MAY 2020

CURRENT PROJECTS

This report is a summary of current projects for the months February, March and April 2020
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## UNDERGROUND

### Coal Burst

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<th>Project Code</th>
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<td>C25004</td>
<td>Review of Australian and International Coal Burst Experience and Control Technologies</td>
<td>University of New South Wales</td>
<td>Ismet Canbulat</td>
<td>$404,000</td>
<td>May 2020</td>
<td>Coal Burst Task Group</td>
<td>Patrick Tyrrell</td>
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A draft report is being reviewed by the industry monitors.

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<td>C26060</td>
<td>Mechanics of Gas Related Coal Bursts in Mining</td>
<td>SCT Operations</td>
<td>Winton Gale</td>
<td>$273,750</td>
<td>May 2020</td>
<td>Coal Burst Task Group</td>
<td>Peter Bergin</td>
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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.

A draft report is being reviewed by the industry monitors.

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<td>C26062</td>
<td>New Outburst Risk Determination Measures Along With Data Gathering and Analysis for Coal Burst Assessment</td>
<td>Sigra</td>
<td>Jeff Wood</td>
<td>$612,200</td>
<td>June 2020</td>
<td>Coal Burst Task Group</td>
<td>Peter Bergin</td>
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This project is long overdue due to many operational complications and more recently the fact that internal modelling of outbursts threw a lot of assumptions into question with a lot of checking now needing to be done. Once done the researcher will able to finalise the report for submission.

### 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: May 2020
Industry Monitor(s): Coal Burst Task Group
ACARP Contact: Peter Bergin

A draft report is being reviewed by the industry monitors.

### C26068

Use of Real Time Rib Drilling Data to Determine the Propensity for Coal Bursts During Roadway Development

Dynamic Efficiency
Peter Mastalir

Value: $150,000
Report Expected: August 2020
Industry Monitor(s): Coal Burst Task Group
ACARP Contact: Peter Bergin

Work on this project has not progressed during the quarter for the following reasons:
- Covid 19 travel restrictions; and
- Mine site 1 representative for the project has left the site so we are pursuing advice for replacement mine site 1 representative, awaiting reply.

Looking for an alternative mine site 2 to continue the project if mine site 1 does not wish to proceed. Discussions are currently being held.

We require confirmation of site to lock in the drill rig that will be used to perform the test. Interfaces and sensor selection will be done on the knowledge of what brand of rig will be used. In the event that the current site is not available, a site requirement will be that it has variable rib condition to allow for correlation of any variances in rib stress to validate the concept.

### C27020

Management of Coal Bursts and Pillar Burst in Deep Mines

University of Adelaide
Giang Nguyen
Murat Karakus

Value: $380,240
Report Expected: May 2021
Industry Monitor(s): Coal Burst Task Group
ACARP Contact: Peter Bergin

A draft report is being reviewed by the industry monitors.
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: June 2020
Industry Monitor/s: Coal Burst Task Group
ACARP Contact: Peter Bergin

It has been found in previous and internal studies that the effect of intermediate stress can modify the strength of the rock. The stress anisotropy can lead to lower strength and modify the failure distribution about a roadway or ribside. The aim of this project is to measure the strength of coal measure rocks under a range of true triaxial stress conditions. The rocks will be tested with variation in maximum, intermediate and minor stresses. Work has been undertaken in understanding the sampling requirements and the testing procedures. Currently rock samples have been tested due to some limitations in the sample preparation system. Further work is required to assess coal sampling for the system. Samples of sandstone and laminated siltstones have been sourced for testing and sent to Curtin University.

Results have been obtained and show consistent effects of the role of intermediate stress in the strength of rock samples. The results are very interesting and indicate the application of this testing approach to understand the full rock failure criteria.

The results as used in computer models demonstrate the need for full stress characterisation to simulate key effects in roadways such as guttering and biased failure modes.

The project report is being written up.

C27041
Ground Support Requirements in Coal Burst Prone Mines

University of New South Wales
Ismet Canbulat

Value: $150,000
Report Expected: June 2020
Industry Monitor/s: Coal Burst Task Group
ACARP Contact: Peter Bergin

The objectives of this project are to:
- 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 to
- 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 this quarter includes:
- An analytical, time-based coupled model developed as part of project C26066 has been upgraded to include the influence of roof bolts in a case of a coal burst event;
- A risk-based approach has been developed to identify the risk categories (ie risk zoning) in development and longwall faces, this approach has been enhanced with the outcomes of project C26066; and
- The framework for coal burst management plan, which was proposed as part of project C25004, has been updated to reflect the new risk based approach.

The project is on track and is progressing within its anticipated timeframe. A draft final report is currently being compiled.

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: June 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 project will involve investigation of 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.

The data processing and interpretation work have been completed. Microseismicity associated with longwall caving processes has been reliably obtained by using DOFS in the field trial. This project has successfully proven the concept of using DOFS to replace geophones for microseismic monitoring in coal mining environment. The final report is being written and it will be submitted to industry monitors shortly.
C27060
Damage and Risk from Seismic Events

SCT Operations
Stephen Meyer
Winton Gale

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

The aims of this project are to:

- Develop and significantly improve the velocity models within the coal mine strata at 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;
- Review the damage and risks for longwalls and roadways for seismic events in coal mines.

Work has been undertaken to scope a monitoring network at a site. 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 at a site and data is being collected.

Computer studies have been undertaken to assess strain burst effects on longwall panels and compare the ground motions to seismic patterns.

Reporting for this project has commenced.

