter Bergin

The aim of the project is to design, build and characterise an intrinsically safe optical telemetry system based on an optical network of multi-gas sensor stations to monitor methane, CO, CO2 and O2. This aim will be accomplished by exploiting the unique properties of novel liquid crystal based optical transducers and a purposely designed remote terminal unit (RTU) where the analogue signal is processed and the sensor is virtualised in software. Reduced power consumption at the sensor end and the incorporation of Power-over-Fibre technology enables the powering and querying of sensors over a single optical cable, making UPS unnecessary.

Work undertaken in the past quarter includes:
- Requirement collection/understanding and system design of optical gas monitoring network in collaboration with industry monitors;
- Understanding of intrinsic safety standards (international) and gas monitoring regulations (domestic and international);
- Optically powered O2 sensor has been developed and tested and development of CO, CO2 and methane sensors on track;
- Project documentation (project management plan, work breakdown structure, project resource requirement, risk register, stakeholder register, procurement list, bill of material, MOM, etc) are in place and available on-line for all team members.

Work planned for the next quarter:
- Optical gas sensor station housing design;
- Electrical and optical design for methane, CO and CO2;
- Gas calibration design, development and testing;
- Remote terminal unit (RTU) design and development; and
- Project documentation update.

At this stage, we foresee no important technical holdups. Newly defined technical requirements related, e.g. to calibration and on-site alerts, might impact the total budget but represent no specific technical difficulties.

Development of a Safer Underground Explosive

University of New South Wales
Andres Castro, Duncan Chalmers

Value: $323,500
Report Expected: September 2019
Industry Monitor/s: Bharath Belle, Brad Elvy, Danny Brouwer, Russell Thomas

ACARP Contact: Patrick Tyrrell

The Resources Regulator has engaged a consultant to CFD model and evaluate the shock waves that are generated by the gallery. They will provide advice in attenuation methods to be applied to the facility and once that done then recommissioning can recommence. The chief investigator has supplied footage of tests conducted under previous ACARP projects so that an evaluation of the CFD modelling can be conducted to ensure that the modelling matches reality. At this stage, progress is continuing, and the monitors will be updated when there will be a recommencement date.

Adaptive Protection Techniques in Mining Electrical Systems

ResTech
Clint Bruin

Value: $304,150
Report Expected: September 2019
Industry Monitor/s: Brad Lucke, Greg Briggs

ACARP Contact: Peter Bergin

The key objective is to demonstrate test the value of adaptive protection techniques at one or more mine sites. Our specific objectives can be set out as follows:
1. 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.

• Analyze all data obtained and report on the results.

In past months, the software for the trial was completed and fully bench tested. It was also tested communicating with two IPX relays over the network.

A typical screen shot during system configuration is shown below.

The system was successfully installed and commissioned at the trial site and is now completed. Data is being analysed and the report is being written.

**C27051**  
**Assistive Shuttle Car Guidance System - Stage 2 Implementation**

**CSIRO**  
**Jonathon Ralston**

**Value:** $227,275  
**Report Expected:** December 2019  
**Industry Monitor/s:**  
Bruce Davies  
Roadway Development Task Group  
**ACARP Contact:**  
Patrick Tyrrell

This project aims to develop and demonstrate a new guidance capability that will enable a shuttle car to repeatedly tram the path between a continuous miner and the conveyor bootend in an automatically manner. The central motivation for the work is improve personnel safety and development performance.

The project’s objectives are to:

- Develop a retrofittable guidance prototype to enable supervised auto-tramming;
- Demonstrate the tramming system operating in an analogous underground environment;
- Evaluate performance in a non-operational context with relevant control features.

The key project deliverables are a prototype guidance system and a report that describes project development, outcomes and recommendations.

The last quarter has progressed developments towards the required ‘auto tramming’ shuttle car demonstration, ie perception, guidance and machine interfacing. The first underground evaluation provided the opportunity to observe the shuttle car operating under production conditions and to make a short preliminary laser-based evaluation. A second underground evaluation was organised and conducted in June to make a more systematic evaluation. This evaluation provided the opportunity to evaluate different types of laser sensors, assess the practicality with different sensor mounting locations, install temporary navigation indicators for validation, and perform a more comprehensive data collection campaign. Laser data was successfully collected on a mobile shuttle car during both maintenance and production conditions. This data was subsequently processed offline to provide new insight on the likely mapping performance of the system and to inform the guidance control methodology. Significant effort was also made to engage with OEMs and mine site to identify the most feasible method to interface the control system with the shuttle car, with emerging options now being assessed.
C27055
LASC Automation 10 Years On

CSIRO
Jonathon Ralston

Value: $101,770
Report Expected: August 2019
Industry Monitor/s: Brad Lucke
ACARP Contact: Patrick Tyrrell

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

C28017
Integrated Longwall Creep Control System

CSIRO
Jonathon Ralston

Value: $263,305
Report Expected: May 2020
Industry Monitor/s: Loz Hemmings, Richard Porteous
ACARP Contact: Patrick Tyrrell

This project aims to develop a new automatic longwall creep control system prototype to help minimise the need for corrective fly cuts and maintain equipment in an optimal roadway position.

The current approach for managing longwall creep relies on manually monitoring to maintain equipment within creep control limits. This measurement and prediction process task is often complex and time consuming with impacts on mining performance. In response to this problem, this project’s objectives are to:

- Measure and model the relationship between longwall creep and lead-lag factors;
- Develop a control algorithm to generate a recommended incremental fly-cut correction profile suitable for integration into an existing LASC face alignment system; and
- Stage a series of controlled, supervised evaluations on a production longwall – from manual open loop to automatic closed loop – to determine system performance.

Progress has been made since last quarter with highlights including:

- Uploading and initial processing high-performance position data units from the sensors in the TMU and CME. The data has shown strong correlation between anticipated movement of longwall maingate and tailgate equipment. Further activity to underway validate and synchronise the data to provide formal a ground-truth measurement for the laser-based creep measurement.
- A second mine site has been secured to deploy the creep sensing system. This will provide another opportunity to capture data and help to minimise any potential projects impacts that may arise from panel moves or underground maintenance issues at mine site.
- The laser-based creep measurement system has been installed, underground device networking established and confirmed to be operational. Multiple laser point data sets have since been collected. Creep line targets and validation methods have been arranged with mine site to facilitate the initial validation stages.

C28018
Longwall Floor Horizon Sensing

CSIRO
Andrew Strange
Peter Reid
Zak Jecny

Value: $269,680
Report Expected: August 2020
Industry Monitor/s: Jarod Chadwick, Richard Porteous
ACARP Contact: Patrick Tyrrell

Effective horizon control is essential for both safety and productivity in underground longwall mining. The key to achieving this outcome is a reliable means of actively sensing the geological strata. A ground penetrating radar sensor was demonstrated on a longwall for this purpose in project C25064. However, it was not in a suitable form for installation on a production longwall. This project will undertake the necessary engineering tasks required so that a long-term trial of the sensor can be completed on a production longwall. This includes the development of a non-metallic flameproof enclosure.

Experiments were conducted in the laboratory to compare the performance of a variety of ground penetrating radar systems and configurations. The motivation for these experiments was to determine system which would be most suitable for the long-term trial. The processing and analysis of the experimental data has been completed and a final system configuration determined. A design of how the sensing system components interconnect for housing within an explosion protected enclosure satisfying AS60079 has been developed. The system in this configuration was powered using a commercially available IS power supply and reverse barrier to determine if the current draw exceeds the allowable limit. The measured current draw of the system was only 46% of the allowable current limit.

The next milestone involves the design and preliminary construction of a model non-metallic explosion protected enclosure. To that end, an investigation into the different explosion protection methods permitted under AS/ANZ60079 is currently underway.
C28021
Benchmarking Study of Underground Coal Mining Logistics

University of Wollongong
David Walker

Value: $71,000
Report Expected: December 2019
Industry Monitor/s: Roadway Development Task Group
ACARP Contact: Patrick Tyrrell

The primary objective of this project is to identify the incremental and step changes in underground coal mine logistics that have the potential to address the key performance and productivity challenges faced by the existing Australian underground coal mines. Furthermore, the project is to undertake:

- A desk research component that will establish the state-of-the-art in logistics practices.
- A field study component that will evaluate the current underground logistics practices, processes and technologies in underground coal mines in NSW and Qld.
- To develop into a project pipeline for supply chain management research within Australian underground coal mines.

Visits to operations have commenced. So far Illawarra, Central West and Hunter operations have been visited. We have viewed shaft, drift and adit operations, with also a combination of Rubber Tyre and Rail transport for either partial or all material delivery. It must be noted already we are seeing a broad spectrum of logistical management strategies already. Follow up visits for some operations will need to occur. Desktop study is underway and the appointment of a senior research fellow has been appointed to continue this work.

Roadway Development

C25058
Self Drilling Bolt Automation Trial

OKA Rock Bolt Technologies
Mark Levey
Paul Charlton

Value: $1,396,000
Report Expected: September 2019
Industry Monitor/s: Paul O’Grady
ACARP Contact: Patrick Tyrrell

The project objectives are as follows:
- The OKA Technology is further refined using findings from the first phase of the 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;
- Assembly of the chemical injection modules is complete;
- The software control system components and associated wiring are now completed;
- Testing and commissioning of the injection modules in the workshop began April 2018. The intrinsically safe 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 over 12 months;
- Load transfer testing is currently taking place using the Oka system to install bolts into a workshop purpose-built test rig. Once all testing is complete, the injection units will be stored until they are relocated to the continuous miner site at another workshop for commissioning of the software to allow for simultaneous bolting from three bolting rigs; and
- The host site has now confirmed that the continuous miner for use in the trial will be available for fit-out early September 2019 to then conduct the underground trial.

C25068
Automated Long Tendon Installation System

Conway Engineering
Des Conway

Value: $184,500
Report Expected: October 2019
Industry Monitor/s: Roadway Development Task Group
ACARP Contact: Patrick Tyrrell

No progress on this project this quarter.
C26051
Machine Bolting and Geotechnical Monitoring System

CSIRO
Jonathon Ralston

Value: $275,490
Report Expected: September 2019
Industry Monitor/s: Roadway Development Task Group
ACARP Contact: Patrick Tyrrell

This project will develop a machine-based, bolt placement and roadway geometry profiling system based on laser scanning technology to provide new information streams to assist operational and geotechnical personnel achieve a more robust, deterministic and efficient roadway development process. The objectives of this project are to:

- Develop a laser-based 3D scanning system suitable for retrofitting on underground vehicles;
- Validate mapping software for bolt location and type, and local profile deformation; and
- Determine achievable sensing performance in stationary and mobile configurations.

The approach is based on the use of laser sensing to measure the roadway profile. This profile is then processed to identify the location of installed roof bolts. A parallel activity is to explore the degree to which roadway deformation can also be measured. All experimental and technical aspects of the core work program have been completed. Major activities undertaken in the last quarter included an ongoing review of project process and key outcomes, analysis of major results and implications, ongoing writing for the final report and targeting recommendations to stage future high value activity to advance roadway development automation. The project report is in final stages of development.

C27076
Underground Coal Mine Gateroad Development Continuous Haulage System

Premron
Mick Whelan

Value: $3,055,000
Report Expected: December 2019
Industry Monitor/s: Roadway Development Task Group
ACARP Contact: Patrick Tyrrell

This project aims to develop a semi-autonomous Continuous Haulage System for mine gateroad development, utilising the closed conveyor system of the Premron CHS®. This work being undertaken in this project is a continuation of projects C22009, C23017 and C24023. 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 ‘the host 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 Premron CHS commissioning is still in a semi-functional state with ongoing delays caused by the original electrical subcontractor, namely surrounding hardware and software issues. Premron have outsourced the programming and remaining electrical scope to alternative subcontractors and consultants. Over the last three weeks, Premron can report good progress with the Premron CHS electrically. The CHS has been operating on the surface in this semi-functional state now for about 200 hours and is pushing forward with wet testing later in the month.

The Sizer Feeder machine is now on site and commissioned by alternative electrical subcontractors. It will be wet tested in July and integrated with the Premron CHS in August for full system testing. The surface trial will include both dry/wet testing, standard rom coal (various lump sizes) and fully simulated operating gate road trial, with boot end, panel belt structure, fans, vent tube, services (power/air and water), catenary, sizer/feeder and other mining equipment, which will ensure integration of the Premron CHS machine.

The underground trials are likely to occur towards the later part of 2019.
Strata Control and Windblasts

C25057
Review of Rib Failure Mechanisms and Performance of Rib Support

SCT Operations
Yvette Heritage

Value: $186,500
Report Expected: October 2019
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 rib deformation monitoring covered three different seams in the Bowen Basin, Western Coalfield and Southern Coalfield, respectively. The Bowen Basin and Western Coalfield monitoring is complete.

The monitoring to date suggests 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 observed mechanisms driving the rib deformation ranged from bedding shear failure along weak claystone bands, to vertical shear fractures, to kinematic failures driven by shear failure dilation. The site specific failure mechanisms are required to be understood in order to effectively implement these controls.

Some conclusions from the modelling of rib support performance include:
- Confinement of the rib is key. Whether it is due to an increase in horizontal stress increasing the rib
- From a shear failure perspective, modelling showed that rib bolt length from 4ft to 6ft does not appear to have a major impact on rib deformation, except for angled bolts providing confinement on weak bedding planes. A risk based approach to controlling kinematic failures should be considered when choosing bolt length.
- Rib bolts need to be located in the zones of highest deformation to provide confinement to these locations. The location of these zones can vary depending on the rib lithology.
- A rib bolt support pattern should consider both the control of shear failure deformation and kinematic failures.

The project is waiting access to the Southern Coalfield mine to complete the last site in the development stress environment.

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

SCT Operations
Stuart MacGregor

Value: $339,787
Report Expected: September 2019
Industry Monitor/s: Brian Vorster, Peter Corbett
ACARP Contact: Peter Bergin

No report received.

C25060
Borehole Shear Monitoring Device for Routine Application in Roadways

SCT Operations
Stuart MacGregor

Value: $149,863
Report Expected: August 2019
Industry Monitor/s: Brian Vorster, Peter Corbett, Roger Byrnes
ACARP Contact: Peter Bergin

A draft report is with the industry monitor(s) for review.
C26063
Reliable Estimation of Horizontal Stress Magnitudes from Borehole Breakout Data

University of New South Wales
Joung Oh

Value: $123,000
Report Expected: August 2019
Industry Monitor/s: Brian Vorster
Roger Byrnes
ACARP Contact: Peter Bergin

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

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

University of New South Wales
Serkan Saydam

Value: $298,940
Report Expected: September 2019
Industry Monitor/s: Adam Lines
Brian Vorster
Patrycja Sheffield
Peter Corbett
ACARP Contact: Peter Bergin

The main objective of this project is to conduct a comprehensive multidisciplinary investigation into floor failure mechanisms and controlling factors using experimental, numerical and analytical methods. 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.

A new rating system for coal mine floor, Coal Mine Floor Rating, has been developed. The new floor rating system quantifies the stability of floor strata by considering two main factors, uniaxial compressive strength and discontinuity spacing of the floor units.

From five coal mines in Australia, 28 cases with significant floor heave on development and 30 unfailed cases have been collected. Conducting statistical analysis on the database, an empirical method, Floor Heave Index, has been developed. The Floor Heave Index chart which consists of the Coal Mine Floor Rating and Horizontal Stress Rating, a proxy for the magnitude of horizontal stress.

The new floor classification system and the empirical method assess the potential of significant floor heave in coal mine roadways for new mining projects or future workings. For further improvement, this work is currently being reviewed by Dr Christopher Mark, who developed the Coal Mine Roof Rating system.

The floor heave monitoring using shear strips and GEL floor extensometer is underway at Mine B. Due to the technical and operational issues, the second installation of floor instrumentation at Mine B might get cancelled. The effect of longwall retreat on the deformation of the floor is studied. The monitoring will continue until September.

With the expected completion of the field monitoring in September, the final report is currently being prepared.

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 Mirzaghorbanali
Najdat Aziz
Paul Hagan

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

The project objectives are to:
- Improve understanding of roadway mechanisms with particular reference to shear displacement and its impact on support systems; and
- Development of an advanced numerical modelling tool that will enable a broad range of factors to be evaluated in terms of their contribution to the failure mechanisms in underground workings.

To this end, progress has been made in each of the three major elements of the project as defined in Figure 1.

![Fig 1. Conceptual diagram of the three elements in the project methodology.](image-url)
The second phase of the experimental work involved the preparation of samples at the University of Wollongong for shear testing of different types of cable bolts. Three sets of samples were prepared with each set having three individual concrete blocks, as shown in Figure 2. A pair of cable bolts were later installed at an inclination angle of 45° where a single cable bolt spanned two concrete blocks. Three types of cable bolts were used, these being: 15.2 mm diameter seven plain strand 25 t capacity; 28 mm diameter Sumo bolt of 63 t capacity; and, Megabolt MW9PS of 62 t capacity. The bolts in each set of blocks were simultaneous pretensioned to an equivalent load of 2 t using individually dedicated Blue healer pensioners. It was earlier found in the earlier trial tests that higher pretension loads led to the blocks moving out of alignment as the blocks slipped sideways.

![Figure 2. Isometric view (left) and side view (right) of the double shear test sample arrangement with inclined cable bolts.](image)

The three sets of samples were transported to the University of Southern Queensland laboratory at Toowoomba, where they were tested in a high capacity 250 t capacity press, shown in Figure 3. The load was steadily increased at a low rate to the central block until both cables either failed or the structural integrity of the test samples was deemed to be no longer safe to withstand any further loading. The test results for the 15.2 mm plain cable bolt are shown in Figure 5. The load/displacement graph indicates a high initial stiffness with a peak load resistance of around 800 kN (approx. 80 t) after 20 mm vertical displacement. Interestingly, beyond this peak load, the system was still able to maintain some load resistance with a gradual reduction in load in a stepwise manner evident to around 25% of peak load after an additional 110 mm displacement.

![Figure 5. Shear test of 15.2 mm cable - post failure of each strand is evident.](image)

A further set of shear testing at an inclination angle of 30° inclined is now being planned.

Two-dimensional modelling of the frictionless double shear test has been simulated using the distinct element method code, UDEC, with the model arrangement shown in Figure 6. Initially, the model considered a pure shear arrangement at zero degrees inclination based on test results from previous ACARP projects on double shearing (UOW) and axial pull-out tests (UNSW). Later the model was modified and calibrated using the recent results from the 45° inclined cable bolt tests. In coming months, it is planned to extend the numerical model approach from 2D to 3D utilizing 3DEC with simulations to be carried out at both 30° and 45° cable inclinations.

![Figure 6. Numerical model arrangement in UDEC of cable bolts tested in shear at an inclination angle of 45° (left) and, comparison of the model response against measured behaviour in a double shear test with inclined 15.2 mm cable bolts (right).](image)

Numerical models have also been developed using UDEC to investigate the effect of pre-tension of cable bolts installed in the roof of a roadway on the behaviour of the surrounding strata as shown in Figure 7. The strata and roof support system (cable bolts and rock bolts) are based on data provided by Mine Site A. The design and material properties from the mine have been used to correlate with field observations of strata movement. The current models include bedding planes in the sandstone above the roof, and varying levels of pre-tension in the roof support system. The next phase will consider the detailed geology at Mine Sites A to be incorporated into the numerical models.
The field measurement work is progressing well. The team has received 22 GB data from Mine Site A that includes core sample analysis, in-situ stress, support design parameters, and borescopes etc. The data is being used to calibrate the numerical models under development at UNSW concerning considering the effect of various pre-tension on cable bolt performance. Two shear strips have been delivered to the mine and are awaiting on installation. The location to install the shear strips has been selected in the roof of a heading adjacent to a new longwall development. Installation of the shear strips is expected to occur at the end of July subject to availability of equipment and other operational issues at the mine. It is planned to monitor and collect field data over a three-month period, to record the dynamic impact of longwall face retreat on behaviour and response in the roof.