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 Monitor/s: Coal Burst Task Group
ACARP Contact: Peter Bergin

This project aims to make improvements in health and safety as well as sustainability of underground coal mining operations by conducting a thorough study on dynamic behaviour of Australian coal.

Due to COVID-19, access to Monash Laboratory has been restricted and consequently some experimental works have been affected adversely.

To date, the work undertaken includes:

- An extensive literature review on different aspects of coal burst including the source of energy, location of burst and role of failure criteria in identifying the coal burst mechanism are progressing;
- For the compressive true triaxial tests, the design of experiments has been completed where the specimens’ response due to the unloading effect under different stress path scenarios will be investigated;
- For in-situ tensile stress condition, the design of a rectangular biaxial box has been finalised. Also, a 225kN biaxial shear box apparatus has been modified to accommodate the loss of confinement during the roadway development; and A large number of specimens have been prepared for conventional laboratory rock experiments including point loading, indirect tensile (Brazilian), and uniaxial compression tests (Figure 1).

Figure 1. Examples of coal samples for conventional tests
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 micro fractures can propagate to form closely spaced macro fractures 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 micro fabric in coal around structures such as dykes and faults relative to ‘normal’ unstructured coal and the role of 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.

Progress:
• Samples of coal adjacent to dykes and faults have been collected and will studied by a optical microscopy to determine the micro fabric and porosity.
• Samples in non structured ground have also been taken;
• Samples of areas of difficult drilling have also been tested in this manner;
• Samples from two mines have been collected and are currently being analysed;
• We are awaiting the results of optical microscopy and then the synthesis of data will be undertaken. Currently approximately 50% of samples have been tested.

C29007
Innovative Coal Burst System to Investigate the Influence of Confinement Loss and Pre-Conditioning on Coal Burst Mechanism
University of Adelaide
Giang Nguyen
Murat Karakus

Value: $329,000
Report Expected: May 2022
Industry Monitor/s: Coal Burst Task Group
ACARP Contact: Peter Bergin

A draft report is being reviewed by the industry monitors.

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: August 2020
ACARP Contact: Patrick Tyrrell

The project objective is to provide an additional spontaneous combustion control technique and to:
• Procure a full system ready for deployment;
• Deploy the system in at least one underground longwall panel;
• Evaluate the cost and effectiveness of using CAF’s to alter goaf ‘micro ventilation circuits’;
• The system will be retained by NSW Mines Rescue, and maintained similarly to MineShield for use by both the New South Wales and Queensland industry as a tool to manage accelerated oxidation of coal.

Trials are currently suspended as non-essential business as part of the COVID-19 precautions. The program also incorporates oversight by a key operator from the German OEM who also has COVID-19 constraints. The equipment and foam has arrived in Australia and is on hand at Hunter Valley Mines Rescue Station. A surface trial is currently being organised to train Australian operators and to get the equipment operationally ready to deploy. Underground trials will be conducted at a New South Wales underground mine post COVID-19 constraints.
C29013  
**Evaluating GAG Docking Connections/Simulations**  
University of New South Wales  
Duncan Chalmers  
Guangyao Si  

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| Industry Monitor/s: | Bharath Belle  
John Grieves  
Ken Singer  
Phil Fletcher |  
| ACARP Contact: | Peter Bergin |  

A literature search is underway which has been limited by the Covid 19 shutdown. It is expected that the project will be ramped up during the next two months to bring the project back on track.

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**Environment - Subsidence and Mine Water**

C27052  
**FO-RO Site Trial at Newstan Colliery**  
CSIRO  
Ramesh Thiruvenkatachari  

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<td>June 2020</td>
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| 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 will evaluate the treatment performance of the FO-RO system under mine site conditions. The maximum water recovery and the quality of the treated water in meeting the discharge and reuse water quality criteria will be evaluated under varying feed water characteristics.

Site trial experiments were carried out using the FO-RO prototype test unit at the mine site. FO and RO have been individually tested followed by integrated FO-RO tests using different qualities of mine water. Information was obtained about the optimum operating conditions, water recovery, energy consumption and the quality of treated water. The results show that from the FO-RO operation, for every 100L of mine wastewater treated, about 90L of reusable quality water was recovered with total dissolved solids concentration of less than 300mg/L. The FO-RO process was also able to operate with very high solids containing feed water. The specific energy consumption for the prototype FO-RO unit was found to be highly efficient with 2.85-3.3 kWh for producing 1000L of water. Key outcomes and learnings from this site trial demonstration were presented at the project review meeting in April.

The draft project final report is being prepared and will be submitted for industry monitor review, in the next quarter.

C27059  
**Swamp Hydrology Modelling for Advancing Rehabilitation Planning and Management**  
University of Queensland  
Mandana Shaygan  
Neil McIntyre  
Thomas Baumgartl  

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<th>Value:</th>
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<td>May 2021</td>
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| Industry Monitor/s: | Bernie Kirsch  
Gary Brassington  
Peter Corbett |  
| ACARP Contact: | Patrick Tyrrell |  

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

For mine site one, calibration of the HYDRUS model for these swamps is being conducted, using the measured soil hydrological properties and soil water potentials of mine site one swamps, which will cover the modelling of soil moisture conditions of swamps from August to December 2019. In December a devastating bushfire moved through the swamps and damaged the monitoring sites. Four soil moisture monitoring stations were purchased to replace the damaged ones, and we are waiting COVID-19 travel restrictions to be lifted and to obtain permission to access the swamps in order to re-establish the experiments. For mine site two, one soil moisture monitoring station was procured for installation in one of the swamps, but the fieldwork was delayed due to COVID-19 travel restrictions. The next step of this project is to recover data (if any) from experiments affected by the bushfire, conduct field work in mine site one and two swamps, and further calibration and validation of the HYDRUS model for mine site one and two.
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

In the past three months there has been significant restrictions on travel and university activities. During this time the project has been reoriented to allow progress against the original timeframe by transferring field activities to analogue communities on the Sunshine Coast. Negotiation with Noosa Shire Council and National Parks to allow drone flights is progressing at present. Flights will be conducted once weather conditions are warmer.

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

This project has continued with analysis of site samples, data processing and preliminary reporting for site B. Water and biofilm tracer samples were prepared for analysis at ANSTO (Australian Nuclear Science and Technology Organisation). These water tracer samples were collected from site in late 2019. Most results, including isotopes have now been received, however, analysis of some isotope samples at ANSTO has now paused due to the pandemic. New portable equipment for rapid analysis of iron and sulphate some other water tracers in water were commissioned and tested at the university laboratory, ready for the next sampling trips. Analysis and interpretation tracer data from site B has progressed, with raw data and a preliminary interpretation of results provided to site B. Samples were obtained from dewatering bores at the mine, local groundwater and surface water samples, and a discharge area through a sandstone cliff with associated ecosystem, that overlies a river. Preliminary results indicate that the water chemistry fingerprint and stable isotopes of the water samples from a groundwater discharge site are of a different character to groundwater or surface water across site B. This is possibly due to mixing along a relatively short and shallow flow path. The findings of this study will provide clearer understanding

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, Nathan Emery

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

The overarching objective of the project is to successfully translocate and monitor multiple populations of Persoonia hirsuta and Persoonia hindii in mining offset and rehabilitation areas. Scientific 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.

The past three months have seen a reduction in field work capacity due to park closures and COVID-19. We have been unable to visit wild populations that were impacted by fire and conduct post-fire assessments and establish monitoring protocols. However, both translocation sites were monitored in early March prior to lockdown restrictions. Both P. hindii and P. hirsuta translocations have experienced further plant mortality since January with 62.5% and 27.3% of plants surviving, respectively. Following discussions with industry monitors it was decided that Stage 2 translocations should be delayed until 2021 due to setbacks from drought, fires and COVID-19.

Data analysis will begin shortly following the completion of the thermogradient germination experiment for P. hirsuta. Plant propagation will be increased for the rest of 2020, and all unused seeds are currently being propagated to increase the number of plants in the nursery. On the advice of our industry monitors we have submitted an extension proposal to help overcome project setbacks over the last six months.
**C28030**
Reducing Brine Volume through Membrane Distillation Crystallizer

CSIRO
Ramesh Thiruvenkatachari

Value: $214,350
Report Expected: December 2020
Industry Monitor/s: Clinton Brockwell, David Baker, David Randall, Gavin Rootsey, Jason Fittler, Paul O’Grady, Patrick Tyrrell

ACARP Contact: Patrick Tyrrell

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

A lab-scale membrane distillation crystalliser (MDC) test unit was developed, and the tests have been carried out using two hypersaline mine water brines. Results from the MDC process showed that both highly saline brine wastes were able to be concentrated to saturation and salt crystals were obtained. For example, an acidic brine of pH 2.5-2.8 with salt concentration of 13,400 mg/L was able to be concentrated to saturation levels of 146,000 mg/L and achieving crystallisation with simultaneous recovery of reuse quality water. A phase change from liquid brine to solid crystals was demonstrated with minimum heating requirement of 55°C. The proof-of-concept of the application of this novel low thermal MDC process was established through these lab-scale studies and the key results obtained were presented at the project review meeting in April. The third brine sample received is now being tested.

**C29016**
Southern Coalfields Coal Washery Reject (CWR) Characterisation and Classification, including Management Strategies for Applications in Civil Engineering

SLR Consulting Australia
Christopher Meikle

Value: $160,000
Report Expected: April 2021
Industry Monitor/s: Gary Brassington, Bernie Kirsch, Rae O’Brien, Julian Potten, John Terrill

ACARP Contact: Peter Bergin

Despite decades of successful use in civil engineering projects, the utilisation of coal washery rejects has not been embraced by legislators, regulators, government agencies and other project stakeholders. A key constraint is the lack of contemporary reference resources that address modern environmental and geotechnical performance criteria. The project aims to develop and publish a peer reviewed research paper that addresses these issues. This project has very recently commenced.

**Exploration**

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

CSIRO
Binzhong Zhou

Value: $374,000
Report Expected: June 2020
Industry Monitor/s: Cheryl Miffin, Heather Schijns, Paul O’Grady

ACARP Contact: Patrick Tyrrell

This project focuses on an evaluation of the algorithms developed in project 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 work on the project aims to:

- Improve the current algorithms to work with dipping or gently folded coal seams;
- 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.

In the last quarter, the 3D data analysis results, which demonstrate that diffraction analysis significantly improves the interpretation confidence of subtle structures, have been communicated to the industry monitors and data providers. The project team is reviewing the data with new information from the data providers. In addition, the project team have refined the diffraction extraction algorithms and made a standalone Windows program for processing both 2D and 3D seismic data, which can be distributed to the ACARP stakeholders for use at the end of the project. A draft final project report is in preparation and will be ready for submission at the end of May.