C27045
Assessment of Longwall Mining Induced Connective Fracturing: Stage 2
CSIRO
Deepak Adhikary

<table>
<thead>
<tr>
<th>Value:</th>
<th>$201,250</th>
</tr>
</thead>
<tbody>
<tr>
<td>Report Expected:</td>
<td>December 2019</td>
</tr>
<tr>
<td>Industry Monitor/s:</td>
<td>Peter Corbett</td>
</tr>
<tr>
<td>ACARP Contact:</td>
<td>Peter Bergin</td>
</tr>
</tbody>
</table>

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 e.g. sandstone, siltstone, claystone, shale, coal etc;
- Extend and fine tune the technique developed in project C24020 of initiating and propagating fractures, estimating fracture apertures and connectedness and thereby calculating the mining induced permeability of strata from first principles; and to
- 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 the heights of connected fractures were quantified for 2 mines only); and come up with simple to use charts that can be used to (a) assess the height of mining induced connected fractures at other mine sites; and (b) further refine with additional mine site data when they become available.

The project deliverables will be a report containing charts/tables and a numerical modelling guideline (including all the source codes developed in the project) for estimating the height of connective fracturing that can create pathways for increased groundwater inflow and excessive gas emission into longwall workings from adjacent gassy seams.

Review of functionality of existing processes and software has been completed, a slight modifications to PFC subroutines has been made.

PFC models representing mine site 1 LW 3 and LW 9 are developed and run; the model results indicated a very different pattern of connective fracturing compared to the results obtained for a mine site reported in C24020. These data are analysed and now we have moved to mine site 2 study.

PFC models representing mine site 2 are developed. Detailed modelling work on site 2 has been completed and currently modelling results are being analysed.

Data from mine site 3 has been received; the mine site data is being analysed. Numerical model is planned to be built in mid-September.

C27071
Intrinsically Safe Digital Networked 3D Roof Bolt
Holville
Anne Wylie

<table>
<thead>
<tr>
<th>Value:</th>
<th>$140,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Report Expected:</td>
<td>January 2020</td>
</tr>
<tr>
<td>Industry Monitor/s:</td>
<td>Mick Stadler</td>
</tr>
<tr>
<td>ACARP Contact:</td>
<td>Roger Byrnes</td>
</tr>
</tbody>
</table>

The project objective is to develop an intrinsically safe instrumented digital roof bolt that will:

- Accurately measure axial strain and bending in 3 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 ¼ bridge strain gauged roof bolts.
A prototype 3D bolt using low cost strain sensors has been completed and bench tested and found to be comparable in accuracy to commercially available 2D instrumented bolt.

Low cost methods of producing the slots in the bolt and bonding the gauges to the base of the slots has been developed and successfully tested.

A novel method of measuring strain which also works at very large strains has had some encouraging preliminary.

Two different analogue multiplexers have been designed and manufactured and are undergoing comparison testing. The next stage is to mount the prototype circuitry in a bolt.

The IS handheld data collection terminal to be used for this project has had a draft certificate issued from Ex Testing And Certification Pty Ltd.

**C27073**

**Roadway Stability Monitoring System**

**CSIRO**

Chad Hargrave

**Value:** $239,565  
**Report Expected:** March 2020  
**Industry Monitor/s:** Jim Sandford, Roger Byrnes  
**ACARP Contact:** Patrick Tyrrell

This project is an extension to 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. This project takes 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 industry monitors have emphasised the relative importance of temporal coverage (continuous monitoring), so the primary goal of the extension project is to demonstrate this capability in order to deliver a sensor capable of reliable continuous monitoring that can be demonstrated to the mining industry for future take up and integration into their underground mine management processes.

As noted in the May update, the construction of the new radar sensor system is ongoing as per the revised project plan. New antennas are under development to rectify the mismatch issue noted previously. Testing on the first batch of the new antennas has indicated an improvement in terms of matching and operative bandwidth, however work is still ongoing to ensure that all the elements have the correct tuning frequency for the application, which will require the acquisition of some additional antenna elements.

While it would be possible to finalise the radar hardware with the current antennas, it would result in a reduced system performance that could compromise the viability for the roadway stability application. The project team has therefore elected to continue with refinement of the antennas, which will result in a revised hardware delivery date of August, rather than July. This minor delay does not impact on the project delivery date (reporting in March 2020) however the project team will continue to monitor the situation to ensure that the hardware delivery does not slip further. The rest of the hardware has been successfully tested as far as possible, so it is anticipated that the complete system can be commissioned rapidly once the new antennas are received.

**C28011**

**Prevention Techniques for Stress Corrosion Cracking Failures of Rock and Cable Bolts**

**University of New South Wales**

Serkan Saydam

**Value:** $298,380  
**Report Expected:** November 2021  
**Industry Monitor/s:** Patrycja Sheffield, Peter Corbett  
**ACARP Contact:** Peter Bergin

This project will start in September.

**C28015**

**Evaluation of the Chinese Outburst Assessment Methodology and its Applicability to Australian Low Permeability Coal Seams**

**CSIRO**

Qingdong Qu

**Value:** $238,270  
**Report Expected:** July 2021  
**Industry Monitor/s:** Bharath Belle, Ken Singer, Rae O’Brien, Russell Thomas, Sharif Burra  
**ACARP Contact:** Patrick Tyrrell

The project aims to evaluate the Chinese outburst assessment methodology that is used in managing China’s thousands of outburst coal mines, and its applicability to Australian low permeability coal seams. The final goal is to improve outburst assessment methods and control strategies for Australian underground coal mines.
Information available in relation to outburst assessment including publications, industry standards and government legislations are being gathered for analysis.

**C28020**

**Optimising the Cablebolt Pre-Tensioning Practice to Control Roadway Roof Failure Using Advanced Combined Axial and Shear Testing Facility**

Monash University
Hossein Masoumi

**Value:** $165,000
**Report Expected:** May 2021
**Industry Monitor/s:** Brian Vorster, Jose Pizarro, Patrycja Sheffield, Roger Byrnes

**ACARP Contact:** Peter Bergin

The main objective of the project is to investigate the long history issue of cable bolt pre-tensioning practice in Australian coal industry. It is aimed to find a sensible understanding of selected level of pre-tensioning and the technical reasons associated with such a selection.

The team has provided a data sheet to be completed by the site geotechnical engineers which includes some practical parameters related to the cable bolt pre-tensioning practice. Some communications have been conducted with the mines in New South Wales for completion of first round of data collection process. The review of all the earlier materials on this problem primarily published by well-known industry experts as well as academics are ongoing. The findings from the hard rock mines regarding this problem have been extensively reviewed and the plan for the testing program and specifically testing design for the combined shear and axial cable bolt testing with various pre-tensioning levels will be finalised by the next round of project review. After completion of data collection from coal mines in New South Wales, the data collection will be continued from the mines in Queensland.

**Ventilation, Gas Drainage and Monitoring**

**C25072**

**New Approaches to Mine Gas Analysis and Ratios**

Simtars
Fiona Clarkson

**Value:** $416,192
**Report Expected:** February 2021
**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.

- Using a medium scale reactor, profile the gases evolved from the heating of a Queensland coking coal with a methane / ethane seam gas composition and a New South Wales coal with a carbon dioxide seam gas.
- Compare these gas profiles to the normal carbon dioxide seam gas and methane / ethane seam mine fingerprints identified in the first stage of this project and project C10015.
- Expand the current “Fire Ladder” to include additional alkanes below the ethylene point which can be used to give earlier warning of a developing heating / spontaneous combustion and incorporated into TARPs.

The work status is as follows:

- Configuration of the medium scale test apparatus for the heating of a coking coal -
  - hardware verified,
  - control program rewritten,
  - rewiring of the test apparatus is in progress;
- Development of a revised analytical method for the gas chromatography based on the Stage 1 findings -
  - configuration and validation of a two channel GC for analysis of alkanes and VOCs in progress,
  - limit of detection of less than 0.5ppm achieved for C5-C7 alkanes and cycloalkanes,
  - limit of detection of less than 1ppm achieved for benzene and toluene,
  - determination of the limit of detection of propane and butanes in progress;

A literature survey of relevant reports and papers is in progress.
C26050
Floor Seam Gas Emission Characterisation and Optimal Drainage Strategies for Longwall Mining

CSIRO
Qingdong Qu

Value: $153,075
Report Expected: August 2019
Industry Monitor/s: Bharath Belle, David Webb
ACARP Contact: Patrick Tyrrell

The project aims to characterise floor seam gas emissions in longwall mining and establish optimal gas drainage strategies. The expected objectives include:
• characterisation of mining induced floor strata, groundwater and gas behaviours;
• an improved floor gas emission prediction model;
• floor seam gas flow patterns; and
• optimal floor gas drainage strategies.

The project works are completed, and the draft report is with the industry monitors for review.

C26055
Control and Management of Outburst Risk

University of Wollongong
Dennis Black, Najdat Azziz

Value: $100,000
Report Expected: August 2019
Industry Monitor/s: David Webb, Russell Thomas, Sharif Burra
ACARP Contact: Peter Bergin

A draft report is with the industry monitors for review.

C26058
Optimisation of the Coal Seam Gas Predrainage Process

Palaris Australia
Mark Blanch

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

This project will:
• Define the current status of gas predrainage design and management practices across the industry;
• Establish a benchmark of coal seam permeability and its relationship with stress, cleat, coal rank and type, and assess how permeability measurements are best applied in the gas drainage design process;
• Establish a set of guidelines that will provide -
  o a framework for gas predrainage design, management and validation,
  o a protocol for the acquisition, validation and application of key gas drainage and gas reservoir parameters.

Work in this quarter included detailed modelling and assessment of one of the mines involved in Stage 2 of the project:
• Reservoir characterisation;
• Assessment of permeability data from in situ measurements;
• Reservoir modelling; and
• Assessment of gas drainage performance and planning in low to ultra-low permeability conditions.

Work planned for the next quarter includes:
• Complete the assessment of the Stage 2 Bowne Basin Mine;
• Commence data acquisition and assessment of the Stage 2 Bulli seam Mine;
• Completion of the permeability benchmarking; and
• Commence work on gas drainage guidelines.

C27035
Automatic Leak Detection for Tube Bundle Systems

Simtars
Sean Muller, Snezana Bajic

Value: $220,000
Report Expected: February 2020
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.

An extension was requested for the project and granted due to events which required significant industry
support from Simtars. Due to unforeseen delays and the extended involvement for Simtars in provided industry technical support, the project work will be recommencing in Q3 2019. A review meeting is proposed in August/September to discuss an updated timeline for the project and to present the findings from the underground visits and investigation work completed to date.

C27037
Modelling of Strata Gas and Water Transport to the Mining Area
CSIRO
Zhejun Pan

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

The objective of this project is to further develop the reservoir simulator, SIMED II, to calculate the amount of gas (and water) migration to the working area, which is capable of accurately and simultaneously describing:
- Gas (and water) release mechanism from the working coal seam;
- Gas (and water) release mechanism from the goaf;
- Gas (and water) release mechanism from mined or unmined coal seams above and below the working coal seam;
- Gas (and water) release mechanism from gas containing sandstone/siltstone and mudstone/shale; and
- Gas and water through the drainage boreholes.

During the previous reporting periods, different case studies on gas released from overlying and underlying formations to the goaf and working area have been carried out. The effect of stress change and its impact on permeability has been included in the case studies. During this reporting period, more simulation case studies for two mines were performed and the final report is being prepared.

C27072
Intrinsically Safe Borehole Survey Tool
Holville
Anne Wylie

Value: $120,000
Report Expected: June 2020
Industry Monitor/s: Mick Stadler, 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; and
- 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.

Progress:
- The electronics used in the survey tool is finalised.
- A camera/lens combination with wide angle, low distortion and good depth of field has been tested.
- A method of transferring control signals from the base station to the survey tool and video from the tool to the base station has been tested successfully.
- A prototype housing for the survey tool has been made.
- Real-time streaming of position data from the position sensor is working correctly.

C28006
Impact of Gas Composition on Outburst Propensity of Coal
University of Wollongong
Dennis Black, Ting Ren

Value: $125,000
Report Expected: November 2020
Industry Monitor/s: David Webb, Russell Thomas, Sharif Burra
ACARP Contact: Peter Bergin

The main objectives of this project is to demonstrate, through laboratory testing and review of historical outburst event data, that carbon dioxide (CO₂) rich coal does not represent a significantly greater outburst risk than methane (CH₄) rich coal, in equivalent coal seam / sample conditions.
The project will also investigate sorption hysteresis and the effects of gas composition and coal particle size has on gas desorption. The results of preliminary investigation indicate that the current approach to determine isotherms for use in gas reservoir and gas emission modelling is not representative of in situ coal seam conditions and underestimates gas desorption rate.

In this quarter, the project commenced with collaboration between University of Wollongong and CoalGAS. Setup works have been completed in the university gas lab in readiness to commence coal sample testing. Contact has been made with a number of mine sites requesting supply of coal samples and historical data from areas mined where gas content remained above conventional outburst TLVs. Work is ongoing to access this data from supporting mines. Coal samples are being sourced to prepare and use in laboratory testing.

C28007
Impact of Core Sample Recovery Time on Accuracy of Gas Content Measurement

Capricorn Management
Dennis Black

| Value:   | $69,750 |
| Report Expected: | May 2020 |
| Industry Monitor/s: | Danny Brouwer, David Webb, Sharif Burra, Peter Bergin |
| ACARP Contact: | Peter Bergin |

The main objective of this project is to investigate and quantify the impact that core sample recovery time, specifically recovery times ranging between 40 and 180 minutes, have on the accuracy of gas content measurement. In this quarter, the project commenced and mines are being approached to carry out core sample testing to investigate the impact of extended recovery time of the accuracy of gas content measurement. Through consultation with mine site representatives, the core sample collection and testing procedure has been revised for using a 3.0 metre core barrel. This change achieved a significant reduction in the time required to complete sample collection and testing at each test location.

Testing has been completed at two separate locations at one supporting mine which has provided encouraging results. Further testing is needed to expand the dataset, canvassing for mine site support is continuing.

C28016
Ventsim Goaf Model Development - Stage 1: Equivalent Resistance Model

CSIRO
Martin Griffith
Qingdong Qu

| Value:               | $145,665 |
| Report Expected:    | October 2020 |
| Industry Monitor/s: | Bharath Belle, Peter Baker |
| ACARP Contact:      | Patrick Tyrrell |

The project aims to develop an equivalent resistance model of goaf gas flow which can be incorporated into Ventsim — the industry standard ventilation modelling tool. It is the first phase of the overall development of Ventsim goaf model which is attempted to enable mine ventilation officers to model and assess goaf flows at a site level.

Theoretical analyses of goaf structures and flow mechanisms will be carried out in the this first quarter of the project.

C28027
Effect of Occlusions by Coal and Stone Dust on the Sensitivity and Time Response of Methane Gas Detectors in Underground Coal Mines

Ampcontrol
Ian Webster

| Value:               | $90,000 |
| Report Expected:    | August 2020 |
| Industry Monitor/s: | Bharath Belle, Ken Singer, Patrick Tyrrell |
| ACARP Contact:      | Peter Bergin |

The overall objective of this project is to:
- Establish the existing degrees of occlusion of real time methane sensors in service in underground coal mines by qualitative survey, and hence determine the potential compromise in performance; and to
- Verify and quantify the susceptibility of real time methane detectors to occlusion by coal and stone dust by controlled laboratory testing of typical methane sensing devices.

The project is continuing in accordance with the stated objectives and budget.

The survey of in-situ fixed and machine mounted gas detectors in underground mines is continuing.

Methods of measurement of response time remain an area of uncertainty. The differences between measurement techniques that are designed for
laboratory type testing, and techniques that can be practically executed in-situ, remain the subject of investigation elsewhere.

A list of fixed and machine mounted detectors in use on Qld and NSW underground coal mines has been compiled. Sample detectors for testing have been identified that are representative of the population.

Where detectors cannot be sourced from OEM suppliers, samples will instead be borrowed from mining operations.

The construction and commissioning of the dust exposure test rig is scheduled for Q3 2019.
**Open Cut Projects**

**Drilling and Blasting**

**C27034**

*Top of Coal Detection Phase 4*

University of Queensland  
Byron Wicks  
Erik Isokangas

- **Value:** $395,310  
- **Report Expected:** October 2019  
- **Industry Monitor/s:** Max Ayliffe  
- **ACARP Contact:** Cam Davidson

Mining3 have developed a novel approach in determining coal seam location while drilling in a rotary air blast (RAB) drill rig. By using a geotechnical measurement technique the top of coal detection system has been proven to be capable of mapping the location of the coal seam in a rotary air blast drill rig during routine drilling on a hole by hole basis. Furthermore it has been proven that the system is capable of making measurements of the overburden during the drilling process. This information correlated well to drilling conditions and may prove to be useful for optimising blast design.

The system mechanical, electrical and user interface designs have been validated at the Mining3 test facility. Manufacturing of mechanical components has commenced. Preparation for field trials at mine site 1 occurring, with trial scheduled for September and will run for three weeks duration.

**Environment**

**C25031**

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

Edith Cowan University  
Melanie Blanchette

- **Value:** $232,293  
- **Report Expected:** August 2019  
- **Industry Monitor/s:** John Watson, Michael Moore  
- **ACARP Contact:** Patrick Tyrrell

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

**C27009**

*Tailings Revegetation through the Vegetative Water Pump*

CSER Research  
Carmen Castor  
Mike Cole

- **Value:** $447,000  
- **Report Expected:** February 2021  
- **Industry Monitor/s:** Chris Urzaa, Shaun Booth, Trent Cini  
- **ACARP Contact:** Patrick Tyrrell

This project has a primary objective of developing a vegetative water pump to allow tailings dams (TDs) to be dried through the plant transpiration stream and make TDs safer and capable of being capped or used for other purposes.

Flooding has impacted on field studies again this quarter, however, in the week ending 12 July the water had been pumped out mechanically. Safe access has now been achieved and on 24th July replanting has begun. Some individuals of *Casuarina glauca* and *Melaleuca quinquenervia* have survived the flood and this will be evaluated over the next few weeks. The delay in planting since the December floods has meant that some of the plants to be used are very advanced and will allow cost benefit analysis of very large plants (over 1.5m high) for *Eucalyptus camaldulensis* and *E. robusta* to be assessed against smaller plants. These plant differences will also allow further assessment of the development of leaf area index (LAI) which is likely to be critical to the effectiveness of the vegetative water pump. Because of the flooding delay for the experiments we have been focussed on developing a protocol for the maintenance of leaf chlorophyll levels and fertilizer frequency to maximize the plant growth response over the remaining period of the grant. This will be confirmed and further developed in the field once the replanting is completed.
We have also been developing a model of environmental conditions at site 1 TD for factors that impact on plant transpiration. For instance, in the diagram we show solar radiation through the day (left to right) and through the year (front to back).

Other factors such as temperature, wind speed and relative humidity are being assessed. We are also continuing to build baseline models of species function and they will be tested in the field as soon as plants have recovered or been replanted and established.

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

NSW Department of Primary Industries
Neil Griffiths

Value: $166,203
Report Expected: November 2019
Industry Monitor/s: Bill Baxter, Nigel Charnock, Stephen White
ACARP Contact: Patrick Tyrrell

The project objective is to undertake a desk top collation and review of past and present mine pasture rehabilitation work undertaken in the Hunter Valley coal region, and conduct field assessment on a range of selected sites to identify practices which are most successful and likely to support sustainable grazing.

This project will identify the main drivers and successful practices for re-establishing functioning soil and pasture systems, potentially leading to faster rehabilitation outcomes and sustainable grazing land use management options for mine closure. It will identify and prioritise research opportunities to further improve practices for mine rehabilitation to pasture which meet the needs of both the mining and farming communities.