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: June 2020
Industry Monitor/s: John Terrill
ACARP Contact: Peter Bergin

The main objectives of this project are to:
• Explore the advances in sonic log for extraction of different poromechanical properties of coal seam;
• Use sonic log along with other downhole logging data to estimate the poromechanical parameters of the coal seam at in-situ condition; and
• Develop a coupled sorptive-flow-stress model that takes the extracted parameters and predict the stress re-distribution in coal seam due to degassing/dewatering.

As part of the project, we:
• Investigated the physics of gas sorption in coal in details using state-of-art measurements such X-ray micro-computed tomography as well as the poromechanical effects on acoustic wave propagation using both modelling and experimentation,
• Developed a new model based on percolation theory that converts the sonic data to poromechanical coefficient in coal;
• Developed a physic-guided AI model to predict the coal permeability from logging data;
• Developed an excel-based code that takes the logging data and calculate the in situ stress and pore pressure, and other required properties for the modelling; and finally,
• Derived a set of constitutive equations based on equilibrium thermodynamic to take into account all obtained physical processes and solved the constitutive equations by developing a Finite Element based code in Fortran ie the final Fortran model reads the data from the developed spreadsheet and calculates the stress re-distribution around a borehole in a coal seam. In addition, we showed how the sonic measurements can be managed/improved in coal mining industry to estimate coal seam properties more precisely.

Figure: top) Log driven in situ stress-pore pressure profile along an explorative borehole and bottom) numerical results showing the maximum effective stress distribution due to degassing at two different times for a drainage borehole in a coal seam of a coal mining operation.
C27057
Automated Structural Mapping using a Mobile Laser Scanner

University of New South Wales
Simit Raval

Value: $108,146
Report Expected: August 2020
Industry Monitor/s: Brian Vorster
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.

During the quarter gaining access to a mine site to complete the final objectives of this project was stalled due to COVID-19. Structural mapping of an exposed rock face on the surface was suggested by the industry monitors as an alternative approach to complete this project in the given circumstances. The main objective of evaluating the mobile laser scanner for structural mapping was still possible to achieve albeit with respect to the above ground conditions.

As a result during the quarter, previously obtained point cloud data of an exposed rock face was utilised to map the orientation of rock faces in terms of dip and dip direction. Further, it is planned to conduct the change detection simulation in a laboratory condition in the next quarter.

(a) Image of the rock face and (b) the structural details observed in the point cloud.

C28031
Longwall Geological Risk Minimisation using Advanced Electromagnetic and Sonic Technologies

CoalBed Energy Consultants
Scott Thomson

Value: $178,750
Report Expected: November 2020
Industry Monitor/s: Jonathan Lowe
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.

A suitable site for the trial of both techniques was selected in January and the site prepared for an April survey date. COVID-19 restrictions rendered it impossible to bring in the German team to complete the ISS part of the survey. RIM is being undertaken at the site routinely and this data has been processed and reported. The decision has been made to suspend the project until we can mobilise the ISS team. RIM will then be undertaken over the same survey area. It is anticipated that the project can proceed as soon as international travel restrictions are eased.
Health and Safety

C24009
Establish 'At Risk' Distance from Hydraulics

University of New South Wales
Gary Nauer

Value: $26,908
Report Expected: June 2020
Industry Monitor/s: Paul Gill
ACARP Contact: Patrick Tyrrell

No report received.

C24010
Proximity Detection Systems Specification for Underground Coal Mining Machines

Simtars
Andre De Kock

Value: $565,988
Report Expected: June 2020
Industry Monitor/s: Brad Lucke, Glenn Owens, Peter Nelson
ACARP Contact: Patrick Tyrrell

The objectives of the project are to:
• 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 start meeting it was decided to add a literature review to the project. The aim of the literature review is to document:
• The status of suppliers, and their systems involved in the original project — C24010;
• Identify any new entries into the underground coal mining proximity detection arena.

The challenge now facing the research team is how to conduct interviews remotely. At present a suitable platform is sought that is accessible through all the different company IT systems. Computer access will be another challenge, as not all interviewees have access to a computer for the estimated at least two hours interview time. As soon as these issues are resolved the interviews will commence.

C26047
Real Time Dust Monitor

University of New South Wales
Charles Harb
Duncan Chalmers

Value: $184,300
Report Expected: May 2020
Industry Monitor/s: Bharath Belle, Brad Lucke
ACARP Contact: Peter Bergin

A draft report is being reviewed by the industry monitors.

C26048
Improving Respirable Coal Dust Exposure Monitoring and Control

University of Queensland
David Cliff
Mark Shepherd
Nikky La Branche

Value: $250,000
Report Expected: May 2020
Industry Monitor/s: Bharath Belle, Peter Smith
ACARP Contact: Patrick Tyrrell

A draft report is being reviewed by the industry monitors.

C26065
Dustless Longwall and Development Face

University of Wollongong
Peter Wypych

Value: $339,700
Report Expected: July 2020
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; and
• Measurement of dust concentrations after the implementation of the new systems and comparison with previous dust levels.
Work in the past quarter has included:

- Mine agreed to have a new dust suppression system installed on a recently overhauled 12CM30 miner; but this installation has been delayed due to rescheduling, etc;
- Further delays have been experienced due to COVID-19;
- Mine has recently advised that installation of dust suppression equipment should occur by early June.

In the next quarter it is aimed to:

- Following the installation of the system, testing will be conducted on a pair of miners operating at the mine (i.e., the one with the dust suppression system installed and one without). This will allow for a direct comparison to be made allowing for the performance of the system to be assessed (assuming coal properties are similar);
- The project team is in regular contact with the mine to ensure the work and testing are completed at the earliest opportunity;
- Complete a draft report.

C27010

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

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

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**ACARP Contact:** Patrick Tyrrell

The aim of this project is to collect information on a large cohort of coal miners who have a confirmed Coal Mine Dust Lung Disease (CMDLD) diagnosis.

We initially intended to collect information by a clinical questionnaire delivered to coal workers within their respiratory physician appointments. Following a questionnaire being drafted, it was reviewed by the research team and collaborators to ensure the information collected would be of clinical value, and ultimately assist in research aimed at preventing future CMDLD cases. However upon review, key issues with this collection modality were identified, including incomplete representation of CMDLD cases due to questionnaire completion requiring opt-in participation, as well as the logistics and time constraints of completing a questionnaire within clinical workflow.

In addition, because of the time constraints, the data obtained through the questionnaire would not be any more descriptive than that already collected in the course of standard medical practice. It was identified that the information collected during standard medical care would be of more value to our research work than that which could be identified in a short questionnaire. We have subsequently changed the data collection method with clinical and occupational data now being collected via review of medical records. This method to data collection has commenced; a centralised repository has been established and currently data from 25% of identified cases has been collected.

At the present time, work of the research team is focusing on continued collection of data.

C27015

**Coal Characteristics and Pneumoconiosis**

**University of New South Wales**
David Cliff
David Waite

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**ACARP Contact:** Patrick Tyrrell

A draft report is being reviewed by the industry monitors.

C27049

**Mine Rescue Vehicle Radar Sensing Integration**

**CSIRO**
Gareth Kennedy
Lance Munday

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<td>Brad Lucke</td>
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**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 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; and
- Enhanced productivity for mining machinery, where operation is impaired due to dust, smoke or water vapour.
Due to lack of mine access in the quarter, work continued to improve the system hardware and software. The hardware was redesigned and miniaturised so that the radar, gyro, power supply and embedded controller all fit inside the approved transparent flameproof enclosure. The display for the vehicle operator resides on the dashboard and communicates with the system via WiFi. The revised design allows multiple devices to simultaneously connect to the system, enabling real-time access to the radar data from anywhere within the WiFi network. This could be useful for traffic control, i.e., with multiple units mounted in the mine and on vehicles. The system could also be extended to provide two-way communication (with no hardware changes required). This could allow the control room operator to send messages to an in-cab display.

For the field trial, the system is configured to be battery powered. Therefore, the Drift Runner vehicle does not require modification, which simplifies system installation and testing.

A newer version of the radar hardware was also purchased; it promises improved performance in terms of a wider field of view and faster target updates. Testing of the new radar unit is currently underway.

Due to COVID-19, non-critical mine access was indefinitely suspended so the underground field trial scheduled end April did not occur. The project is extended until the end of September. New dates for mine access will be negotiated once the lockdown restrictions are lifted and external contractors are allowed back on site.

We have completed a draft final report for stages 1 and 2 which is with monitors for review. The specific objectives of stage 1 and 2 were as follows:

- Develop a UAV that is capable of self-hovering in a safe location in an underground roadway with bump protection and high-powered LED lighting for navigation;
- Develop a simple driver interface that enables simple control of a UAV – in terms of up/down, left/right, forward/back.

The objectives were successfully met, and the scope expanded to rationalise UAV batteries and test flight duration in an underground mine. Although the flight duration met the set target, we identified other areas for improvement with the anti-collision sensors. The current plan is to complete the following:

- Develop a technical specification that will be incorporated into Request for Quote (RFQ) process for developing a UAV with explosion protection characteristics and ability to carry WiFi nodes;
- Undertake RFQ process to gather budget estimates for the development of the UAV using reputable companies;
- Develop project controls such as detailed schedule (Gantt chart), budget estimate with contingency, establish management structure of project and governance through reporting;
- We will then develop a proposal to progress the project to stage 3 and stage 4.

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

C28001
Fit for Purpose "Self Aware Unmanned Aerial Vehicle (UAV)" for Remote Underground Deployment: Stages 1 and 2

Mines Rescue
Alaster Wylie
Paul Martin

Value: $228,500
Report Expected: June 2020
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 noted.
distribution patterns at different locations along the longwall face.

Two CFD models of longwall faces with different cutting heights have been developed and initial modelling simulations have been carried out to obtain air velocity profiles and respirable dust flow patterns under different mining conditions. Modelling studies have been carried out to simulate the effect of longwall ventilation quantity on face airflow and dust distribution profiles. In the previous quarter, CFD simulations have been carried out to investigate the effect of airflow/velocity on dust re-entrainment at different locations, i.e., at BSL area in the main gate, and at cable tray area of the longwall face with cutting height of 3.6m (mine A). In this quarter, CFD simulations have been carried out with face cutting height of 2.6m (mine B) to investigate the effect of airflow/velocity on dust re-entrainment at different locations under different mining conditions with different cutting height. The results of these modelling simulations are being analysed to understand the effect of face airflow/velocity on dust re-entrainment and dust distribution patterns on the longwall face.

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

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

Due to the restriction on the lab activities during this COVID-19 pandemic, the team has brought forward the tasks related to the flow path design and focused on optimising the pressure drop within the device via simulation approach. In addition, the team also compiled the related chemical compositions for the baseline investigation based on the comments received in the previous review meeting. Moving forward, the team plans to complete the flowrate simulation in June and hope to be able to go back to the lab when the restriction lifted. The recruited PhD researcher has submitted the VISA application and will join the team as soon as the approval is granted.