Progress during this quarter:

- Four mine sites have been accessed with 24 soil pits and surrounding pastures sampled and assessed. Soil samples to measure soil profile development were taken for laboratory analysis. The botanal pasture assessment technique was used to assess pastures for groundcover, species diversity and herbage mass. Preliminary results are showing useful trends in pasture development over time.
- A poster presentation outlining the project aims and preliminary observations was made to the 2019 Mine Rehabilitation conference held in Newcastle, and to the NSW Grassland Association conference held in Gunnedah.

C27038
Self Sustaining Ecological Mine Rehabilitation that Achieves Recognised Ecological Communities

Umwelt (Australia)
Travis Peake

Value: $286,970
Report Expected: November 2019
Industry Monitor/s: Bill Baxter, Nigel Charnock
ACARP Contact: Patrick Tyrrell

The core objectives of the project 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. We aim 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. The project has a national context, with a focus on the Hunter Valley.

To date, we have undertaken comprehensive review of the relevant literature, as well as legislation, policies and guidelines. Consultation with the New South Wales Department of Planning, Industry and Environment (DPIE) (formerly the Office of Environment and Heritage) is ongoing regarding programs on mine rehabilitation, with DPIE also assisting with project relevance from a government perspective. The field sampling was completed in May where ecological data relating to composition, structure, and function was collected at rehabilitated areas and remnant woodland from five mine sites. This data is now being processed and is in the early stages of analysis. Liaison with DPIE is also being undertaken so that revision to the New South Wales plant community type classification system, which is central to the ‘recognisability’ component of the project, is adequately considered.
C27042
Adaptation of Design Tools to Better Design Rehabilitation and Capping Over Highly Mobile Mine Waste

University of Newcastle
Garry Willgoose
Greg Hancock

Value: $439,000
Report Expected: June 2020
Industry Monitor/s: Alicia Hooper
Chris Quinn
ACARP Contact: Patrick Tyrrell

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 (e.g. 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).

There has been work on 3 of the four tasks in this project. Two of the three mines that are test sites for the software in this project have provided us with LIDAR elevation data from their current operation. This has allowed us to select the field sites to be for testing of the software. Work has commenced in earnest on the adaptation of the SSSPAM software for this project. The model has been developed now to where it is predicting realistic (albeit qualitatively correct) predictions. Testing and modification is now ongoing.

Mine 1:
- Mine 1 contacted and need for DEMs indicated.
- Field visit discussed but put on hold due to Environmental Team commitments regarding planning for mine expansion/upgrade and submission of plans to relevant authorities
- Need to liaise now regarding the acquisition of LiDAR data over the site to capture erosion features
- Need to liaise for representative mine spoil to be sent to Uni of Newcastle for erosion parameter development
- Alternatively other sites need to be recommended and made available.

Mine 2:
- LiDAR DEMs and orthophotos have been supplied.
- They have been systematically worked through and we have found that while the data has extensive coverage over the site, the point density is quite low for much of the site. This means that any erosion feature with a length scale less than this will not be captured in detail, modelling is not possible as there are insufficient points to correctly represent the gully.
- We tried calibrating SIBERIA to match the gully form based on this DEM and made good progress.
- Results: The calibration has not been successful due to the low quality of the DEM and lack of knowledge of the site history. This site has been abandoned and new sites sought. This discussion is ongoing.

Mine 3:
Mine 3 has not been approached for LiDAR data at this stage because to date we have been focused on Mines 1 and 2. They will be approached shortly. Staff changes have made this difficult. However, negotiations are underway.

Software development:
- Determining (1) what components of the SSSPAM are necessary and (2) focused efforts of speeding up SSSPAM simulations is largely finished. Software testing to determine the minimal data requirements that are needed to gain accurate results is currently underway. Some preliminary simulations using SIBERIA for the DEMs for Mine 1 and Mine 2 have been performed but they are not yet ground truthed at this stage.
- SSSPAM is now being evaluated using the Newcastle teams existing data for other sites.

C27043
Towards Closure of Saline Pit Lakes: Understanding Biophysical Processes for Condition Assessment and Remediation

Edith Cowan University
Mark Lund

Value: $246,040
Report Expected: January 2020
Industry Monitor/s: John Watson
Ross Gooley
ACARP Contact: Patrick Tyrrell

In Australia, many community members and regulators expect that final voids will be backfilled. However, a lack of backfill materials combined with prohibitive costs ensures that pit lakes will be a permanent feature of most post-mining landscapes. Pit lakes are considered the ‘greatest legacy of open cut mining’ due to the
potential for safety issues, ground and surface water contamination, and in-lake toxicity. Additionally, pit lake science has struggled to find a foothold in mainstream literature, limiting wider scientific exposure to the issue of pit lakes and holding back advancement of the development of remediation and closure approaches. Therefore, the broad objective of our proposed research is to understand pit lake biophysical processes for condition assessment and remediation options for Hunter Valley and Bowen Basin pit lakes.

Salinity is a key water quality issue with many Australian pit lakes. Many natural lakes are saline and have valuable ecosystem values. Understanding the role of catchments and nutrient inflows in maintaining salinity within useful ranges and driving ecosystem processes is therefore important to determine the range of future uses for these pit lakes. These future uses may include conservation, recreation, and aquaculture.

The overall project approach has two main components: *In situ* lake biophysical, and Experimental.

**In situ component**

We will determine the quantity of salt in the lake in conjunction with thermal stratification – key considerations in lake processes and closure options. We will also assess the risk of toxic metal leachate from void walls or backfill through a comprehensive water quality testing program. Biological endpoints (including cutting-edge microbial work) will be collected over time from the lake. Companies wishing to close pit lakes will need evidence in the form of robust data to discuss closure options. Development of a simple, low-cost monitoring framework that can identify the risks and opportunities associated with individual pit lakes allows companies to make informed decisions about relinquishment, ultimately reducing the risk associated with closure. Another benefit to industry from this project component will be a pit lake ‘report card.’ We have developed a ‘sliding scale’ of pit lake assessment, whereby pit lakes are ‘graded’ on their difficulty to rehabilitate. Both the monitoring program and report card are transferable and adaptable to pit lakes in other areas of the Hunter Valley and Bowen Basin, across Australia, or internationally.

**Experimental component**

Carbon (in the form of terrestrial organic matter) determines the nature of the aquatic food web and creates important habitat. Using tank mesocosms (1000 L) on site, we will test the effects of adding coarse, low-cost organic matter on lake water and sediments on biophysical and chemical endpoints (as measured in the lake). The purpose of this experiment is to test the water quality and biodiversity benefits of carbon addition in the pit lake. Our previous work has demonstrated that modifications to the edges of pit lakes to support plant growth, addition of organic matter, and planting of riparian zones prior to filling offer an effective, low-cost way to promote more rapid evolution of the lake towards improved water quality and biodiversity. We will use data collected from the lake to validate the ‘controls’ (tanks with no organic matter) and compare seasonal temporal trajectories of collected data. The experimental component of the project provides companies with an indicator of what could be achieved under different lake closure scenarios using the passive treatment approach.

The first two rounds (February and May 2019) of pit lake sampling and establishment of the field experiment was completed successfully. A third round is being organised for August 2019.

A paper based on our research in project C23025 was presented at the joint ICARD and IMWA conference in Denver, USA in February. Two papers based on projects C23035 and C25031 were presented at the IMWA conference in Perm (Russia) and can be accessed for free at https://www.imwa.info/docs/imwa_2019/IMWA2019_BLanchette_645.pdf and https://www.imwa.info/docs/imwa_2019/IMWA2019_Lund_477.pdf. The researchers are also co-editing a special issue on ‘Pit Lakes’ for the Mine Water and Environment Journal that should be out middle of 2020.

**C27044**

**Testing the Resilience of Mine Site Rehabilitation with Fire**

University of Queensland
Phill McKenna

<table>
<thead>
<tr>
<th>Value:</th>
<th>$239,537</th>
</tr>
</thead>
<tbody>
<tr>
<td>Report Expected:</td>
<td>March 2021</td>
</tr>
<tr>
<td>Industry Monitor/s:</td>
<td>Craig Lockhart, Pieter Swart</td>
</tr>
<tr>
<td>ACARP Contact:</td>
<td>Patrick Tyrrell</td>
</tr>
</tbody>
</table>

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 satellite, drone and LiDAR products to assess the post-fire recovery dynamics and measure recovery and resilience.

Work undertaken in this quarter includes:
- Analysis of field data and drone imagery for mine 2 for the 6 month post-fire assessment and mine 1 for the 3 year post-fire assessment;
- Downloading and analysis of Planet Imagery of sites 2 and 3 for time series response to burns on August and September 2018 respectively;
- Proposals have been submitted for fires at two new mines with work proposed in 2019-2020 depending
on weather conditions and site availability and follow up meetings to discuss the project work;
• A number of earlier site proposals have not been successful due to site budget constraints;
• Progress report submitted to mine 2 detailing the results so far for the time-series work;
• Ongoing discussions with QPWS, QFES and UQ Gatton regarding future works.

Figure 1 Native fauna using burnt areas of rehabilitation captured with fauna cameras (top Australian Bustards, bottom Kangaroos).

Figure 2 Drone imagery of the burnt site showing vegetative recovery 6 months after the burn.

C27061
Open Path Boundary Monitoring for Operational Dust Control

ERM Australia Pacific
Damon Roddis

Value: $54,912
Report Expected: September 2019
Industry Monitor/s: Andrew Speechly, John Watson
ACARP Contact: Patrick Tyrrell

During the last quarter we concentrated on finalising the draft report, this is expected to be complete in August/September.

C28035
Topsoil Deficits in Site Rehabilitation Accelerated Transformation of Spoils to Functional Soils

University of Queensland
Emma Gagen

Value: $226,450
Report Expected: January 2022
Industry Monitor/s: Stephen White, Toni Ward
ACARP Contact: Patrick Tyrrell

The objectives of this project are to understand and harness the microbiological processes behind transformation of coal mine spoils, to functional soils. The overarching aim of the research is to accelerate soil formation from spoils, in order to overcome topsoil deficits that hinder effective site rehabilitation of open cut sites, particularly in the Bowen Basin.

A field trial to compare soil chemistry and soil microbiology differences under topsoil vs topsoil deficit conditions was planned prior to this project (July 2018-June 2019) at mine site 1. However, topsoil chemistry at the trial area was found to be no different to that of the underlying spoil (Permian). Severe drought in Queensland and New South Wales has meant a shortage of organic matter which delayed preparation of the trial area according to best practice guidelines for dispersive soils and spoils (outlined in project C24033). Mulch and gypsum have now been sourced (April 2019) and a 45 ha trial at mine site 1 is in preparation to compare various treatments for their ability to promote improved soil chemistry and to identify the microorganisms associated with this improvement. As a substitute for good quality topsoil at the trial area, commercially available biological amendments have been included as comparisons, including manure, compost, worm extract with Catapult™ microbial inoculant, and Troforte® slow release fertiliser with microbe mix. Planting is anticipated early September and the first samples for microbiology and chemistry will be collected at that time.
C28037
Local Scale Dispersion Modelling to Refine Emission Factors
ERM Australia Pacific
Judith Cox

Value: $86,344
Report Expected: March 2020
Industry Monitor/s: John Watson, Ngaire Baker
ACARP Contact: Patrick Tyrrell

The objective of this project is to complete site specific dispersion modelling to compare the use of US AP-42 and Australia specific PM10 emission factors, control factors and other relevant information that are available. The intended outcome of the project is to provide a robust demonstration that the particulate emission factors developed through a previous project, can be used to improve atmospheric dispersion modelling performance against actual observations. This will provide further evidence that the particulate emission factors are applicable to the Australian mining industry, and should be adopted as industry standard.

In this quarter, we have selected the mines to use for the site specific dispersion modelling and are in the process of updating the emission inventories to complete preliminary dispersion modelling.

C28043
Scale up Leaching Tests for Spoil Salinity Predictions
University of Queensland
Mansour Edraki

Value: $198,500
Report Expected: March 2021
Industry Monitor/s: Jason Fittler, Stephen White
ACARP Contact: Patrick Tyrrell

The kick off meeting was held on Wednesday, 20 March, 2019. There has been no changes to the objectives stated in the long proposal:
- Development of a database of salt decay curves based on medium scale (IBC) leaching test results, and associated leaching models, to establish long-term salt generation rates for a sample of spoil pile classes;
- Development of scale factors that relate laboratory results to IBC results;
- Extension of a spoil classification system that permits leaching models to be transferred between spoils within each class; and
- Recommendations for combining the research results with hydrological models to provide dynamic decay curves for specific spoil piles and capping and rehabilitation practices.

In this quarter the focus was on augmenting laboratory column leaching experiments. The previous funnel leaching experiments showed the residence time of water was not enough to encourage degradation of spoils and release of salts. Therefore, new columns 30 cm high and 10 cm wide were set up to hold moisture and spoil. The experiment is underway with leaching under both saturated and unsaturated conditions. This will make the comparison of bench-top leaching results with the medium-scale IBC tank leaching results more meaningful.

Column leaching set up at The University of Queensland

C28044
User Driven Refinement of Decision Support Tools to Inform Final Mined Landform Outcomes
Tree Crop Technologies (t/a Verterra)
Glenn Dale

Value: $250,220
Report Expected: March 2021
Industry Monitor/s: Craig Lockhart, Jason Fittler
ACARP Contact: Patrick Tyrrell

Project C24033 developed a framework to support practical, cost-effective management of dispersive spoil, including a Bayesian network-based decision support tool to facilitate application of project results. The present project aims to facilitate transfer of Project C24033 outputs into practice, and to refine the package of decision support tools through a combination of user-driven training and analysis of results from operational mine rehabilitation outcomes. The project will also extend the application of the existing decision support tools to all mined land rehabilitation in order to support improved quality and cost of rehabilitation outcomes, and confidence in meeting regulatory commitments.

An initial training session was held in Brisbane to test reception to mine rehabilitation tool and training session format. This workshop covered the principles of challenging mine spoil management; the functional basis of management interventions; and use of the Mine Spoil Rehabilitation decision support tool to forecast erosion likelihood. Based on feedback from this, the data input interface to the decision support tool is being updated to improve data entry and allow batch runs by users. When these updates are complete, a series of regional workshops will be delivered throughout Queensland and New South Wales.
Throughout the 2019 dry season, detailed site assessments will be undertaken across a range of rehabilitated site conditions, approaches, and performance outcomes to improve parameterisation of the existing Bayesian Decision Support Model and associated Best Management Practices. This will involve application of digital remote and proximal sensing approaches (electromagnetic surveying, multispectral surveying and digital terrain mapping) to characterise fine-scale (5cm resolution) spatial variation in spoil properties, vegetation occurrence, and terrain. These data layers will be used to derive secondary data layers for each pixel across the sites surveyed, including slope, slope length, catchment area, vegetation cover and erosion. The surveys will generate millions of data points for each site, and will be used to develop probability distributions for the likelihood of any given set of conditions relating to a quantitative measure of erosion.

**Exploration**

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

*University of New South Wales*
Ismet Canbulat
Joan Esterle

*Value:* $396,685
*Report Expected:* August 2019
*Industry Monitor/s:* Dan Payne
Gavin Lowing
Gift Makusha
Cam Davidson

*ACARP Contact:* Patrick Tyrrell

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

**C26023**
Borehole Data Standard

*GeoCheck*
Brett Larkin

*Value:* $87,500
*Report Expected:* August 2019
*Industry Monitor/s:* Ben Thompson

*ACARP Contact:* Patrick Tyrrell

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

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

*University of Queensland*
Joan Esterle

*Value:* $141,050
*Report Expected:* January 2020
*Industry Monitor/s:* Damien Trickey
Peter Handley
Richard Ruddock
Tim Buddle

*ACARP Contact:* Patrick Tyrrell

No report received.

**C28032**
Test of Downhole Geophysical Logging System that Provides an Assay from the In-Situ Rock Mass

*Qteq*
Benjamin Birt
Masoud Jangani
Tim Hopper
Tom Neville

*Value:* $50,000
*Report Expected:* October 2019
*Industry Monitor/s:* De Nicholls
Gareth Johnson
Mark Laycock

*ACARP Contact:* Patrick Tyrrell

We are yet to get access to a suitable field site to undertake the trial. Therefore the site component of the project work has not yet commenced.
C28033
Raw Ash to Yield Relationships
McMahon Coal Quality Resources
Chris McMahon

Value: $29,120
Report Expected: April 2020
Industry Monitor/s: Hugo Kaag, John Terrill, Rod Doyle
ACARP Contact: Cam Davidson

This project has not yet commenced.

C28045
Coal Spectral Libraries for Scanning Devices
University of Queensland
Sandra Rodrigues

Value: $86,363
Report Expected: October 2020
Industry Monitor/s: Jennifer Peats, Rick Jeuken, Rod Doyle
ACARP Contact: Cam Davidson

The objective of this project is to create a spectral library for coal (organic material) that can be used in different hyperspectral core scanning devices. Currently no spectral library for coal exists. The project will scan different coal samples with different ranks (lignite to anthracite) and coal types (focus on the lithotype banding) using sensors from the VNIR, SWIR, MIR and TIR, covering a wavelength range from 400 to 14300 nm. The concept of a ‘standard coal series’ will also be explored, using crushed samples at different size ranges, which also assists in testing the robustness of the system. This would also assist in upscaling issues from the core to the highwall, where the target is bulk variation between plies.

We currently have two core samples of each coal measure, including Baralaba Coal Measures, Moranbah Coal Measures and Rangal Coal Measures, with vitrinite reflectance values ranging from 1.2% to 1.5%. Additionally, one sample from the Juandah Coal Measures and one from the Taroom Coal Measures, with reflectance values around 0.45%. These 8 pieces of core were halved. One set of 8 halves has been scanned at Corescan (Perth) in the VNIR-SWIR range using the HIC-3 system. The MIR and TIR data set will be collected in the next months. The other halves are being prepared at the University of Queensland (UQ) for chemical (proximate and ultimate) and petrographic (reflectance and maceral composition) analyses.

Note that, except for the two pieces of core from the Rangal Coal Measures, all the other core samples came from the UQ archive. We are currently seeking support from the companies to provide small core samples (around 20 cm length) at different ranks.

Geotech

C25035
Coal Subsurface Mapping for Open Cut Selective Mining
CSIRO
Andrew Strange

Value: $412,660
Report Expected: July 2020
Industry Monitor/s: Brett Domrow, Margaret Stewart
ACARP Contact: Cam Davidson

There is a need for a reliable seam sensing system to provide selective mining capabilities for open cut coal mining. This project extends the outcomes completed in a previous stage to develop a machine-mounted radar sensing system that provides seam thickness measurements of the top layer to operators during mining. The sensing system will eventually be attached to a dozer or surface miner to provide the depth of the seam floor to operators in real-time as part of a production pilot trial.

Stage 2 involves conducting an evaluation of the sensing system attached to a mini-digger. During this evaluation, the antenna is to be housed within a metallic enclosure that protects the system from physical damage caused by coal and rock debris spilling over the top of the dozer blade during the mining process. The purpose of this stage is to establish the performance of the sensor when it is housed within a metallic enclosure when attached to similar mining machinery but prior to initiating modifications to a production machine.

Laboratory experiments have been conducted to determine which angle of metal enclosure walls introduce the least level of interference into the data. A stealth enclosure was designed and manufactured using 3mm aluminium sheet. Modifications to a mini-digger blade are currently being undertaken at CSIRO so that the antenna enclosure can be attached to the blade for this stage 2 evaluation.
C25040
Shear Strength Characterisation of In Pit Mud to Ensure Low Wall Stability

University of Queensland
Adrian Smith
David Williams

Value: $210,000
Report Expected: August 2019
Industry Monitor/s: Gavin Lowing
Leigh Bergin
Shaun Booth

ACARP Contact: Patrick Tyrrell

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

C26032
Autonomous Sensors for Evaluation of Groundwater in Spoil Dumps and Tailings Dams

University of Queensland
Byron Wicks
Erik Isokangas

Value: $349,760
Report Expected: September 2019
Industry Monitor/s: Kim Peckett
Martyn Robotham
Cam Davidson

ACARP Contact: Cam Davidson

This project will develop a sensing device to deliver greater certainty about groundwater conditions and stability of any scale of spoil dumps or tailings’ dams. The device will be able to sense the groundwater pressure, which will allow better monitoring of slope stability for spoil dumps, and embankment stability for tailings dams. A monitoring system comprising the new groundwater sensors will likely be scalable; coupling multiple sensors into meshes as opposed to single sensor monitoring; should be able to integrate into autonomous risk management systems in real time; and be low-cost.