C28029  
**Personal Real Time Dust/Particulate Monitor (Direct Mass Based Measurement)**  
**Lear Siegler Australasia**  
Peter Phaedonos  

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We are getting to the later stages of this project with prototypes being assembled for testing and debugging. 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.

Quick dot point status of project:
- Electrical and mechanical design was slightly modified to cater for IECEx requirements;
- Software/firmware development ongoing, with testing continuing;
- Initial prototypes of all the hardware have been assembled and hardware debugging commenced mid-January;
- Additional units to be assembled in the coming months for the IECEx testing and certification;
- SIMTARS is the selected Test/Certifying house for IECEx/ANZEx certification;
  - commenced reviewing the electrical schematics against standards,
  - due to some re-design requirements the major documentation handover has been put back to mid-May,
  - this stage seems to be moving slowly as we needed to work in with the re-design, and the certifying house,
  - once Working prototype ready one or two units will be made available for testing;
- LSA and selected stake holders will start performance testing of the prototype units -
  - this will be an opportunity to iron out any bugs and fine tuning its performance,
  - this is anticipated to be an ongoing process for at least three months,
  - we are hoping to commence this now in June/July.
Activities undertaken this quarter are as follows:

- An overview on the latest developments in real time silica monitors has also been undertaken. Reviews of immediately past and current ACARP dust related projects have been continuously undertaken;
- Assistance has been provided to targeted researchers to develop a project for a methodology development for analysing PDM3700 filters for free silica contents. The project is now funded by ACARP. First phase of the project has commenced in late March. Research tasks are now being carried out by researchers;
- A research work package for a potential project investigating the relevance and applicability of inhalable dust and issues with AS3640 was developed. Researchers have been identified and a research proposal has been submitted to ACARP for 2020 funding run consideration;
- Meetings were held with the researchers for the project C28029 on the development of new PDM and providing technical inputs on developing firmware and its user-interface software program. Assistance was also provided to researchers in finalisation of the project extension proposal;
- Scope and draft proposal has been developed for the definition and applicability of breathing zone airborne particular contaminants. A short research proposal has been submitted for ACARP 2020 funding consideration.

**C29020**

**Resilience and Mental Health in Mining**

**Macquarie University**

Rebecca Mitchell

Value: $201,666

Report Expected: April 2022

Industry Monitor/s: Rae O'Brien, Sharif Burra

ACARP Contact: Patrick Tyrrell

This project will investigate the work related factors contributing to the resilience of coal mining employees. The objectives of the project are to:

- Understand the link between workplace experiences, resilience, and mental health in coal mining;
- Understand the practices that support resilience and mental health at work in coal mining, and those that may undermine resilience and mental health;
- Provide guidance regarding the practices and strategies that support resilience and mental health in coal mining.

The first project phase will use interviews to explore the perceptions and practices of employees and senior leaders regarding the strategies and practices that are successful in supporting resilience and mental health and the barriers that may lessen or undermine this goal. The second quantitative phase will involve disseminating an online survey to employees and managers to uncover the pattern of factors that are most likely to explain and predict resilience at work.

The research team is in the process of finalising the first draft of our interview schedule to be used in the first phase of the study; the format and the content of this schedule will be shortly discussed and finalised in collaboration with our industry monitors. Once the interview schedule is finalised, we will be ready to submit our application for ethics approval of the research protocol. A research coordinator has recently been appointed to the project who will be involved in the detailed design of the study, systematic literature reviews, assist in the coordination of the project, and will contribute to data collection and analysis and reports. We have also shortlisted candidates for research associate positions. Over May and June, as guided by our liaisons and dependent on mine readiness, we will be embarking on the process of negotiating access to participants for the first phase of the study.
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 project has been delayed for more than three months due to COVID-19. The manufacturing of the prototype reactor has been completed over the last quarter. The UV light panels are expected to be delivered in July. Then the prototype reactor will be assembled with the light source and ready for testing with the diesel engine exhaust.

C27006
Lightweight/Compact IS 12VDC UPS Portable or Fixed Supply
KRS Technologies
Kurt Schober

Value: $141,800
Report Expected: July 2020
Industry Monitor/s: Graeme Relf, Graham Café, Greg Briggs
ACARP Contact: Peter Bergin

The objective of this project is to produce a light weight and compact I.S. portable 12VDC UPS with an extended capacity of up to, 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.

During this quarter we made changes to the IS Power Supply Output Board. We also carried out extensive design testing in house, so as to verify the 12V DC output does not spark during a short circuit on the output. We then submitted the design change drawings to Test Safe who subsequently approved them on 17th April. The process was long winded due to the current virus situation and test engineers working from home.

The new PCB design was immediately sent away to obtain new blank boards plus a solder paste stencil. When the new blank PCB’s arrive, the boards will be built and sent to Test Safe for final approval. The blank PCB Boards are currently still in customs, but we should be in a position to have them very soon.

C28003
Lithium Traction Battery for Underground Coal
3ME Technology
Justin Bain, Martin Kime, Richard Eveleigh, Steve Howell

Value: $1,268,500
Report Expected: February 2021
Industry Monitor/s: Brad Lucke, Greg Briggs, Paul Wyatt, 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 (EV) system that meets Australian hazardous area compliance requirements. In Stage 1, 3ME Technology conducted a successful design verification of the battery. In Stage 2, 3ME progressed from a mark one (MK1) to mark 2 (MK2) battery design and commenced certification activities. Stage 3 will support the final development and certification requirements for the battery modules and supporting drive systems components as a complete hazardous area EV system.