Partnership between Mining3 and Company 1 leveraging both companies’ technologies to create a functional prototype. Modelling and optimisation of transmitter, receiver and transmission path requirements (image below). Field trial planned for Mine Site 1 to verify technology in near future.

C27011
Predicting the Impact of Complex Joint Structures on Mine Operations

University of Newcastle
Anna Giacomini
Marc Elmouttie

Value: $273,711
Report Expected: May 2020
Industry Monitor/s: Gift Makusha
Leonie Bradfield
Walter Keilich

ACARP Contact: Cam Davidson

This project proposes to develop a method for improved prediction of the 3D spatial distribution of rock mass defects and their properties ahead of mining. The project also intends 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.

Structural data from Mine Site 1 have been partitioned to define domains upon which the random fields can be based. Mean, standard deviation and correlation length of each parameter were estimated to produce evenly spaced random fields. For this purpose, a new algorithm to compute spacing statistics was implemented in both Matlab and Mathematica. Spacing and persistence statistical distributions have also been identified. The activity is still ongoing to provide adequate parameters to the statistical analysis.

Discrete fracture network analysis of a Mine Site was undertaken to provide the 3D structural data for multiple (5) strips based on completed structural mapping. Production data from Mine Site 1 has been provided. Assessment by the project team has indicated more resolution in data (spatially and temporally) is required for the proposed data mining techniques to be of value. The mine site is currently assessing this request for additional data.

Structural mapping of Mine Site 2 is in progress with initial mappings awaiting review from mine staff.
C27046
True Vector from Slope Radar Monitoring

CSIRO
Marc Elmouttie

Value: $163,036
Report Expected: October 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 is field testing integration of high precision computer vision technology with slope stability radars to address this problem. Mining companies and radar providers are supporting this project, with GroundProbe (operating at mine A) and IDS Georadar (operating at mine B). The objective of the project is to design an integrated system that is not specific to any particular slope monitoring system and can therefore provide maximum benefit to the industry.

In this quarter of the project, mine A data analysis has been completed with promising results validating the proposed system. An imaging system has now been installed at mine B. Observations of the deforming slope are being undertaken and analysis of the images has begun.

In the next quarter, further analysis of the field data (radar and imagery) provided by radar companies for mine B will be undertaken to determine the performance of the algorithm against different deformation scenarios.

C28038
Groundwater Pressures and Flows Within Spoil Dumps

University of Newcastle
Stephen Fityus

Value: $257,200
Report Expected: April 2021
Industry Monitor/s: Gavin Lowing, Kim Peckett, Leonie Bradfield
ACARP Contact: Cam Davidson

Groundwater conditions in waste dumps are critical to dump stability but they are poorly understood. The objectives of this project are to produce a detailed baseline profile of the hydrological characteristics of an advancing waste rock dump in an active mine, based on factual evidence and laboratory measurements. The project will record detailed observations of the evolution of the water table(s) and adjacent spoil moisture conditions in an advancing waste rock dump over a period of 12-18 months and use this data to produce general, high-quality hydrogeological parameter datasets for soils of category 1-1.5 and 2.5 to facilitate detailed hydrogeologic modelling of any specific waste dump.

Activity during the first quarter of this project involved installation of a set of 4 vibrating wire piezometers and 4 suction sensors in a 200m borehole in a waste dump on a participating mine site. Real time pore water pressure and suction data is now available online. Due to the amount of water needed to achieve the hole, the preliminary data shows that the moisture conditions were disturbed and are still re-equilibrating.

A capable PhD student has been identified and has been brought on board and is now engaged in conducting the literature review.

Plans are being developed for a study of textural assessment of old spoil in a deep pile at another mine site.

C28040
GSR and Numerical Modelling for Open Cut Rock Mass Characterisation

Monash University
Hamid Roshan, Hossein Masoumi

Value: $116,500
Report Expected: June 2021
Industry Monitor/s: Gavin Lowing, Lewis Carter, Thomas Hahn
ACARP Contact: Cam Davidson

This project has only recently started.

C28041
Guidelines to Improve Blasting Geotech Outcomes

University of Queensland
Italo Onederra, Sarma Kanchibotla

Value: $242,266
Report Expected: June 2021
Industry Monitor/s: Chris Davis, David Drakeley, Ross Burden, Warren Hitchcock
ACARP Contact: Cam Davidson

The main objective of this project is to develop industry guidelines and practical tools to minimise geotechnical risks and improve blasting productivity. The project will
focus on specific issues at mine sites by conducting field studies to understand the impact of adopted blasting strategies. The monitoring work will be complemented by an industry review; advanced modelling techniques and local site experiences.

The first kick off meeting for this project was held with industry monitors; at this meeting a revised program of work and budget was tabled and agreed by monitors. As part of the project, a postgraduate scholarship was advertised and the selection process completed. The scholarship was awarded to an engineer with relevant blasting experience who will be supporting all components of this project. Preliminary discussions have been held with industry monitors to secure access to sites and funding support for field related work. Site visits/workshops are currently being organised to define the details and the final requirements of the monitoring program that will be key to the development of practical guidelines.

**Health and Safety**

**C25026**  
**Reducing Risk Taking Among Australian Coal Miners**

*University of Newcastle*  
Anna Giacomini  
Mark Rubin

- **Value:** $302,235  
- **Report Expected:** April 2020  
- **Industry Monitor/s:**  
  - Bharath Belle  
  - Doug Kennedy  
  - Robyn Masters  
- **ACARP Contact:** Patrick Tyrrell

This multi-phased project aims to investigate the cause of risk-taking behaviour in Australian open cut and underground coal mines (Phase 1) as well as develop a practical intervention to reduce dangerous risk-taking (Phase 2). The aim is to improve safety outcomes through reducing risk-taking and, consequently, accidents and injuries. 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 team has finalised the procedure for the Phase 2 intervention, the Safety Choices Task (SCT) which was developed based on the results of Phase 1. The aim of the intervention is to improve positive safety norms at participating mine sites and consequently reducing risk-taking. The research team has also secured approval from the University of Newcastle’s Human Research Ethics Committee to conduct the research and we are now ready and able to proceed with data collection.

We are currently recruiting mine sites to participate in the intervention. To date we have received expressions of interest from four coal mines and are in the process of securing formal organisational consent. All four mines are from the open cut coal mining sector. We continue our recruitment efforts, concentrating on underground sites to obtain a balanced sample. We remain in discussion with approximately 20 mines throughout the Hunter Valley and the mid- and central-Western regions of New South Wales. We aim to secure an additional two to four sites for participation.

A member of our research team will be attending the Queensland Mining Industry Health and Safety Conference in August. We will present a summary of the project and outline the results of Phase 1 and our plans for Phase 2. We thank ACARP for their support in attending this conference.

**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:** August 2019  
- **Industry Monitor/s:** Occupational Health and Safety Task Group  
  - Tony Egan  
- **ACARP Contact:** Patrick Tyrrell

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

**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:** January 2021  
- **Industry Monitor/s:**  
  - Ellen Roots  
  - Shane Apps  
  - Troy O’Reilly  
- **ACARP Contact:** Patrick Tyrrell

The objectives are to:

- Develop, demonstrate, and evaluate iOS and server software to allow continuous monitoring and analysis of earth-moving equipment operator vibration exposures using off-the-shelf hardware;
- Utilise this system to obtain an enhanced understanding of the sources of elevated whole-body vibration and impact loads associated with haul truck and dozer operation at a surface coal mine; and to
• Make the software freely available for adoption by other sites.

An iOS application was written to allow iPhones to be installed in haul-trucks, 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 utilising a Raspberry Pi microcomputer has been designed and software coded to replace the iPhone. A change of site was also required.

Data are now being obtained from accelerometers mounted in both floor and seat of trucks at a central Queensland coal mine and progress has been made on analysis software. Additional modules are awaiting installation by the mine. The data have been demonstrated to be effective in identifying potential opportunities for control measures to be implemented.

C26028
Proximity Detection System Performance Testing Framework

University of Queensland
Joji Quidim
Rajiv Shekhar
Susan Grandone

Value: $268,000
Report Expected: February 2019
Industry Monitor/s: Matt Clements
Tim Gray
Tony Egan

ACARP Contact: Cam Davidson

No report received.

C27062
Augmentation to Emissions Factors

ERM Australia Pacific
Damon Roddis

Value: $78,040
Report Expected: September 2019
Industry Monitor/s: Andrew Speechly
John Watson

ACARP Contact: Patrick Tyrrell

No report received.

C28034
Mining Equipment Human Factors Design for Workforce Diversity

University of Queensland
Robin Burgess-Limerick

Value: $187,350
Report Expected: August 2020
Industry Monitor/s: Brendan Wilkins
Iain Curran
Skye Searle
Tony Egan

ACARP Contact: Cam Davidson

The objectives of the project are to:
• Identify and describe design issues with current mining equipment which are a barrier to workforce diversity;
• Document and evaluate remedial control measures currently undertaken at sites; and to
• Communicate the results of the investigation to equipment designers and mine sites.

Visits were undertaken to four Queensland surface coal mines from April 29 to May 2. Three focus group workshops were undertaken involving 17 surface mine operators and maintainers, as well as task observations at each site. The information gained has been used to begin populating an EMERST control framework for HFDD. Two required operating states are defined:
• Earth-moving equipment can be safely and comfortable operated by people of a maximum range of anthropometric diversity;
• Earth-moving equipment can be safely and comfortable maintained by people of a maximum range of anthropometric diversity.

A range of credible failure modes were identified based on the information gathered during the focus groups and site observations. A second round of site visits is planned for September.
Maintenance and Equipment

C26020
Preventing Fatigue Cracking Via Proactive Surface Dressing

Bureau Veritas AIRS
Simon Krismer

Value: $126,940
Report Expected: January 2020
Industry Monitor/s: Shane Saunders
ACARP Contact: Patrick Tyrrell

The aim of this project is to test a theoretical method for prolonging asset life, reducing down time, and reducing weld repair costs. Rather than simply monitoring the condition of equipment and structures to identify cracking as it develops, and then having to carry out the repairs, it is theorised that significant savings could be achieved by proactively surface dressing locations that are known to be susceptible to fatigue cracking, in order to remove the fatigue damage accumulated at the surface. It is proposed that the proactive surface dressing would be carried out as part of a planned maintenance program, preventing cracking from developing.

Work has commenced in the treatment of steering arm castings on the Komatsu 830E truck fleet at the partner mine site for this project. The steering arms across the fleet vary in age, ranging from original installed some years ago, to recently replaced. This offers the opportunity to demonstrate proof of concept on the older steering arms in the shorter term.

In the course of carrying out the treatments, it has already been noted that significant variation exists in the surface quality of the castings. In particular, some have heavy grind marks in regions of known potential cracking. It is not clear whether the grinding marks relate to rectification of cosmetic defects in the castings, or whether weld repairs had been carried out of the castings at the foundry. This may introduce some further factors for consideration as part of this project.

In addition, early testing is underway for the lab based rotation bending fatigue test samples that aim to demonstrate “proof of concept” for the fatigue damage removal process.

C26021
Verification of Interoperability - Collision Awareness and Avoidance Systems

CSIRO
Jeremy Thompson

Value: $105,844
Report Expected: September 2018
Industry Monitor/s: Iain Curran, Matt Clements, Paul Forsaith, Tim Gray, Tony Egan
ACARP Contact: Cam Davidson

Collision management is a major issue for the open cut coal mining industry from both safety and cost viewpoints. Proximity detection systems for mobile equipment and people are therefore vital in establishing effective collision avoidance strategies. However, there are many different proximity detection systems on the market, each one with its own proprietary hardware, communications, logging and warning systems and performance. This creates problems for a typical mine site with equipment from different manufacturers, and means either that workers are restricted to entering only certain parts of the mining operation or that they must wear multiple devices to ensure detection. The fundamental lack of interoperability between proximity detection systems is impacting the uptake of proximity detection technology and limiting the development of integrated collision management systems.

The original stage of this project developed an independent software verification tool to assess the compliance of proximity detection systems with an open industry communications protocol (ISO 21815). This tool helps to address major gaps in systems interoperability within the industry. This project is an extension of this work and will update the software tools in line with the final released ISO 21815 specification.

The current version of the specification is stable and will be considered at the August meeting of the ISO committee. Based on the feedback from this meeting the decision will be made to complete the extension project using the current version.
C27074
Mining Truck Tyre Integrity Monitoring
CSIRO
Garry Einicke
Jim Callow

Value: $107,144
Report Expected: August 2019
Industry Monitor/s: David Goodale
Ivan Heron
Stephen Broad
Tim Gray
ACARP Contact: Cam Davidson

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

C28036
Wireless Health Monitoring Mine Equipment Using RFID and Machine Learning
Monash University
Nemai Karmakar

Value: $250,000
Report Expected: April 2021
Industry Monitor/s: Stephen Broad
Tim Gray
ACARP Contact: Cam Davidson

The main objective of the project is to develop a robust yet simple monitoring system for the conveyor belts in coal industry through coupling RFID and machine learning techniques.

A PhD student has been appointed to the project and thus the literature review is progressing extensively. This includes the review of UHF and chipless RFID sensors as well as readers and different physical parameters. The selection of the optimum machine learning technique is carrying on which depends on the availability of some field data related to conveyor belt monitoring. The team is planned to visit a mine site in New South Wales for further consultation with the site engineers and to better understand the practical complexities associated with the operation of conveyor belts as well as data collection. Such a visit is expected to happen towards the end of July or early August. The team is also working on the design and analysis of the sensing structure of electromagnetic simulations which is a trial and error process and requires a conveyor belt sample. Such a sample is expected to be supplied by mine site during the field visit. Design and initiation of medium to high gain antennas is progressing parallel to the other activities listed above.

C28039
Low Frequency Noise Prediction and Validation Study
ERM Australia Pacific
Aaron McKenzie

Value: $89,584
Report Expected: March 2020
Industry Monitor/s: John Watson
ACARP Contact: Patrick Tyrrell

This project will undertake a study into the modelling and prediction of low frequency noise emission (sub 63Hz) propagation from mining operations. The objective of this project is to improve confidence in the modelling and prediction of low frequency noise impact from mining activity. This will be achieved by:
- Better quantifying of LFN emission and LFN noise propagation; and
- Improve modelling methodology in the lower frequency (sub 63Hz) spectrum validated to measured LFN levels.

To date, ERM has undertaken a literature review of both acoustic modelling algorithms applied for the purpose of noise modelling mining operations and the scope for modelling at frequencies sub 63Hz. Acoustic measurement equipment and techniques for low frequency noise components have also been reviewed. The next stage of the study will include the measurement of low frequency noise emissions from selected mining operations, with the measured low frequency noise components compared to model predictions.

C28046
Broader Contribution of Coal Sector Employment to Indigenous Individuals, Families and Communities
Myuma
Michael Limerick

Value: $199,472
Report Expected: June 2020
Industry Monitor/s: Anthony Galante
Hayden Leary
ACARP Contact: Patrick Tyrrell

The project aims to investigate the impact and contribution that employment of Indigenous persons by coal companies has made to the life circumstances of those individuals and their families and communities. The research will involve interviews, surveys and quantitative data collection in respect of a cohort of Indigenous employees at Bowen Basin coal mines. It will explore the impacts of employment on individuals and
their families in terms of not only material wellbeing, but other social and economic dimensions, including health, education, emotional wellbeing, levels of social capital and even cultural resilience.

The project commenced in May. A literature review is underway to explore current knowledge about impacts of employment for Indigenous people and to identify relevant measures, tools and comparative datasets for material, social and emotional wellbeing. The literature review will inform the design of interview questions and a survey tool. The research team has negotiated with the University of Queensland to waive the usual fee for human research ethics approvals for non-University researchers on the basis that Myuma is a not-for-profit Indigenous organisation with charitable objectives. There have been preliminary discussions with the two coal companies represented by the industry monitors about access to sites in the Bowen Basin to interview Indigenous employees. Formal arrangements for site access will be negotiated once the research design is completed and the requirements for participants are defined. In relation to one of the companies’ sites, participants will be recruited through the local Traditional Owner organisation, which has supported a number of its members into coal mining jobs.

In the next quarter, the objective is to complete the literature review and research design and seek ethics approval.

### Overburden Removal

#### C26035
Dynacut Fundamental Development: Phase 2

University of Queensland
Dihon Tadic
Erik Isokangas
Isaac Dzakpata

Value: $1,333,000
Report Expected: October 2019
Industry Monitor/s: Andrew Lau
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.

All of the experimental activities of the project have now been completed. Equipment preparation and sandstone cutting trials were performed at Komatsu’s test facility in New South Wales in April and May, with cutting in multiple rock domains investigated. Encouraging results were realised, with cutting rates significantly improved from the prior test program.

The work on conceptual mining systems has advanced in parallel and continued into June.

The final project report is currently being compiled, with submission for monitor review scheduled in the coming weeks.

#### C27063
SATS Automated Mission Planning

University of Queensland
Peter Beasley
Ross McAree

Value: $346,046
Report Expected: September 2020
Industry Monitor/s: Brian Neilsen
Shaun Booth
Stephen Broad

ACARP Contact: Cam Davidson

The Caterpillar Semi-Autonomous Tractor System (SATS) facilitates autonomous execution of production bulldozing in strip mining applications. The system is capable of performing several variants of production bulldozing; Push-To-Edge, Tip-Head and Pivot-Push.

To autonomously perform production bulldozing, the current SATS system must be provided with missions that are designed by an operator at a remote work station. Missions are the ‘packages’ of work that the bulldozer completes autonomously with one operator overseeing several bulldozers.

The project aims towards high utilisation of available time by planning plan missions autonomously and choreographing dozers.

This project aims to adapt and deploy these planning algorithms to deliver automated tactical planning capability to production dozing operations and help realise a significant reduction in the cost of overburden removal.

Work completed in the last quarter includes (i) the analysis of data collected from a field trial to benchmark the performance of the current SATS technology with results to be used as a basis for quantifying the impact of the project on productivity, (ii) the validation of
choreography algorithms for multiple dozers and a highwall excavator in pivot push to maximize the rate of overburden movement to prime, and (iii) integration of the mission planning into MineStar.

At this time the planner performing choreography has been tested with multiple real-world pit geometries. It can simulate a pushing a work block to completion in a fairly short time (in the order of seconds for a workblock of reasonable size with an arbitrary number of slots and dozers). This simulation includes a low-detail 3D material push simulation, and the resultant terrain is reasonable.

Although there are a number of unmodeled simulations still to be generated, the simulated dozing time to complete a pit correlates well with field trial data.
COAL PREPARATION

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: October 2019
Industry Monitor/s: Mario Salazar
ACARP Contact: Nerrida Scott

This project extension now focuses on direct plant tests of the deaeration techniques. 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;
- Demonstrate economic benefits by implementing a deaeration technique in plants.

In the last three months, the deaeration unit was further upgraded to improve its efficiency, including the application of wedged wire screen in froth-slurry separation, the addition of different types of impeller design at stage 1 deaeration, and the installation of a rotating sample distribution plate and agitation at stage 2 deaeration. All the units have been connected together to allow a continuous operation. Preliminary lab testing using plant coal samples has shown that nearly 80% to 90% froth reduction can be achieved at the stage 1 deaeration, while a complete froth deaeration can be achieved after stage 2 deaeration.

The pilot scale deaeration unit has been set up in a coal preparation plant in Central Queensland. A small flotation product stream will be diverted from the plant flotation product sump and fed continuously to the trial unit. The trial in the first plant is expected to be completed in two months. If there is any modification required for the deaeration unit, a second trial will be conducted after the modification to ensure the final design will be further scaled up into a full plant scale.

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

QCC Resources
Andrew Swanson
Bob Drummond

Value: $437,393
Report Expected: September 2019
Industry Monitor/s: Mario Salazar
Rod Fox
ACARP Contact: Nerrida Scott

Hyperbaric disc filters have been used to dewater fine coal concentrates in coal applications for approximately 30 years. There are in excess of 100 hyperbaric disc filter installations dewatering fine coal and froth flotation concentrate slurries, with the majority of these coal installations located in Eastern Europe and China.

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

<table>
<thead>
<tr>
<th>Feed type</th>
<th>Min. Moist. (%)</th>
<th>Avg. Moist. (%)</th>
<th>Max. Moist. (%)</th>
<th>Steam %</th>
<th>Air %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal Flotation Concentrate</td>
<td>12.4</td>
<td>15.4</td>
<td>18.5</td>
<td>15</td>
<td>25</td>
</tr>
</tbody>
</table>

The objective of this extension phase 2 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 C24047). 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 10 sites that have agreed to contribute a sample towards the research. Sample collection has been completed and all samples from the contributing sites were delivered to Bokela in Germany during 1st quarter 2019.

The raw laboratory data and preliminary report has been issued by Bokela. It is anticipated that the research will be completed, and a preliminary report will be issued for review by the end of September.

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

University of Queensland
Anh Nguyen

Value: $296,000
Report Expected: August 2019
Industry Monitor/s: Penny Walker, Rahul Patel, Steve Vaughan
ACARP Contact: Nerrida Scott

No report received.

C25018
Improving Solids Recovery and Moisture Reduction in Ultrafine Coal Dewatering

University of Queensland
Liguang Wang

Value: $184,000
Report Expected: September 2019
Industry Monitor/s: Rahul Patel
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);
- Conduct a cost-benefit analysis to compare the cost of the chemicals to the increase in solids recovery.

Over the past quarter, the particle size distribution of an SBC feed collected at a new participating site has been analysed. The results revealed that the particle size distribution of the feed largely differed from that of the previous participating site. A series of benchtop centrifugal dewatering tests were, therefore, conducted to examine the effectiveness of previously selected reagents on the newly received SBC feed. The results of the benchtop tests confirmed that these reagents could improve the solids capture (see Figure 1) while the moisture levels of the final dewatering products were comparable to each other.

Figure 1. Solids loss in bench-top screen bowl centrifuge (SBC). The upper part of each bar represents the solids loss in the screen section of the SBC and the lower part of each bar represents the corresponding solids loss in the bowl section.

In the following quarter, the newly received feed samples and the reagents selected from the bench-top scale tests will be tested using the pilot scale SBC at The University of Queensland. The final project report including a cost-benefit analysis will then be prepared.

C27016
Eriez HydroFloat in Plant Evaluation

Eriez Magnetics
Darren Mathewson, Liam Davis

Value: $155,600
Report Expected: November 2019
Industry Monitor/s: Clinton Vanderkruk, Steve Vaughan
ACARP Contact: Nerrida Scott

The Eriez HydroFloat is a small footprint, high capacity coarse particle flotation technology capable of recovering coal from a fine (e.g. -2.0 +0.3-mm) material stream using both density and surface chemistry properties of the feed. This hybrid technology combines the capacity and throughput of a density separator, with the selectivity of a flotation device.

The workplan for this project includes on-site testing at two Queensland coal processing plants. This testing is to be similar to previous test work conducted in the USA with the emphasis on determining this technology’s applicability to Australian coals. There are currently no Eriez HydroFloat units installed in the Australian coal industry and no pilot plant test work has been performed in Australia. 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.
Trials on an existing TBS feed stream have been completed at the first test site. A number of feed, frother and sampling challenges had to be addressed. Due to the very low feed ashes, the yields for the 19 tests were very high at an average of 97.1% (range of 96-98.8%) (ad) at the low product ashes with an average of 8.8% (range of 6.8-10.6%) (ad). The tailings ashes were high at an average of 75.4% (range of 66.0-79.7%) (ad) and the combustibles recoveries were extremely high at an average of 99.2% (range of 98.4-99.7%) (ad). As expected, the greatest variation in performance was in the +1.4 mm size fraction which ranged from 79 to 96.3% (averaged 89.4%) (ad). The yield of the other size fractions was >95% (ad) on all but one occasion (ie for one size fraction for one test). The feed, product and reject samples from eight tests were float-sunk. The results are being confirmed by the lab, but the preliminary conclusion are that the cut points were high at ~2.4 RD with negligible coarse coal losses.

Testing at the second site (on a flotation tails feed stream) has been delayed until October, after a major shutdown has been completed.

C27064
Dry Beneficiation Using FGX and X-Ray Sorters
A&B Mylec
Glenn Sherritt

Value: $112,000
Report Expected: September 2019
Industry Monitor/s: Naomi Pritchard, Rahul Patel
ACARP Contact: Nerrida Scott

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 mine sites where either wet processing is an unpalatable option or an in-pit option for those Australian coal mine sites where either wet processing is an unpalatable option or an in-pit option for those Australian coal mine sites where either wet processing is an unpalatable option or an in-pit option for those Australian coal mine sites where either wet processing is an unpalatable option or an in-pit option for those Australian coal mine sites where either wet processing is an unpalatable option or an in-pit option for those Australian coal mine sites where either wet processing is an unpalatable option or an in-pit option.

The samples for the FGX middlings test procedure have been returned to ALS for final float/sink testing to complete the test program.

C27065
Integrated Investigation of Solid Capture and Moisture Reduction of Fine Clay Tailings
University of Queensland
Anh Nguyen

Value: $220,000
Report Expected: July 2020
Industry Monitor/s: Steve Vaughan, Tom Wilson
ACARP Contact: Nerrida Scott

The main objective of the project is to design experiments and test work and examine the effect of chemicals (flocculants and surfactants) on the coal tailings concerning the dual functionality of capturing fine clay particles and reducing the final moisture of dewatered tailings.

Process water chemistry of three different CHPPs were collected and analysed. It was identified that Na+, Ca2+ and Mg2+ ions are the main salts in the process waters. The effect of these salts concentrations on pure kaolinite and montmorillonite flocculation behaviour using cationic, anionic and non-ionic polyacrylamide (PAM) flocculants was studied.

The results on anionic (widely used flocculant in coal and coal tailings dewatering) and cationic PAM showed that the presence of 2000 mg/L Na+ decreased the settling rate of kaolinite sharply due to the inhibition of kaolinite flocculation. In the presence of 100 mg/L Mg2+ or Ca2+ ions similar behaviour was observed. However, consolidation of the settled particles was increased. Further studies on flocs size, shape and suspension viscosity revealed that these salts can contract both anionic and cationic flocculants, resulting in the flocculation efficiency reduction. But, surface charge neutralisation was the reason for improved settled particles consolidation ratio.

Interestingly, non-ionic PAM resulted in an improved settling rate and consolidation in the presence of the salts. It was confirmed that Na+, Mg2+ and Ca2+ do not interact with non-ionic PAM and they only contribute on...
kaolinite particles surface charge neutralisation.

In addition to the previous finding that currently applied flocculants in most CHPPs cannot flocculate montmorillonite (smectite type clay), it should be noted that applied anionic PAM in most CHPPs is not salt tolerant and its efficiency decreases with increasing process water salinity.

Polymerisation facilities have been established at our lab and designing/modifying salt-resistant and montmorillonite selective flocculant is underway.

C28052
Application of Agglomeration to Minimize Moisture and Maximize Yield

University of Newcastle
Kevin Galvin

Value: $146,342
Report Expected: August 2020
Industry Monitor/s: Clinton Vanderkruk, Kevin Rowe, Penny Walker
ACARP Contact: Nerrida Scott

The objective of this project is to investigate a new application of a novel agglomeration technology to improve the dewatering of fine coal flotation product. Laboratory based studies will be conducted to determine the yield, ash, and moisture benefits of the technology versus the oil consumption to establish the technical and economic viability of the approach.

The novel fine coal agglomeration technology, applied at reduced binder levels, is expected to cause partial agglomeration of the ultrafine coal, reducing the losses of ultrafine coal in a screen bowl centrifuge. The partial agglomeration will also reduce the final moisture content, ensuring the extra yield does not result in excessive moisture. It is also anticipated that there will be further reduction in the product ash.

C28062
Improving Operation and Control of Centrifugal Dewatering Using a Novel Online Tool

University of Queensland
Liguang Wang

Value: $157,400
Report Expected: November 2020
Industry Monitor/s: Josh Kowalczuk, Rahul Patel
ACARP Contact: Nerrida Scott

The objectives of this project are to:
- Develop and evaluate an online tool for monitoring the solids content and particle size distribution of the feed and discharge of centrifuges;
- Improve the operation and control of centrifugal dewatering for ultrafine coals.

An apparatus for measuring the solids content of a material stream has been built. An imaging acquisition and analysis system has been developed.

In the following quarter, the newly built apparatus and the image analysis algorithm will be used to quantify the solids content of the feed and discharge of centrifugal dewatering test units.

Environmental Improvement

C27067
Tailings Management - Dewatering of Slurry Tailings at Disposal Site

University of Newcastle
Craig Wheeler

Value: $150,000
Report Expected: October 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.

Complete pilot scale testing on a dewatering flume has been conducted and a steady state model of the flume has been developed, which is a function of the system
geometry, material properties and operating conditions. The model was found to provide good agreement with measurements and further provides the ability to predict scale-up performance of a system. A 3:1 scale of the original pilot rig is currently in the build stage, which will be used to validate the model under scale-up conditions. Once validated under scale-up, the model can be used to design flumes of any scale, including full-scale. Furthermore, the transient behaviour of a dewatering flume is also being examined through simulations, the development of which will use the experimental and steady state model results.

C28059
Impact of Water Quality in CHPPs

Basacon Services
Bruce Atkinson

- **Value:** $111,414
- **Report Expected:** February 2021
- **Industry Monitor/s:** Kevin Rowe, Rebecca Fleming
- **ACARP Contact:** Nerrida Scott

This project involves the monitoring of CHPP water quality across eight different CHPPs, every month for an eighteen month period. During that period, sets of three standard corrosion test coupons are located at each of three different locations at each CHPP, for a total of twelve months, ranging from background reference locations to regularly wetted locations within the CPP.

Detailed water quality will be analysed monthly for each of clarified water and ‘fresh’ makeup water. The project will quantify:
- Degree of concentration of water quality parameters that results in CPP recirculation (difference between clarified water and makeup water);
- Corrosion rates for standard mild steel specimens (coupons) located at each site;
- Any correlations between measured corrosion rates and water quality;
- Any correlations between site reagent consumption (flotation and dewatering reagents) and water quality.

Reference corrosion ‘coupons’ were placed at each of the eight CPPs during May 2019, and monthly water collection and analysis has commenced.

**Fine Coal**

C23045
Full Scale Trial of the Reflux Flotation Cell

University of Newcastle
Kevin Galvin

- **Value:** $294,820
- **Report Expected:** September 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 m$^3$/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 rougher product was then cleaned in a second stage. In general, the final product ash values were about 5%, and always well below the result indicated using the tree curve. The work has built confidence on the potential for cleaning. Other experiments have been conducted to examine much higher throughputs, equivalent to well over 1000 m$^3$/h in a 2.0 m diameter unit.

There have been significant changes to this 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.

Following the tender process, it was necessary to review the design for trialling the Reflux Flotation Cell to bring the project into budget. Previously it was assumed that the existing Rix Creek facility would result in project savings, this has not happened due in part to the refurbishment requirements. The main conclusion is that a single RFC unit will now be sufficient for achieving high throughput, recovery, and high level product cleaning. It
will be possible to undertake a rougher trial at rates approaching 1000 m³/h, and also a rougher-cleaner combination in the one cell.

The final design for this project has been completed. Full design and Hazop reviews have been undertaken. The RFC modular system is largely constructed, and the electrical system design completed. It is therefore anticipated that the construction phase will be well underway by the next quarter. The design scope has been released to tenders, and the tenders received. These are currently being reviewed.

C24049
Performance Enhanced Diesel Collector for Coal Flotation
CSIRO
Shenggen Hu

Value: $148,013
Report Expected: August 2019
Industry Monitor/s: Clinton Vanderkruk, Mario Salazar
ACARP Contact: Nerrida Scott

The final report for this project is being internally reviewed prior to being sent to the industry monitors for approval.

C25009
Rapid Extraction of Frothers from Process Water
University of Newcastle
Jamie Dickinson

Value: $122,965
Report Expected: August 2019
Industry Monitor/s: Kevin Rowe, Mario Salazar
ACARP Contact: Nerrida Scott

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

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

Value: $165,582
Report Expected: July 2019
Industry Monitor/s: Mario Salazar, Rahul Patel
ACARP Contact: Nerrida Scott

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

C25019
Adaptation of Coal Grain Analysis to Improve Yield Estimation
QCC Resources
Bruce Atkinson

Value: $165,584
Report Expected: August 2019
Industry Monitor/s: Dion Lucke, Jason Schumacher
ACARP Contact: Nerrida Scott

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

C26001
Impact of Sub Optimal Operation: Stage 2
CSIRO
Mike O’Brien

Value: $41,500
Report Expected: September 2019
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 update of the spreadsheet is not yet completed.
C27012
Towards Better Fine Coal Classification

QCC Resources
Andrew Swanson
Mike O’Brien

Value: $99,920
Report Expected: September 2019
Industry Monitor/s: Mario Salazar
Rod Fox
Tom Wilson

ACARP Contact: Nerrida Scott

The objectives of this project are to:
• Review/correlate all past NERDDC and ACARP work on fine coal classification (going back to the original fine coal classification at CRL in circa 1979);
• Literature survey on what is happening in research and other minerals in fine classification;
• Hold extensive discussions with OEMs to work out what are the trends around the world;
• Identify current best practice in Australian and overseas coal industry;
• Carry out simulations to indicate what the potential current losses/future gains there will be from fine coal classification improvements;
• Provide a framework for plant operators and designers to make the best choices for fine coal classification equipment/installation; and to
• Make recommendations with regard to future R&D on fine coal classification and/or pilot plant trials.

The literature review of NERDDC and ACARP, Australian Coal Preparation conference papers and International Coal Preparation Congress papers has been completed. The literature review identified considerable work into cyclones, sieve bends and ultrafine vibrating screens but no new processes for the classification of fine coal. Further research is now being carried out to identify if there are fine particle classification technologies currently in use, or development, in other mineral industries that may be of interest to the coal industry.

Six fine particle classification OEM’s were surveyed to gather information regarding best practice, common problems or challenges and the direction of the OEM’s research and development in these areas. This information was collated and is used to develop a survey for plant operators. The survey of plant operators is currently underway and will lead into a desktop study to quantify the impacts of differing technologies and performance on overall yield.

C27021
Model Informed Control Strategy for Coal Flotation

University of Queensland
Kym Runge
Nee San Yap

Value: $199,571
Report Expected: January 2021
Industry Monitor/s: Clinton Vanderkruk
ACARP Contact: Nerrida Scott

The objective of this project is to develop a model informed control strategy for coal flotation. The project will involve application of AMIRA P9 flotation models developed for metalliferous flotation informed by measurements performed by CSIRO’s new Interfloat™ sensor (Figure 1) and a froth vision system.

Test work for this project will be conducted on a mine site in Queensland. Sensors will be mounted above an operating Jameson cell which will be operated at different operating conditions. Sampling will be performed to determine yield and ash content and correlated with sensor measurements. Models will be calibrated and tested to determine if they can be effectively used for control – maximising coal yield and selectivity and minimising reagent use.

This project is a collaboration between the SMI-JKMRC, University of Queensland and CSIRO. The UQ master’s student who will perform the experimental test work for this project has been recruited and commenced in January 2019. The student has reviewed the literature and put together an experimental site test work program, after a visit to site for planning in March. Over the last three months camera and other measurement equipment has been purchased by the SMI-JKMRC and is currently being tested. CSIRO has built the Interfloat™ sensor suitable for installation above the Jameson cell and is currently commissioning the device in Melbourne. The plan is for a team of researchers to be onsite for six weeks to collect the data for this project in August and September.
C27025
Quantifying the Step Change Benefit of Reflux Flotation Cell Circuits

University of Newcastle
Kevin Galvin

Value: $167,020
Report Expected: October 2019
Industry Monitor/s: Kevin Rowe
ACARP Contact: Nerrida Scott

The objective of this project is to quantify the value proposition of applying the Reflux Flotation Cell (RFC) in a number of identified applications, utilising a broad range of feeds supplied by producers. Laboratory scale RFC circuits will be used to obtain the data. The concept of complete recovery of liberated fine coal and complete washing of the product will be investigated, thus quantifying the trade-off between the recovery, moisture, grade, and throughput, and hence return on investment. The project will provide a basis for maximizing the feed throughput achievable and hence a clear understanding of the value proposition of applying this technology as a “bolt-on” or green-field solution. New circuit configurations will be examined.

This study will be conducted in the laboratory using laboratory scale Reflux Flotation Cells. The expected outcome will be valuable knowledge showing the relationship between product grade and combustible recovery as a function of throughput. The Reflux Flotation Cell will be configured in new ways aimed at addressing known challenges. A first stage RFC rougher will be used to firstly maximize the overall system throughput, while the second stage RFC will be applied to the cleaning of the first stage product. A recycle ratio, R, will be applied to the first stage tailings, returning R x the tailings rate back to the feed. This approach ultimately permits complete recovery of the combustible material prior to the cleaning stage, and a basis for undertaking a cost-benefit analysis in terms of the throughput, and ultimately the required capital.

A series of experiments was conducted using a relatively high feed flux. This work suggests that a wash water flux of about 0.9 cm/s will be sufficient for a feed flux of 3 cm/s and also 5 cm/s. Very strong cleaning was observed as a function of the wash water flux taking the separations to well-left of the tree curve. These results show that the rougher-cleaning can be achieved within the one system at very high throughput. We are further examining the issue of recovery and its dependence on the water content reporting with the gas flux to product.

A new tailings sample, at 51.1% ash, derived from a PCI coal, was investigated. The tree curve indicated a 23% recovery at 13.3% ash. The RFC system, operated at 3 cm/s feed rate, achieved a recovery of 74.8% at a product ash of 10.1%. Then at 5 cm/s the RFC achieved a slightly lower recovery of 72.4% at 9.9% ash. Other recent work involved a thermal coal feed with an ash of 55%, with excessively large particles up to 2 mm. The product ash was 9.2% ash, but the recovery varied with the operating conditions due to the coarse particles. The data is being reviewed for a finer size range up to 0.5 mm. Other work concerned with maximizing recovery and cleaning is continuing.

C27026
Ultralow Ash Coal by 3D Binder Flotation

University of Newcastle
Kevin Galvin

Value: $152,020
Report Expected: October 2019
Industry Monitor/s: Kevin Rowe, Rahul Patel
ACARP Contact: Nerrida Scott

The objective of this project is to investigate the potential to produce a coal-water mixture fuel, ideally less than 1 wt% ash, through liberation by grinding, followed by beneficiation via a novel agglomeration method referred to as 3D Flotation. Different levels of grinding will be used to achieve increasingly lower ash product. The final clean coal product will be further investigated in terms of its size distribution, rheology and stability to quantify its suitability for transport, storage, and utilisation. Thus this study is a precursor to a larger scale trial using an engine system to generate electricity.

Different levels of fine grinding will be used to achieve different levels of liberation. Each feed will then be subject to the 3D Binder Flotation technology to produce a fine coal product. A series of experiments will be undertaken to optimise the binder addition to maximize yield. The combustible recovery-versus product ash will be plotted for different levels of liberation in order to assess the limits on what is possible for the coal. Several coals will be studied, ideally identified by coal grain analysis.