Key activities conducted to date:
• Design, manufacture, testing and validation of prototype components;
• Battery Management System (BMS) software development;
• Progression of subcomponents of the MK2 battery through internal and independent certification review and into formal certification;
• Progression of the prototype battery towards assembly, mechanical and electrical integration validation;
• Preparation of the electric flameproof motor and controller hardware. The documentation was internally reviewed and updated to meet IEC60079 standards. The motor and controller are now with the certifying body; and
• Completion of validation testing of suitable underground battery charger.

The integration planning and preparations have continued to progress in collaboration with 3ME’s mechanical integration partner:
• Completion of the personnel transporter EV design and engineering for the ancillary integration;
• Progression of the electrical system and mechanical integration drawings towards final design;
• Progression of the EV mechanical preparations, component overhaul and modifications supporting the batteries, drive systems and new electrical system is ongoing.

Key tasks to be conducted include:
• Certification of outstanding battery subcomponents.
• Additional Battery Management System (BMS) developments;
• Final assembly, testing and certification of the MK2 battery prototype;
• Integration of certified battery modules and complete the electric vehicle (EV) system into the proof of concept EV;
• Charger testing and final certification; and
• Field trialling of the proof of concept EV in an underground coal mine.

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

Vayeron
Mark Walter
Ryan Norris

Value: $170,000
Report Expected: June 2020
Industry Monitor/s: Brad Lucke
                  Dave Young
ACARP Contact: Patrick Tyrrell

A draft report is being reviewed by the industry monitors.

C28010
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.

Figure 1. 3D printed enclosure prototype for gas monitoring station as designed in collaboration with Tiller Design (housing) and And/Or Design (PCB). The housing abides by IP54 ingress protection standard and house all four sensors (CO, CO2, O2, CH4).

Work undertaken in the past quarter includes:
• Gas monitoring station PCB design has been approved by ExTesting as intrinsically safe and are now at fabrication stage;
• Enclosure and marking design has been finalised with the first enclosure prototype reviewed by ExTesting and ACARP monitors (see Figure 1);
• The design of the RTU is in progress which includes the completion of the photodetector board design and on-going development of data acquisition and user interface;
• 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:
- To complete printed-circuit boards assembling and to continue firmware development for gas monitoring stations;
- To complete two gas monitoring enclosures for intrinsic safety test;
- To develop user interface and Ethernet communication for RTU;
- To work with mine sites on installation logistics and fibre network arrangement for field trial;
- Project documentation update.

We foresee no important technical holdups. Given the current state of development, we still expect the field tests of the gas sensing network to occur around October thus allowing for six months of in-situ testing – in line with the work schedule.

### C28025
**Integration of DAS Conveyor Monitoring into SCADA to Enable Smart Maintenance Scheduling**

**University of Queensland**

**Mining3**

Paul Wilson

**Value:** $300,147  
**Report Expected:** December 2020  
**Industry Monitor/s:**  
Brad Lucke  
Clinton Vanderkruk  
Kevin Rowe  
Stephen Broad  
**ACARP Contact:** Patrick Tyrrell

This project is engaging new research to detect rapid failures (using DAS monitoring) in real-time or ‘near real time’ to enable smarter and more responsive operational performance and maintenance. The research challenge is to identify rapid failure events in real-time without detailed processing of large volumes of data in a signal with significant noise.

The approach works to quickly identify segments in the signal that represent a high probability of containing characteristics of current or pending failure, then deploy existing high integrity algorithms to characterise these detected high probability events.

This approach moves away from a ‘batch’ processing to a continuous ‘production line’ approach.

The project kicked off following a change of scope to the original project plan. The whole objective is to speed up the processing of the data using a range of techniques and approaches to present the conveyor condition in real time fast enough to capture sudden conveyor failures.

To date the entire code base has been restructured to remove any signal processing not required at that point in time. Each part of the processing only occurs ‘just-in-time’ in a way similar to a modern production line. The smallest inefficiency was removed and the program now runs considerably faster. The second modification was to implement an auto-regressive filtering structure which is radically different from the original design. The downside of this method is that the early results can be somewhat vague and imprecise and they become considerably clearer as more data comes in and clarifies the results presentation much like a camera slowly coming into focus. The advantage is that the results are presented on a continuous basis. The instrument and software is now continuously acquiring data from the conveyor and is simultaneously processing and presenting the results.

The next stage is to use a machine learning approach to focus processing attention on the more severely worn and more critical areas of the belt.

### C29009
**Control of Touch Potential Transients During Switching**

**ResTech**

Peter Stepien

**Value:** $114,000  
**Report Expected:** April 2021  
**Industry Monitor/s:** Barrie Alley  
**ACARP Contact:** Patrick Tyrrell

During a number of investigations into electric shock incidences in the past, machine frames measured touch potential transients when switchgear closed or opened. There were no faults present in the equipment or the earth fault limited supply, yet touch potentials occurred. The aim of this project is to understand the method by which these touch potentials occur and determine a method to eliminate them to improve mine safety. Initially, the construction of an ELV and then LV hardware equivalent models will allow for convenient experimentation. Finally, outcomes will be a demonstration on typical mining equipment at normal system voltage.

Preliminary work commenced prior to the start of this project by two final year electrical engineer students at the University of Newcastle under the guidance of ResTech. This is now being continued by one of the students developing a 41.5V hardware equivalent model. This will consist of a 415/41.5V transformer, an NER, cable model, switchgear and induction motor. Parasitic capacitance between phases and earth found in typical mining equipment will be implemented using discrete capacitors. A microcontroller is used to coordinate switching and measurement, with test point for voltage and current available.