An initial program of experiments was conducted, commencing with a flotation product generated from the cyclone overflow stream that is presently sent to tailings. The flotation product is preferred for three reasons, firstly, because the agglomeration only needs to be applied to about 20% of the original feed volume, secondly the subsequent grinding only needs to be applied to the fine coal (and not the mineral matter), and the grinding proceeds at a higher solids concentration.

We observed a small reduction in ash% from 6.2 to 4.9%. We are looking to conduct coal grain analysis to confirm this. Further analysis showed that the level of iron in the
product had increased significantly, due to the use of the grinding media. The extra iron in the product gave the impression of a lower yield, but may also have led to a higher product ash % if the iron was also recovered.

More recently, we have commenced a new series of experiments using a ceramic milling arrangement. The samples are currently being analysed. This new milling arrangement has been successful. However, a number of issues concerning the experimental protocol developed concerning the presence of the salt in the binder, and the methods used to release the salt. In the end a series of experiments at different salt concentrations was conducted. The work involving no salt addition provided an immediate way forward, showing again that this feed does not liberate.

A coarser feed was sourced from NSW, offering prospects for a lower ash through liberation. We continued to use the new approach involving no salt. A clean coal product was generated and then subjected to significant grinding and liberation. The new product released significant levels of brown/grey waste. Initial results indicated the stage 1 product ash to be far too high for this work at 19% ash. Liberation only reduced the ash to 14%. We also concluded the need to limit the binder addition otherwise we simply recover the higher ash composites. We are currently waiting on a feed that we believe offers very strong prospects for achieving lower product ash values.

C27033
Comprehensive Flotation Model using CGA Particle Surface Composition

Basacon Services
Bruce Atkinson

| Value:     | $74,527 |
| Report Expected: | August 2019 |
| Industry Monitor/s: | Chris Urzuaa |
| ACARP Contact: | Nerrida Scott |

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

C28050
Developing a Frother Decision Tree for Australian Coal Flotation Plants

University of Queensland
Yongjun Peng

| Value:     | $168,666 |
| Report Expected: | February 2021 |
| Industry Monitor/s: | Luke Dimech, Mathew Merryweather |
| ACARP Contact: | Nerrida Scott |

The objectives of this project are to:
- Understand frother-saline water-coal interactions;
- Develop a frother decision tree based on coal properties and water properties; and to
- Guide plant engineers to identify the best frother for their coal preparation plants.

More than 20 frother samples, including pure chemicals and commercial frothers, have been obtained for the test work. These frothers cover the major types of frothers currently available in the market and also include the frothers which are currently used in participating coal preparation plants. The properties of the frothers, such as flash point, viscosity and solubility, have been identified.

Four participating coal preparation plants have been visited. The project scope and research plan have been discussed with the plant process team. Plant information including coal type, water salinity, flotation operation conditions and performance have been obtained. Coal samples and process water samples have been collected for the test work. The water samples will be assayed and classified by salinity, ion type and ion content. The coal samples will be classified by ash type and ash content, the degree of coal surface oxidation and their petrographic properties. Both water and coal classification will be used as input of frother decision tree.
Reducing Diesel Consumption while Improving Fine Coal Flotation Through Controlled Diesel Emulsification in Saline Water

University of Queensland
Yongjun Peng

Value: $153,450
Report Expected: February 2021
ACARP Contact: Nerrida Scott

The objectives of this project are to:

- Develop an in-situ emulsification monitoring system in coal flotation based on FBRM technology;
- Evaluate the performance of traditional mechanical techniques (e.g., static mixers, rotor-stator mixers) in diesel emulsification in saline water;
- Develop a new continuous emulsification technique (e.g., power ultrasound) to produce stable sub-micron diesel droplets in saline water;
- Recommend the most suitable emulsification device for continuous operation in the plant based on the emulsification efficiency in saline water and capital and operational costs of the device;
- Identify chemical emulsifiers effective at a low dosage (below 1 ppm) to stabilise diesel emulsions in saline water;
- Develop the most cost-effective emulsification strategy by combining the physical emulsification with chemical emulsifiers; and to
- Comprehensively evaluate the benefits of diesel emulsification for coal preparation plants.

FBRM is developed as an in-situ technique to monitor the emulsification process. Diesel emulsions with a droplet size ranging from 1 micron to 100 micron were prepared and the droplet size was measured by Malvern Mastersizer and FBRM at the same time. Models are developed to correlate the FBRM results with the standard Malvern Mastersizer results. Physical emulsification devices, including static mixer, rotor-stator mixer and power ultrasound, have been obtained and will be developed for diesel emulsification.

Lab scale flotation tests using a mechanical flotation cell will be carried out.

New Approach to Simultaneously Improving Flotation and Subsequent Froth Breakdown

University of Queensland
Liguang Wang

Value: $192,600
Report Expected: November 2020
ACARP Contact: Nerrida Scott

The objectives of this project are to:

- Develop and assess a new approach to improving the flotation efficiency of fine coals while keeping fast breakdown of the discharged froth;
- Prove the new approach on an industrial scale;
- Provide a fundamental understanding of this new approach.

Lab scale flotation tests for a coking coal sample from a participating site have been carried out with the proposed new approach. The tests were conducted in batch mode using a flotation column. The results show significant improvement in the flotation kinetics. More specifically, the results show a 40% increase in the flotation rate constant.

In the next quarter, lab scale flotation tests using a mechanical flotation cell will be carried out.

Review of the Current Australian Standards for Coal Flotation Testing-Phase 1

University of New South Wales
Seher Ata

Value: $120,000
Report Expected: May 2020
Industry Monitor/s: Jack Lauder
ACARP Contact: Nerrida Scott

The objective of the project is to review the types and applications of test procedures that are currently being practiced. It is intended to test the standards by conducting test work using various commercial and research laboratories and then to use their reported results to determine the variation within the data obtained.

Coal products from two separate coal preparation plants were obtained through the industry contact. The samples are currently being under preparation for flotation testing.
C28060
Measuring and Correlating CGA Data at Particle Topsize

Basacon Services
Bruce Atkinson

Value: $55,444
Report Expected: November 2019
Industry Monitor/s: Chris Urzaa, Tim Manton
ACARP Contact: Nerrida Scott

This project involves sizing a coal sample into separate size fractions (-31.5 +16, -16 +8, -8 +4, -4 +2 -2 +1 and -1 mm) to allow CGA to be determined on each size fraction individually, *in the as-received sample state*. In addition, a composite sample has been carefully prepared from the individual size fractions, and the composite has been crushed, subdivided and ground to – 1 mm for a routine raw sample CGA.

The specific objective is to determine whether the CGA data mathematically re-combined from analysis of the individual size fractions ‘at top-size’ retains the same correlation to a ground raw sample CGA as if the raw sample had first been crushed, subdivided and ground to – 1 mm.

In addition, a single lump of coal will be analysed by CGA as progressive slices, and compared to its bulk composition after grinding to minus 1 mm.

The coal sample has been received, sized and subdivided for preparation of all of the CGA specimen blocks. A large number of CGA images have been prepared, and the coal grain analysis has commenced.

---

General

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: September 2019
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 maximize 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’. Figure 1 shows the data to date with a trend in the data showing that as the g force is lowered the amount of minus 1 in the oversize material decreases. The three runs at just above 1 g were all at 8Hz and at different feed rates.

![g-force Versus Retained 1.0 mm material in the oversize](image)

Figure 4. g-force versus the amount of minus 1 mm material in the oversize.

Work is progressing but had been delayed due to issues with leakages in the screen’s infrastructure. This has been addressed and work will commence on the final set of runs this month. Final stages of the test work are expected to be completed by end of August.
C26011
CSIRO Instruments at Multiple Plants

CSIRO
Mike O’Brien

Value: $427,798
Report Expected: February 2020
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 be subject to industry pressures influencing the feasibility of their committing to the project.

The objectives 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;
• Identify and engage with potential commercialisation partners to build a sustainable commercially available source of instrumentation systems.

Work is progressing to install these instruments in a Bowen Basin mine site. Detailed discussion has been held and detailed circuit diagrams and instrumentation specifications have been produced. CSIRO has four units ready to be installed just waiting now for the plant to give the final approval.

C26012
Improved Flotation Recovery Via Controlling Froth Behaviour - Stage 2

University of Queensland
Liguang Wang

Value: $100,000
Report Expected: September 2019
Industry Monitor/s: Naomi Pritchard
Rebecca Fleming

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.

The second round of plant trials for the froth monitoring systems was carried out at the participating CHPP for two weeks in early April. Two froth diagnostic systems, A and B, were installed and tested in parallel in the flotation plant. Compared with the previous round of the plant trial, more data were collected at various operational conditions, facilitated by adjusting frother dosage, aeration, and froth depth. Analysis of the collected samples and data (i.e., the outputs of the froth monitoring systems) suggested that there was a strong correlation between combustible recovery (or yield) and the outputs of these two systems. Both System A and System B were superior to the conventional diagnostic tool that is presently used in the plant.

Attempts were made to analyse the residual MIBC concentration within the coal slurry and the process water samples collected from the CHPP using the newly built prototype of the frother concentration measurement system. An issue with the analysis has been identified with unknown chemical species present in the slurry and the process water, which interfere with the frother concentration measurement. The main focus of the following quarter will be to further improve the current technique to overcome the identified issue.
C26016
Benefits of Online Thickener Underflow Rheology Measurements

Clean Process Technologies
Alexander Everitt
Noel Lambert

Value: $251,000
Report Expected: October 2019
Industry Monitor/s: Mario Salazar
Naomi Pritchard
ACARP Contact: Nerrida Scott

This project will find how useful are the rheology measurements generated by the Thickener Underflow Monitor (TUM). The TUM was developed by Clean Process Technologies (CPT) in project C24048. The TUM is currently able to generate information regarding the rheology of coal thickener underflow (as well as solids concentration m/m and v/v, slurry density and particle density), but the usefulness of this information is not well understood.

It is the purpose of this project to determine if and how these rheology measurements can be applied to standard thickener operations, paste thickener operations, secondary thickening operations, belt filter presses and other mechanical dewatering devices to see if online rheology measurement of tailings thickener underflow can be used to:
• Optimise thickener operation;
• Optimise paste thickener operation;
• Reduce flocculant consumption to belt filter operations;
• Reduce flocculant consumption in secondary flocculation; and
• Provide a means for maintaining more consistent operation of all the above systems.

The Thickener Underflow Monitor and Power Supplies have undergone some rewiring and identification of wiring to conform with site standards.

C27004
Improving Coal Flotation with Oscillatory Air Supply

University of Queensland
Liguang Wang

Value: $217,000
Report Expected: September 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.

Three primary froth databases for review had trending studies with frothing conditions performed.

The focus with data review has been to provide different set examples of evenly distributed mass outcomes with successive effective liberation of coal from non-coal. The purpose being to establish what reasonable liberation / separation looks like for coals of different rank and coal quality character. Next stages will apply statistical methods to the good correlations established from typical froth procedures with regression definition and limits for effectively frothed outcomes.

A significant part of this project has always been to establish reagent dosage effects with rank and other coal quality outcomes and supply guidelines for use. These effects have been observed through the trending analysis done to date and will be documented for use also.
Three secondary sets of froth data have been compiled for their special interest / notes for froth flotation methods.

Presentation to the industry monitors of trends to date has been performed and formal reporting of outcomes is due for commencement.

**C27032**

**Methodologies for Applications of CGA: Handbook**

Basacon Services  
Bruce Atkinson  
Graham O’Brien

<table>
<thead>
<tr>
<th>Value:</th>
<th>$51,422</th>
</tr>
</thead>
<tbody>
<tr>
<td>Report Expected:</td>
<td>August 2019</td>
</tr>
</tbody>
</table>
| Industry Monitor/s: | Chris Urzaa  
Morgan Blake  
Pam White |
| **ACARP Contact:** | Nerrida Scott |

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

**C27050**

**Detection of Non-Ferrous Broken Pick Tips and Clay Balls in the DMC**

CSIRO  
Mike O’Brien

<table>
<thead>
<tr>
<th>Value:</th>
<th>$61,280</th>
</tr>
</thead>
<tbody>
<tr>
<td>Report Expected:</td>
<td>September 2019</td>
</tr>
<tr>
<td>Industry Monitor/s:</td>
<td>Clinton Vanderkruk</td>
</tr>
<tr>
<td><strong>ACARP Contact:</strong></td>
<td>Nerrida Scott</td>
</tr>
</tbody>
</table>

The objective of this project is to adapt an acceleration sensor currently used on screens to ‘listen’ for and alert operators to the presence of non-ferrous pick tips from underground mining operations and for the formation of clay balls in the Dense Medium Cyclone (DMC). Detection and notification to the operators of the presence of pick tips in the DMC will prevent further damage and decrease repair/replacement cost and associated lost production due to down-time. The early detection of clay balls is essential to prevent build up and blockages resulting in misplaced material reporting to the product. Often these pick tips and clay balls go unnoticed while recirculating in the DMC for considerable periods before their presence is observed by the “noise” they make; only then are steps taken to remove them from the cyclone.

The vibration based detection system has been tested in the laboratory and is now ready for deployment. The instrument its cabinet and on board computer are ready to be installed. The team has been in contact with mine-site personnel and are currently waiting for approval before proceeding. Figure 1 shows an image of the signal in red (FFT) with spikes on the red signal being a tungsten carbide tip being scrapped on the surface of a tile in air. The white signal is the background noise collected without any contacts. It is expected that the frequency response will shift to lower frequencies when in the medium in a DMC.

**C28061**

**Quantitative Based Structural Integrity Evaluations Using Modal Parameters Estimation**

Mincka Engineering  
Fidel Gonzalez

<table>
<thead>
<tr>
<th>Value:</th>
<th>$363,651</th>
</tr>
</thead>
<tbody>
<tr>
<td>Report Expected:</td>
<td>April 2020</td>
</tr>
</tbody>
</table>
| Industry Monitor/s: | Kevin Rowe  
Peter Shumack  
Phillip Enderby |
| **ACARP Contact:** | Nerrida Scott |

A dynamic response test was done on the week of 15 July to a nonoperational site to extract the modal parameters of the structure. It was found that this structure does not have enough energy to excite the modes of interest.

Another operational mine site has been secured and a test structure has been selected in agreement with their engineering and maintenance team. An instrumentation plan needs to be sent on the week of 21 July for their evaluation. Mine site requirements for the onboarding of the research team will be issued after the instrumentation and testing plan is approved. It is expected that after the onboarding requirements are met and the instrumentation equipment arrives, the testing will commence at the start of September.
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: | September 2019 |
| Industry Monitor/s: | Clinton Vanderkruk, Rahul Patel |
| 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, e.g., after a shutdown or outage. The most prospective of these options and any operating procedures will be tested at a plant.

The report is undergoing internal CSIRO report review and should be released in the near future.

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

CSIRO
Mike O’Brien

| Value:     | $145,255       |
| Report Expected: | August 2019 |
| Industry Monitor/s: | Mario Salazar |
| ACARP Contact:  | Nerrida Scott |

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

C25015
Pilot Plant Scale Testing of Modified Downcomer in Jameson Cell

CSIRO
Shenggen Hu

| Value:     | $184,149       |
| Report Expected: | September 2019 |
| Industry Monitor/s: | Clinton Vanderkruk, Rahul Patel |
| ACARP Contact:  | Nerrida Scott |

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

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

The pilot scale test rig was developed by modifying a 500L Jameson cell from Glencore Technology with mass flowmeter and RTD test facilities. One suitable plant test site was identified based on the considerations of coal types, frother type and material handling. As there is no ground space for the test rig, the rig has to be installed at the second floor of the plant. The test rig was securely installed in August by considering the structure soundness of the plant floor and safe measures for holding the rig. Pilot scale testing of modified downcomer in Jameson Cell was carried out in September and October. Analysis of samples is being carried out. Based on results obtained from parts of samples, the modified downcomer increased the combustibles recovery by 3 to 8%. It was also found that the use of the modified downcomer can decrease the feed pressure by 21 to 25%.

The final report is being internally reviewed.

C25016
G Force Reduction and Failure Monitoring of Multi Sloped Screens

CSIRO
Mike O’Brien

| Value:     | $190,282       |
| Report Expected: | September 2019 |
| Industry Monitor/s: | Clinton Vanderkruk |
| ACARP Contact:  | Nerrida Scott |

This project has two objectives, designed to address the ACARP priorities of optimising maintenance practices and equipment designs to deliver improved process efficiency at lower cost. It will provide a detailed proof of concept on desliming and drain and rinse screens by:

- Determining the effect of further reducing the screen g force on desliming and drain and rinse screens on screening efficiency;
- Monitoring a screen continuously for failure indicators using the CSIRO/ACARP-developed system to show that the system is viable for use as a long term indicator of imminent screen failures.

The drain and rinse and desliming screen are still operating without failure. The reduction of g force does not appear to have any detrimental effect on the desliming or drain and rinse operation of the screens. Report writing is in progress.
**Major Projects**

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

University of Newcastle  
Kevin Galvin

<table>
<thead>
<tr>
<th>Value:</th>
<th>$1,318,748</th>
</tr>
</thead>
<tbody>
<tr>
<td>Report Expected:</td>
<td>August 2019</td>
</tr>
<tr>
<td>Industry Monitor/s:</td>
<td>Kevin Rowe</td>
</tr>
<tr>
<td>ACARP Contact:</td>
<td>Nerrida Scott</td>
</tr>
</tbody>
</table>

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.

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. The removal of the facility from the site is now complete.

**Process Control**

**C26013**  
Effect of Flotation Water Chemistry on Coal Chemistry, Fluidity and Coke Quality

University of New South Wales  
Noel Lambert  
Seher Ata

<table>
<thead>
<tr>
<th>Value:</th>
<th>$169,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Report Expected:</td>
<td>October 2019</td>
</tr>
</tbody>
</table>
| Industry Monitor/s: | Clinton Vanderkruk  
Rebecca Fleming |
| ACARP Contact: | Nerrida Scott |

The aim of this project is to expand on project C25011. An increased salinity of the water was found to reduce coal fluidity. Previous flotation experiments using an artificial salt water (at pH 9 and varying concentrations of salt) showed that the water recovery increases with water salinity as well as frother dosage. The yield of coal also changed with salt concentration. However, the samples showed limited fluidity. It was suspected that particle size (-150μm) may be a factor. A new sample has been received and is being prepared. The sample will be crushed and classified to -355μm +250μm, -250μm +150μm, -150μm +90μm, -90μm +45μm. The samples are to be split and vacuum sealed. A new set of adsorption experiments and flotation experiments are proposed. The experimental program includes varying the proportion of coarser and finer particles. It is believed that poor desliming could also be detrimental in the fluidity of a coal flotation product since fines have low fluidity and retain more water.

**C28073**  
Novel Processing to Reduce the Cost of Generating Dry Stackable Tailings

University of Newcastle  
Kevin Galvin

<table>
<thead>
<tr>
<th>Value:</th>
<th>$141,342</th>
</tr>
</thead>
<tbody>
<tr>
<td>Report Expected:</td>
<td>October 2020</td>
</tr>
</tbody>
</table>
| Industry Monitor/s: | Andrea Crawford  
Clinton Vanderkruk  
Kevin Rowe  
Penny Walker  
Nerrida Scott |

An entirely new approach to processing tailings will be investigated at a laboratory scale, the ultimate goal being to achieve dry-stackable tailings. Hydrophobic aggregation using cationic surfactants and or polymers will be used to form hydrophobic flocs that can be either agglomerated or floated using ultrafast separations. This
process, combined with more standard dewatering technology, should concentrate and dewater the clay / siliceous minerals to achieve a moisture sufficient for dry-stacking.

We still need to establish a contract with Monash University who will provide the new chemistry.

The formation of dry-stackable tailings is a capital and energy intensive operation primarily because the flocs used in thickening are hydrophilic, hence there is strong water retention in the thickener underflow. This project seeks to reduce the capital and operating cost by producing hydrophobic flocs, and then applying new ultrafast beneficiation technologies to extract the hydrophobic solids from the water, and in turn dewater. This approach will deliver real-time management of coal tailings, limiting the volume of the tailings waste, and aims to reduce the costs of tailings management.

This research could lead to a technology that can be easily retrofitted to an existing plant, allowing much cheaper dewatering technology, or much smaller pressure filters, to be utilised to form the dry stackable tailings. We are well connected with manufacturers who can support such outcomes.
TECHNICAL MARKET SUPPORT

Future Technologies

C28068
Utilisation of CHPP Waste in Value-Added Products

CSIRO
Philip Ofori

Value: $250,000
Report Expected: July 2020
Industry Monitor/s: Morgan Blake, Tim Manton
ACARP Contact: Ashley Conroy

The objectives of the project are to:

- Investigate and develop new geopolymer formulations using CHPP tailings and rejects as source materials for the production of geopolymer binders by activation with appropriate alkali activators and assess the geotechnical and environmental properties;
- Develop new pasted fine coal wash formulations suitable for placement in a longwall goaf area that has sufficient strength to reduce surface subsidence;
- Examine the use of unscreened rejects as the fill material in a novel hybrid Fibre Reinforced Polymer (FRP) tubular standing support for tailgates.

Literature review of previous related work on geopolymerisation of aluminosilicates as currently practised has been completed. Important factors relating to the source materials and the conditions that influence the quality of geopolymer binder formulations have been identified. The identified factors will inform the development of formulations and the experimental design to optimise the formulations. Equipment needed to manufacture the geopolymer binder and for curing under different conditions have been acquired. Ordinary Portland cement mixes has been used to generate baseline data and define experimental methods and procedures.

Significant amount of work has been done to identify suitable binders for washery wastes by comparing the properties of the fines with those of materials currently used to make cement, and the coarse rejects with those of aggregate material to make concrete. Washery products from Mine Site 1 has been used, with coarse rejects utilised to partially substitute for metal aggregate and fine tailings for sand of similar sizes. The concretes made had compressive strengths of 20 MPa and 25 MPa. The results have been consistent with similar studies completed recently by Coal India, showing negligible loss of compressive strength when partially replacing up to 20% of the aggregate with coarse coal rejects, but the loss of compressive strength becomes significant when replacing sand by more than 5% fine tailings.

In the next quarter, samples of Basic Oxygen Steelmaking Slag, (BOS slag) with basicity similar to burnt lime will be tested as replacement for cement as the binder in using finer coalwash as a paste for potential underground emplacement. Also, kaolinite-based geopolymer mixes will be used to further refine experimental methods and provide baseline geopolymer manufacturing information.

General

C25053
Coal Sample Bank

CSIRO
Keith Vining
Lauren Williamson

Value: $279,329
Report Expected: October 2021
Industry Monitor/s: Graeme Harris, Kim Hockings
Technical Market Support Committee
ACARP Contact: Ashley Conroy

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. To date, 38 coal samples have been delivered, stored at -18°C and their details recorded in a database. Of the 38 samples stored coal quality data has been provided by coal producers for 30 of the samples.

A number of coal samples are missing their analysis. A number of new samples have been added to the sample bank to replace depleted samples or to meet the needs of research projects that have commenced in the 2019 calendar year. Samples have been provided to various ACARP projects as detailed below. A researcher has requested the coal data for 021-T-001 to allow them to finalise their report.

Coal and/or Coke samples have been requested by for the following projects in 2019: C28065, C28066, C28069 and C28071.
C26003
Management of SA and ISO Coal Technical Committees Work Programs

Carbon Connections
Barry Isherwood

Value: $185,550
Report Expected: September 2020
Industry Monitor/s: Graeme Harris, Kevin Rowe, Kim Hockings
ACARP Contact: Anne Mabardi

This project is a continuation of ACARP support for the management of and input into both Australian and ISO Coal Sampling, Preparation and Analysis Standards. SA Committee MN/1/1, Coal Analysis held a meeting in July in Brisbane with the prime agenda item being preparation for the 2 yearly ISO TC27 (Solid Mineral Fuels) meeting to be held in Japan in October. Main topics include a number of proposed new Standards or revisions including Chlorine, Sapozhnikov Plastometer, Dilatation and Thermal Stability (gasification).

SA Committee MN/1/2, Coal Preparation held a meeting in June in Newcastle, with the prime agenda item also being preparation for the ISO meeting in Japan. Main topics include Froth Flotation, Float and Sink, On-Line Analysers, Density Tracers and Sampling in Coal Preparation Plants. It is noted that for the last two items, AS versions have recently been published with a view to adopting these within ISO.

SA Committee MN/1, Coal and Coke (main committee), held its annual meeting in Brisbane in July and considered the work and priorities of its S/C’s above and endorsed the delegates to attend the ISO meeting.

ISO TC27, Solid Mineral Fuels preparations for the ISO meetings are progressing well, with the likely attendance of both our Technical Program Manager and an editor to discuss current issues of editing and ASTM collaboration. Continuing dialogue is underway with a number of countries, who either have not attended in the past, or only on an occasional basis and these include Indonesia, India, Egypt, and Tanzania, but not a lot of progress to date.

C26037

Standards Australia
Emilie Mortgensen

Value: $191,493
Report Expected: February 2020
Industry Monitor/s: Graeme Harris, Kevin Rowe, Kim Hockings, Anne Mabardi
ACARP Contact: Anne Mabardi

This project is to offer Standards Australia support for Australian Mirror Committee. The schedule of meetings is as follows:

MN-001 (Coal and Coke)—Mirror Committee for ISO/TC27
- Chairman: Barry Isherwood
- Next meeting: Jun/July 2020, Sydney (SA Office, Date to be confirmed soon)

MN-001-01 (Coal analysis) —Mirror Committee for ISO/TC27/SC3 and SC5
- Chairman: Barry Isherwood
- Last meeting: 11th July 2019, Brisbane (BHP Office, Brisbane)

MN-001-02 (Coal Preparation) —Mirror Committee for ISO/TC27/SC1 and SC4
- Chairman: Dave Osborne
- Last meeting: 27th June 2019, NIER, Newcastle, NSW
- Next meeting: Newcastle. 22nd November 2019, NIER, Newcastle, NSW.

MN-001-02 Subcommittee completed (3) projects to develop Australian Standards:
- AS 4156.1.1 Coal preparation, Part 1.1: Higher rank coal- Float and sink testing, Drafting Leader: Michael Campbell—Published Dec 2018.
- SA HB 196 Guide for Sampling in Coal Preparation Plants, Drafting Leader: Jim Docherty—Published Dec 2018.
- AS 5213 Density tracer testing for measuring performance of coal density separators, Drafting
Leader: Chris Wood — Published, March 2019.

MN-001-05 (Coal Mining and Geology)
- Chairman: Walter Pickel
- No meeting planned; Subcommittee has no work program.

MN-001-06 (Determination of Gas Content)
- Chairman: No Chair
- No meeting planned; Subcommittee has no work program since publication of AS 3980-2016.

C28069
How Inertinite Concentrates in Blends Affect Coke Strength

University of Newcastle
Wei Xie

Value: $99,500
Report Expected: April 2020
Industry Monitor/s: Jay Zheng, Sean Flanagan
ACARP Contact: Ashley Conroy

The aim of this project is to evaluate the fusibility of inertinite/semi-inertinite in different proportional blends with other coking coals and investigate their impact on metaplast phase formation (swelling, permeability and fluidity) and volatile release; characterise coke strength of the blends, and identify the impact of inertinite/semi-inertinite on coke structure development relating to coke strength, use the knowledge gained to provide suggestions on how to optimise the utilisation of inertinite rich coking coals in blends for improving coke strength. To achieve these goals, this project uses reflux classifier to concentrate inertinite particles, CATA for swelling and permeability, DETA for volatiles evolution, Pearson Coal Petrography for coke fusibility analysis, Sole Heated Oven for preparing coke samples and Drop Shatter for coke strength analysis.

This project started in April, during the first quarter, we requested five coal samples from suppliers and the ACARP bank. To date, we have received three samples, and we have completed coal maceral separation for the first coal sample, and starting to conduct CATA and DETA tests. Next quarter, we are expecting to receive the last two coal samples, and complete the CATA and DETA tests for the first batch of coal and coal maceral blends.

Major Projects

C27001
Maritime Regulation Project: Self Heating and Corrosivity Test Evaluation

Goodwin Port Solutions
Ash Goodwin

Value: $1,877,614
Report Expected: January 2021
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. Initial research is now complete for coal and other cargoes and has been peer reviewed. Findings and recommendations were reported to the IMO in September 2018 resulting in guidance note "MSC.1/Circ.1600 – Interim guidance for conducting the refined MHB (CR) corrosivity test" being issued by the IMO in January 2019.

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 from the initial phase of test work were reported to the IMO in September 2018.

Experimental work is continuing to evaluate application of a European test protocol to determination of self-heating potential of coal cargoes.

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: August 2019
Industry Monitor/s: Kim Hockings, Nick Andriopoulos, Oliver Scholes
ACARP Contact: Anne Mabardi

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: September 2019
Industry Monitor/s: Kim Hockings, Nick Andriopoulos
ACARP Contact: Ashley Conroy

This project is a joint collaboration between the University of New South Wales, ANSTO, and University of Newcastle. Prior work in Stages I and II showed that strength at high temperatures was generally independent of CSR content with high CSR cokes showing lower strengths in comparison to low CSR cokes. The strengths increased generally with increase in temperature and showed a correlation with the graphitisation of the cokes. The work in Stage III has focussed on the effects of reactive atmospheres on the high-temperature strengths of one high and one low CSR coke (from Stages I and II, respectively). The cokes were supplied by the industry monitors.

The objectives are to:
• Determine the in-situ high-temperature strengths of high and low CSR cokes after reactivity tests; and to
• Correlate the coke CSR values with the actual modification of strength at high temperatures (before and after reactivity tests) and to associate it with parent coal attributes.

Cylindrical coke samples were cored and then end-polished and subjected to reactivity tests using temperatures and atmosphere profiles simulating a blast furnace. Then the high and low CSR samples were tested at 1100°C, 1400°C, 1550°C, and 1700°C at ANSTO. The test results at 1100°C matched CSR predictions with the high CSR sample showing the higher strength; however, with increase in temperature, the average strengths were higher for the low CSR samples and appeared to increase with temperature, while the strengths tended to decrease with temperature for the high CSR samples. These results from 1400°-1700°C matched trends shown by the same cokes prior to reactivity testing.

Variation in strengths for high-CSR (left) and low-CSR (right) cokes after reactivity tests and high-temperature mechanical testing at different temperatures.

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: September 2019
Industry Monitor/s: Nick Andriopoulos, Oliver Scholes
ACARP Contact: Anne Mabardi

The project is an extension of project C23048 Investigation of the links between microstructure development in softening coal and the characteristics controlling coke quality, and extends the successful outcomes of the previous project. This project addresses the questions of how coke structure is formed within the plastic layer during coking and how these structures control strength of the final coke. It also addresses the question of how different inertinites in coal affect the development of structure and strength in coke.

The 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 final report has been drafted and is undergoing internal review before sending to industry monitors for review.
C26039
Nanoporosity in Cokes: Their Origin and Influence on CO2 Reactivity

CSIRO
Mihaela Grigore

Value: $149,756
Report Expected: September 2019
Industry Monitor/s: Kim Hockings, Nick Andriopoulos, Oliver Scholes
ACARP Contact: Anne Mabardi

A earlier 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.

A draft of the report will be submitted to the industry monitors in August.

C26040
Fusible Content of Individual Coal Grains and its Application in Cokemaking

CSIRO
Karryn Warren, Merrick Mahoney

Value: $161,640
Report Expected: November 2019
Industry Monitor/s: Kim Hockings, Nick Andriopoulos, Oliver Scholes
ACARP Contact: Patrick Tyrrell

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; and to
- Further understand the mechanisms behind why coals from the Rangal Coal Measures have unexpected coking behaviour.

In the last quarter, the CGA of the size fractions from coal D & E IRF grinds was completed and extraction of the size information for each of the fusible and infusible structures was started; the analysis of the 3D CT images of the coke lumps has commenced using the software GeoDict, and pore size distributions, wall thickness distribution and stress responses have been determined for approximately half of the samples; and analysis of the fractographic data has been completed. Radar graphs of the fractography results for cokes from coals D and E are shown below.
In the next quarter the CGA size data extraction and CT image analyses will be completed, and data analysis of the combined results from each of the analysis techniques will be interpreted in preparation of the draft final report.

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: August 2019
Industry Monitor/s: Chris Urzaa
Kim Hockings
Morgan Blake
Stephen Brant

ACARP Contact: Ashley Conroy

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: August 2019
Industry Monitor/s: Chris Urzaa
Jason Nunn

ACARP Contact: Anne Mabardi

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

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: September 2019
Industry Monitor/s: Stephen Brant
Tim Manton

ACARP Contact: Ashley Conroy

The key objective of this project is to develop a more comprehensive understanding of the degradation of cokes from coal blends under the blast furnace (BF) conditions, and the mechanism of coal interactions during carbonisation and their effects on the properties of coke under the simulated BF conditions.

Progress to date:
- The majority of the experimental work of this project has been completed;
- The draft final report is being prepared and will be submitted in August.

Compared to the gasification conducted in the CO-CO₂-N₂-H₂ atmosphere, the addition of H₂O vapor significantly promoted the coke reactivity and caused more remarkable pore structure changes on the lump surface. As a result, the coke I-drum tumbling strength showed more evident degradation than those gasified without H₂O vapour. However, H₂O vapor did not promote the penetration of gasification toward the lump core; therefore, the coke tensile strength, which was the mechanical strength determined in the lump core, did not have extra degradation upon the H₂O containing gasification. The H₂O containing gasification promoted the coke graphitisation, this could be attributed to the faster consumption of amorphous carbon, which had greater reactivity than ordered carbon, by the H₂O containing atmosphere.

Blending coals together resulted in a significant fluidity reduction from the expected values due to different thermoplastic temperature ranges of the coal constituents in the blends. The large amount of volatile matter released from the low rank coal provided a better graphitisation condition for the other coals in the blends, thereby resulting in the pervasively higher measured crystallinity. The Raman analysis indicated that the greater measured graphitisation degree was mainly contributed by the lenticular and ribbon microtextures. Although the caking properties of the blends were remarkably reduced from the expected values, the measured microstrength did not have a significant difference from the weighted average values; the measured macrostrength, on the other hand, was greater than the calculated values. The different thermoplastic temperature ranges of coal components restricted the dilatation but promoted the contraction of the blends, thereby limiting the porosity development and improving the macrostrength of the produced cokes.
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: August 2019
Industry Monitor/s: Nick Andriopoulos
Oliver Scholes
ACARP Contact: Anne Mabardi

In this project we found that the inertinite macerals studied in this project behave as a solid additive that increases the viscosity of the vitrinite-inertinite blend in a largely predictable manner. Inertinite behaves in a similar way to graphite. The main interaction that we observed was an interaction with the volatile release from the vitrinite which influences fluidity development and expansion behaviour. The role of the inertinites’ porous structure was explored.

We have submitted a draft of the final report to the industry monitors for review.

C26046
Relevance of Maceral Concentrates to Whole Coal Coking Predictions

University of Newcastle
Wei Xie

Value: $69,500
Report Expected: August 2019
Industry Monitor/s: Graeme Harris
Kim Hockings
Oliver Scholes
ACARP Contact: Ashley Conroy

The aims of this project are to:
- Clarify how to concentrate maceral components from coke oven feed particles combining the reflux classifier and Coal Grain Analysis (CGA);
- Examine what maceral concentrates represent in whole coal and the extent of the concentrates and the blends modify industrial fluidity of whole coal; and to
- Establish the relevance of coal maceral concentrates on whole coal coking prediction.

To achieve these goals, this project uses 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 concentrated maceral particles containing heterogeneous vitrinite and inertinite, and particles of similar maceral compositions produced from a blend of vitrinite and inertinite dominant particles.

To date, we have completed all laboratory work, including maceral separation, GGA analysis for all coal and coal macerals and Fluidity tests. We just received Fluidity test results for the last batch of samples; we are preparing the final report, and expecting to finalise the report in the coming weeks.

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: October 2019
Industry Monitor/s: Morgan Blake
Sean Flanagan
ACARP Contact: Ashley Conroy

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 blends from different types of coals during coking and its impact on coke formation and coke quality. The project extends the earlier 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.

The research team has used new coal samples and coals left over from previous project to carry out some preliminary experiments. The plastic layer samples have been produced based on a few blending ratios of two sets of coking coals with different rank and vitrinite contents. The FTIR and the C$^{13}$ NMR data have shown that the blending may have significant influence on the plastic layer chemistry. The research team has also purchased the license of the commercial software GeoDict which has been used for 3D image analysis on the micro-CT images. There will be a new analysis on Synchrotron IR and Micro-CT in July and August respectively on the new set of blending samples obtained from the UoN lab-scale coke oven following which the data will be analysed.
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: June 2020  
Industry Monitor/s: Kim Hockings, Morgan Blake  
ACARP Contact: Ashley Conroy  

We have previously demonstrated that techniques used in tribology 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 microtextures. 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 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.

The accessories for upgrading the tribometer to allow tribological testing at 950°C and in gas controlled atmospheres have been manufactured by the supplier Rtec and shipped to the University of Wollongong. The installation of these accessories and upgrade of the software for conducting the tests at high temperature is underway. We expect to conduct trial tests at the end of July, and the bulk of the tribological testing of our samples during the last two weeks in August.

During the last quarter we have been preparing samples from three pilot oven cokes, each from a single parent coal, and near matched blast furnace feed and bosh cokes. Over the next month, we expect to complete polishing and imaging of samples, removal of the sample mounting medium used to facilitate polishing and imaging, and pre-reaction of samples with carbon dioxide at 950°C and 1100°C (including optimisation of the conditions for these tests).

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: September 2019  
Industry Monitor/s: Kim Hockings, Sean Flanagan  
ACARP Contact: Ashley Conroy  

This project follows on from projects C23048 and C25051. We are interested in finding the factors controlling pore contraction because the densification of coke plays a key role in strength development and we are examining the extent that the pore structure has preferential pathways as directionality could be a factor with regards to coke strength.

We have taken three fissure-free coke cubes 1.5 cm³ from a coke sample that was adjacent to the wall. The cubes are from various points in a line that extends from the wall. We have carried out CT scanning and used GeoDict to examine the pore properties and permeability. We have found that for all of the cubes permeability in the up-down direction and direction that is parallel to the wall (x and y directions) are very close to each other, however, permeability in the direction that is perpendicular to the wall (z direction) is almost half that of x and y and the percolation pathway is more tortuous. This finding was not expected. Firstly, we found no directionality in the pore structure of samples taken from the rheometer. Secondly, it was thought that permeability in the z direction (towards the wall) would be the highest as it is the shortest path out. These results have been for just one coke sample.

We need to:
- See whether this finding occurs for other samples;
- Determine why the pathway in the z direction is more tortuous;
- Examine whether the degree of directionality in the pore structure plays a role in the strength and failure of the sample.
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: September 2019
Industry Monitor/s: Kim Hockings, Tim Manton
ACARP Contact: Ashley Conroy

The project addresses:
• Understanding to relate properties of cokes to those of the coals from which they are made; and
• 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; and
• Develop some understanding of how different inertinite types can influence structure development by modifying processes in the plastic layer.

During the last quarter the outcomes from Deep Learning and Isomapping have been completed. The outcomes from this work are still undergoing some final analysis as part of the 3D statistical characterisation phase. The final report is being prepared and a first draft will be completed in the next two weeks.

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

CSIRO
Karryn Warren
Merrick Mahoney

Value: $173,196
Report Expected: October 2019
Industry Monitor/s: Chris Urzua, Tim Manton
ACARP Contact: Ashley Conroy

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?

There has been little progress made on this project in the last quarter due to other ACARP project commitments. However, preliminary aliphatic/aromatic ratios have been determined from the Fourier Transformed Infra-Red (FTIR) spectra for points collected along a reflectance gradient for 1 sample, showing subtle differences (as expected). In the coming quarter, we expect to make further progress with the FTIR data analysis with the addition of a Post-doctoral fellow to our research team.

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: August 2019
Industry Monitor/s: Graeme Harris, Steve Lempereur
ACARP Contact: Ashley Conroy

A draft report is with the industry monitor(s) for review.
C28064
Carbon Structure Transformation in the Plastic Layer and Coke of Australian Coking Coals: Better Understanding of Coke Strength and Reactivity

University of Newcastle
Jianglong Yu

Value: $144,900
Report Expected: April 2020
Industry Monitor/s: Kim Hockings, Morgan Blake, Nick Andriopoulos
ACARP Contact: Ashley Conroy

The main objectives of the project are to systematically investigate the carbon structure formation and transformation in the plastic layer during coking using a suite of Australian coking coals from the ACARP coal bank and to achieve a better understanding of the impacts of carbon structure of coke on coke quality. The project is focused on the characterisation of the chemical structure transition of the plastic layers formed during coking and the evolution and transformation of carbon structure during the coking process, establishing a methodology of quantitatively linking the characteristics of carbon structures of coke and semi-coke to the quality of coke, and investigate the influence of coal rank, maceral composition, and heating conditions during coking on the structure of carbon and subsequently on the quality of coke.

Single and blends of coking coals have been used on coking tests on the 4kg lab-scale coke oven at the NIER site of the University of Newcastle. A number of plastic layer samples have been produced with different ranks and vitrinite contents, for which the analysis has been largely focused on the section from the resolidified part to semi-coke part. The samples have been analysed using the Synchrotron Micro-CT and Synchrotron IR. The focus of the analysis is to investigate the roles of aliphatic structure elimination and further during the formation of carbon-carbon bond formation during the thermoplastic stage and the roles of the elimination of C-H bonds during the later stage of the plastic layers on the carbon-carbon bond formation.

C28065
Effect of Blend Characteristics on the High-Temperature Strength Evolution and Relevant Mechanisms in Cokes

University of New South Wales
Pramod Koshy, Xing Xing

Value: $309,800
Report Expected: September 2020
Industry Monitor/s: Jay Zheng, Nick Andriopoulos, Stephen Brant
ACARP Contact: Ashley Conroy

This project is a joint collaboration between University of New South Wales, ANSTO, and University of Newcastle. Prior work in previous project C25045 (Stages I,II,III) showed that coke strengths (for coals prepared from single coals) at high temperatures were generally independent of CSR content with high CSR cokes showing lower strengths in comparison to low CSR cokes at high temperatures >1400°C. The goal of the present project is to investigate whether the observed strength evolution is valid for coke blends comprised of cokes of varying CSR values. Moreover, in this current project, the same coke blends will be fabricated using both the pilot-scale oven and the lab-scale oven at University of Newcastle.

The objectives are to:
- Determine the high-temperature and room temperature compression strengths for three blended cokes (two from pilot oven and one from lab coking oven) before and after exposure to reactive conditions;
- Develop correlations between the mineralogical, microstructural, and fracture characteristics of cokes fabricated using two methods (conventional vs. lab-scale) with the strength evolution; and to
- Validate the effectiveness of the laboratory coke oven by comparing the properties of the cokes.

The coals to form the blends are being procured by industry monitors to prepare the cokes in the pilot-scale oven. After this, these same coals will be sent to University of Newcastle to prepare blends using the lab-scale oven.
C28066
Influence of Coal Blending on Coke Nanoporosity and CO2 Reactivity

CSIRO
Mihaela Grigore

Value: $151,824
Report Expected: October 2020
Industry Monitor/s: Kim Hockings, Nick Andriopoulos, Sean Flanagan
ACARP Contact: Ashley Conroy

A recent project (C26039) found that closed nanoporosity occur in large proportions in cokes, and almost all pores less than 5 nm are closed. Also, closed porosity in cokes becomes increasingly accessible to the reactant gas (CO2) during gasification. Blending coals may have a significant influence on the coke nanopore structure, since interaction between coals during carbonization was observed in previous studies.

The aims of this project are to determine the effect of coal blending on the amount of open and closed nanoporosity in cokes and gasification rate. The effect of coking conditions on the amount of open and closed nanoporosity will be also investigated.

The coals for this study have been obtained. The cokes are scheduled for preparation in August.

C28071
Improving Understandings of IMDC-RMDC Interfaces

University of Newcastle
Hannah Lomas

Value: $161,076
Report Expected: July 2020
Industry Monitor/s: Kim Hockings, Morgan Blake, Stephen Brant
ACARP Contact: Ashley Conroy

This project will investigate the principal mechanisms involved in determining the microtextural interface properties of metallurgical cokes, using an inertinite analogue to elucidate the influence of particular inertinite attributes. Specifically, two of the key aims of this project are to:

- Develop an inertinite analogue, capable of controlled oxidation and tunable size and shape, to investigate the link between inertinite properties and the properties of the IMDC–RMDC interface and other coke microstructural features using fractographic analysis techniques; and to
- Examine the impact of maceral associations on laboratory carbonising tests as part of improving predictions of coking performance from these tests.

Three coals have been selected by the team for this project. The first coal C448 has been received by UoN and separated into vitrinite-rich and inertinite-rich components using a bench-scale washery. For the first aim, a literature review into suitable materials and methods for preparing the inertinite analogue has been conducted, and six analogue materials were short-listed, including silicon nitride, tungsten carbide, activated charcoal (from anthracite) and graphite. Preliminary tests to assess the wettability of each material during coking, using hand-picked vitrinite from coal C448, have been conducted. The carbon-based materials showed the highest degree of wetting, i.e. interfacial contact, with the reactive maceral derived components in the final coke structure. From here, we will investigate techniques to further improve the wettability of the inertinite analogue materials, as well as investigate the suitability of partially oxidised coal as an inertinite substitute.

For the second aim, the team have planned the coal grain analyses and whole coal reflectograms required to meet the project aims. We intend to conduct these analyses on:

(i) head coals (at coke oven feed size) – four different size fractions
(ii) subsamples of the coals crushed to size for (a) the Gieseler test, and (b) the dilatation test
(iii) subsamples of each of five grinds prepared from a blend of one selected coal, crushed to size for (a) the Gieseler test, and (b) the dilatation test. The blend will comprise both the vitrinite rich fraction and the inertinite rich fraction from the selected coal.
(iv) four different size fractions of each of the five grinds produced at (iii).

Thermal Coal

C27022
Slagging and Fouling During Co-Combustion in HELE Boilers

University of Newcastle
Liza Elliot

Value: $164,350
Report Expected: April 2020
Industry Monitor/s: Chris Urzaa, Jason Nunn
ACARP Contact: Ashley Conroy

Each mechanism responsible for slagging and fouling in pulverised fuel boilers are dependent on particle density and size, ensuring only certain parts of the ash are involved in deposition. However, indices used previously to assess coals for fouling and slagging behaviour are based on the whole ash sample. The chemistry and size of each ash particle is a function of the location of the minerals within the coal during combustion, which is not
replicated when the coal is ashed in a muffle furnace. The indices ignore the impact of mineral associations within the coal (ie does the mineral exist on its own when fired (excluded), in a coal particle (included) or with other minerals in the coal particle such that the minerals will combine to form one ash particle) and the importance of the mechanism of deposit formation.

This project aims to maintain the associations within the coal particles during ash formation by combusting the coal in a drop tube furnace. Collecting the ash produced in specific density/size bins will allow parts of the ash to be analysed for melting behaviour by thermomechanical analysis (TMA) providing a better technique for assessing coals for deposition and allowing selected coals to be assessed for slagging and fouling.

Deposits and matching feed coals from two Australian power stations have been collected. In addition, a sample of coal and economiser ash have been obtained from a Chinese power station. SEM analysis of the deposits is underway.

Drop tube furnace combustion of the samples has been delayed due to broken furnace elements, the discovery of historic not-to-code electrical alterations and failure of the pump in the water cooling circuit. Each of these problems are progressively being overcome. A new syringe feeder is working well.

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: December 2019
Industry Monitor/s: Chris Spero, Greg Wickman
ACARP Contact: Ashley Conroy

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 supports 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.

The research team has engaged the furnace manufacturers to complete the engineering designs. Currently there is a significant delay to the manufacturing and two quotations have been sought from two manufacturers respectively. CFD modelling of the combustion furnace was carried out using the Fluent software to assist the combustion rig design. The furnace design was 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 to. There were intensive communications between the research team and the industry monitors and manufactures during the course of the project. The team is also working with NIER for the lab site preparation.

C27047
Combustion Characteristics of Australian Export Thermal Coals using Advanced Imaging Techniques

CSIRO
Chad Hargrave
Ed Lester
Silvie Koval

Value: $60,644
Report Expected: September 2019
Industry Monitor/s: Graeme Harris, Greg Wickman
ACARP Contact: Ashley Conroy

The draft final report is with the industry monitors for review.

C28063

University of Newcastle
Jianglong Yu

Value: $79,900
Report Expected: April 2020
Industry Monitor/s: Chris Spero, Greg Wickman
ACARP Contact: Ashley Conroy

The objective of this project is to conduct a comprehensive technical review of high-efficiency low-emission (HELE) coal-fired power plants, including supercritical, ultrasupercritical and advanced ultrasupercritical technologies. The review will include characteristics of the HELE technologies, perspectives of HELE technologies in major coal-using countries and coal quality impacts on the performance of HELE boilers. The outcome of the project is critically important to enhance the existing capability to assess combustion performance of Australian thermal coals in advanced HELE.
Our research team has collected technical reports and research articles to conduct a comprehensive literature review and technical survey of currently available in the open literature, as well as under-development HELE technologies. The survey covers operational aspects, process characteristics and material requirements of HELE technologies, steam specifications, flame chemistry, emissions control, and slagging/fouling propensity and modelling efforts on simulating HELE coal combustions. Based on the literature review, coal quality impacts on the HELE performance are being analysed. This review will aim to establish a methodology of identifying coal properties affecting the combustion behaviour, air pollutants formation and slagging/fouling behaviour that may assist to evaluate the performance of Australian thermal coals in HELE boilers.

C28067
Characterisation of Complex Coal Blends, and Methodology to Investigate Thermal Coals Based on Compositional Analysis

CSIRO
Priyanthi Hapugoda

Value: $104,008
Report Expected: October 2020
Industry Monitor/s: Graeme Harris, Greg Wickman, Stephen Brant
ACARP Contact: Ashley Conroy

The objectives of this project are to:

- Validate enhancements to the capability of CSIRO’s Coal Grain Analysis system (CGA) that enable the characterisation of complex coking and thermal coal blends;
- Test a methodology to characterise thermal coals and blends using complementary CGA and SEM analyses to obtain maceral and mineral information in order to improve the understanding of coal used in the combustion process.

Progress to date:

- To date the Task 1 of the project the sample selection of coals: sample selection strategies were discussed in the start-up meeting with industrial monitors;
- CGA software strategies were already started with CSIRO software engineers using the previous coking coal samples used for C25049 project (with wider range of reflectance values) to enhance the CGA system to characterize complex coal blends.

Work in the next quarter:

- Sample selection for testing need to verify with monitors; and
- Sample preparation will start with coking coal samples for analysis (mounting, polishing and imaging) as received.

C28070
Combustibility Predictor for Thermal Coal Utilisation in Pulverised Fuel Boilers

University of Newcastle
Liza Elliot

Value: $145,500
Report Expected: January 2021
Industry Monitor/s: Chris Urzaa, Kay Palmer
ACARP Contact: Ashley Conroy

Combustion performance is, in general, predicted by the coals’ volatile matter, as measured by the proximate analysis, which is a measure of the coals rank. This provides the average expected behaviour, which some low volatile bituminous coals do not follow. This technique treats the coal as a consistent homogeneous mass, which unfortunately is not true. It does not indicate if a portion of the coal is difficult to combust and likely to result in unburnt carbon in ash when utilised in pulverised fuel boilers. It also does not indicate if a portion is easily combusted, which would assist with ignition, the formation of regions of elevated temperatures within the radiant section of the boiler or potential of spontaneous combustion.

This project aims to show that the density of each coal particle can be used as an indicator of combustion performance, and therefore a float-sink (or washability type) curve for each coal can provide the average and extremes in combustibility for the selected coal sample. The hypothesis of this study is that the high density fraction results in poorer combustion, while the low density fraction is easily burnt and therefore the high density fraction determines the final burnout. This would allow identification of issues associated with a portion of the coal, such as carbon in ash, hot spots within the boiler or spontaneous combustion, prior to utilisation.

One of the coal samples has been obtained and is being prepared. New plates for the reflux classifier to produce a smaller gap between the plates are being produced.
C28072
Mineral Redistribution from PF Coal to Ash in Commercial Power Stations

University of Newcastle
Rohan Stanger

Value: $153,270
Report Expected: April 2020
Industry Monitor/s: Chris Spero
                              Kay Palmer
ACARP Contact: Ashley Conroy

This project is based on characterising the mineral components contained in both coal feed and fly ash in several commercial power stations. The objective is to better understand how minerals in the coal are transformed to better understand slagging/fouling issues. The project involves development of a sampling program at selected power stations, acquisition of feed coal, pulverised coal (from the mill) and fly ash. The pf coal and fly ash must be sampled iso-kinetically to ensure accurate representation of all particles. The samples will then be characterised using automated SEM-EDS and thermos-mechanical analysis.

The current status of this project is that the first sampling program is scheduled for the end of July/start of August. This will generate the first samples to be analysed. Training with sample preparation and the automated SEM-EDS has now been completed and is ready to proceed.
MINE SITE GREENHOUSE GAS 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: September 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 (i.e. self-sustaining) at methane concentrations as low as 0.2 Vol%. The Phase-IV project aims at pilot-scale demonstration of the above configuration as well as determining its scaling principles and techno-economic merits. Phase-IV has been defined as a two-year project with the primary aims of:

• Design, construction, commissioning and field trials of a 200 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; and
• A detailed techno-economic assessment of the twin-reactor in the MGS configuration.

Design, construction and commissioning of the twin-reactor SDL pilot-plant has been completed. Initial experimental test work has been completed through continuous operation at The University of Newcastle. Promising results were obtained that demonstrate the looping of calcium carbonate and calcium oxide between the carbonation and calcination reactors. Experimental trials are continuing to obtain further data to inform the scale-up rules and the techno-economic assessment.

C27054
Optimisation of a Thermal Flow Reversal Reactor for VAM Mitigation

CSIRO
Jon Yin

Value: $190,173
Report Expected: January 2020
Industry Monitor/s: 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 previous project C19055, CSIRO 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°C) 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.

The first two milestones were successfully completed by the end of April. Then the project team has been working on the feasibility study of a new catalytic version VAMMIT. Based on the lab scale test results of a number of commercial Pd-based catalysts, the catalytic version VAMMIT is designed through design calculations. The catalytic VAMMIT unit is expected to possess further smaller footprint and operate at lower temperature range (thus enhanced safety management). It is also able to achieve self-sustaining operation with ≥ 0.2% VAM. A 3D Fluent model has been developed using the dimensions determined for the catalytic regenerative bed. The Fluent model for the catalytic VAMMIT is...
currently being operated to predict its performance under various conditions.

C28075
Application and Optimisation of Hybrid Chequer-Bricks in Regenerative Thermal Oxidisers for VAM Abatement

University of Newcastle
Behdad Moghtaderi

Value: $255,480
Report Expected: March 2020
Industry Monitor/s: Donna Dryden, Jim Sandford
ACARP Contact: Patrick Tyrrell

The principal vision in this project is to develop methods for optimisation and/or enhancement of the flame arresting properties of chequer-bricks. To fulfil this vision, the project aims at developing a hybrid chequer-brick configuration that combines several brick types/designs and examines the behaviour of the hybrid configuration under fire and explosion scenarios pertinent to RTO/CTO based VAM abatement systems. The new hybrid bricks properties and configurations will be examined in a small-scale propagation tube and a pilot-scale detonation tube.

With reference to the project structure plan, a number of essential and key tasks of phase one have been achieved:

- A comprehensive literature review was carried out to identify the flame arrestor key design parameters involving in flame mitigation;
- Suitable chequer-brick materials were determined. Brick suppliers were identified, engaged and samples were ordered;
- Design and fabrication of the first version of the small-scale hybrid chequer-brick was completed (see figure below);
- The small-scale propagation tube was modified to accommodate the new designed hybrid chequer-bricks;
- Risk assessment and standard operating procedure were prepared and safety approval obtained; and
- Experimental matrix was developed and all the required consumables ordered.

C28076
Selective Absorption of Methane by Ionic Liquids (SAMIL) - Phase 2: Demonstration in Packed Bed Reactors

University of Newcastle
Behdad Moghtaderi

Value: $190,320
Report Expected: March 2020
Industry Monitor/s: Ben Klaassen, 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 objectives of the project are to demonstrate the ionic liquid absorption and desorption process using a rotating packed bed and obtain key process data to allow for future mine site integration studies. The approach for the project involves:

- Conducting experiments in a rotating packed bed to understand the influence of key process variables such as temperature, ionic liquid viscosity, residence time, bed surface area, and rotational speed; and
- Developing mass transfer models for the absorption and desorption of methane in ionic liquids.

The milestone for the first quarter of the project has been achieved. A commercial rotating packed bed reactor was modified to allow for the experimental program. Standard operating procedures, a risk assessment and safety reviews have been prepared and internal safety clearance has been granted. The experimental program has commenced and is expected to be completed by December 2019.
C28077
Progress in Developing Ventilation Air Methane Abatement Technologies

CSIRO
Shi Su

Value: $90,000
Report Expected: April 2020
Industry Monitor/s: Ben Klaassen, Donna Dryden, Jim Sandford

ACARP Contact: Patrick Tyrrell

This project aims to better understand the current status of ventilation air methane (VAM) abatement technology development, site trials and demonstration, and deployment in the world. Specific objectives are to:

- Carry out a state-of-the-art review of all VAM abatement technologies being developed globally to investigate technical viability and engineering applicability of each technology, and to develop key performance indices (e.g. minimum CH₄ concentration required, energy efficiency, etc.) to compare each technology; and to
- Develop a technology roadmap for the development of a suitable reactor.

The project commenced in May with team members working on the state-of-the-art review of different VAM abatement technologies including thermal/catalytic flow reversal reactors, lean burn gas turbine, chemical looping/stone dust looping, enrichment by adsorbents and ion liquids, photocatalytic oxidation, and catalyst development for VAM thermal oxidation, etc.

C28078
Pulsed Air Continuous Catalytic Rejuvenation Process for Low Temperature Conversion of VAM

University of Newcastle
Michael Stockenhuber

Value: $258,672
Report Expected: May 2020
Industry Monitor/s: Jim Sandford, Trevor Stay

ACARP Contact: Patrick Tyrrell

The processing of VAM streams has been deemed of high importance for minimising the impact of emissions associated with mining. The low methane concentration leads to an inability to process by conventional methods, with studies showing catalytic combustion is a promising technology for reducing emissions. It was found that catalysts are deactivated via the formation of carbonaceous surface species, however the previous project indicated that this was able to be removed and catalyst reactivated. The current investigation examines in situ regeneration via air pulses for the development of a continuously operating system.

The experimental rig from the previous study has been modified to allow for pulses of dry air to be fed to the reactor bed, once activity has decreased, to reactivate the catalyst. Previously, gaseous reaction species were monitored via gas chromatography, however it is anticipated that more frequent concentration measurements will be required to determine the required frequency and duration of air pulses. To this end, more suitable analytical equipment has been sourced and purchased to measure instantaneous carbon dioxide and methane concentration. Catalyst (selected as a result of screening from previous projects) have been prepared and are currently being used to install and test the carbon monoxide cell, with the expectation that methane monitoring will be able to be implemented soon after.