The procurement of parts for the ELV hardware model is complete. The design and fabrication of two custom PCBs for the microcontroller and supporting electronics to control the hardware is also complete, with assembly underway. Once assembly is complete, testing will commence. The first aim will be to reproduce touch
potential transients seen during electric shock incidences and then testing methods for controlling them.

In preparation of the completed hardware, a simulation model of the ELV hardware will evaluate a number of methods for controlling touch potentials. The hardware model will then evaluate promising methods found in simulation.

Mining Technology and Production

C20033
Development of a Safer Underground Explosive

University of New South Wales
Andres Castro
Duncan Chalmers

Value: $323,500
Report Expected: June 2020
Industry Monitor/s: Bharath Belle, Brad Elvy, Paul Wild, Russell Thomas

ACARP Contact: Patrick Tyrrell

Ministerial approval has been given to recommission the test gallery, however the facility is unavailable due to COVID-19. Once restrictions are lifted recommissioning will recommence.

C27051
Assistive Shuttle Car Guidance System - Stage 2 Implementation

CSIRO
Jonathon Ralston

Value: $227,275
Report Expected: June 2020
Industry Monitor/s: 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 automatic manner. The motivation for the project is to improve the productivity and efficiency of roadway development and provide improved safety for personnel.

The project’s objectives are to:
- Develop a retrofittable guidance prototype to enable supervised auto-tramming;
- Demonstrate the trarming system operating in an analogous underground environment;
- Evaluate performance in a non-operational context with relevant control features.

This project has concluded all agreed work program components. For completeness, a set of additional evaluation activities were undertaken to investigate how the original laser scanner equipment might be utilised in existing flameproof enclosures. The interest was to identify how different flameproof configurations influenced sensing performance with respect to range and field of view. As a general observation, it was found that the range and field of view was reduced when trialled through the enclosure windows, but the overall performance was still acceptable to meet the core sensing requirement. Recommendations have been developed based on this outcome to transition the current unprotected electrical equipment (UPEE) devices.

Strong interest from the roadway development community exists to see further development in the assistive guidance system. The final report is now under preparation for submission in shortly.

C28017
Integrated Longwall Creep Control System

CSIRO
Jonathon Ralston

Value: $263,305
Report Expected: June 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 the position of maingate equipment to ensure it is within creepage target limits. This measurement and subsequent prediction process to steer the longwall is often complex and time consuming with impacts on mining productivity. 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 steering correction profile suitable for integration into an existing LASC face alignment system;
- Stage a series of controlled, supervised evaluations on a production longwall in a manual open loop format to determine system performance.

Major effort has focussed on capturing operational data in order to better understand the factors linking maingate-to-tailgate lead/lag distances and maingate creep. This involved collecting a large data set including support locations along the longwall face and creepage. As this information is generated by a set of different systems each had a different data format, resolution and availability. Significant manual effort was therefore...
required in attempting correlate this information, which highlighted the broader need for more continuous data generation. Approaches were made improved data generation consistency by installing a rope “target line” in the main gate roof which provided a highly identifiable tracking target for the ExScan-based creep measurement system.

An intensive two-week system evaluation is currently planned with the hosting mine site in May to complete fundamental monitoring and control demonstration, with the view to submit the final report by June.

**C28018**  
Longwall Floor Horizon Sensing  
CSIRO  
Andrew Strange  
Zak Jecny

**Value:** $269,680  
**Report Expected:** January 2021  
**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 horizon control sensor can be completed on a production longwall. This includes the development of a suitable non-metallic explosion protected enclosure.

As described in the previous update, the Ex. p protection method is being adopted for the radar sensor. A prototype non-metallic enclosure has been designed, fabricated and internal testing for compliance with the relevant sections of AS60079 has commenced. The tests conducted to date include impact, over-pressure, leak and thermal testing. The enclosure prototype has passed all of these tests. The static pressurisation system has also been designed, implemented and also functionally tested to AS60079. The mechanism to manually reset the pressure switches (which are located inside the pressurised enclosure) has been designed and fabricated and successfully tested.

Next steps are to finalise the general arrangement of the equipment inside the enclosure, test the entire system at the test mine site to ensure the system functions as desired, then commence certification of both the enclosure and payload.

**C28021**  
Benchmarking Study of Underground Coal Mining Logistics  
University of Wollongong  
David Walker

**Value:** $71,000  
**Report Expected:** June 2020  
**Industry Monitor/s:** Roadway Development Task Group  
**ACARP Contact:** Patrick Tyrrell

A draft report is being reviewed by the industry monitors.

**C29034**  
Integrated Roadway Development: A Strategic Industry Review  
CSIRO  
Jonathon Ralston

**Value:** $100,355  
**Report Expected:** June 2020  
**Industry Monitor/s:** Roadway Development Task Group  
**ACARP Contact:** Patrick Tyrrell

This project is undertaking a strategic review of past and current roadway development practices including current technology applications and identified needs in order to clarify priorities and recommendations to target high-value roadway development.

Longwall operations have benefitted from the industry’s sustained interest in automation technology development which has improved personnel safety, extraction rates and production consistency. Notwithstanding the ACARP CM2010 initiative, the roadway development community has received far less attention in terms of focussed technology innovation, despite the complex and critical nature of the development process. The project objectives are therefore to:

- Capture past and current technology and directions by engaging with key stakeholders;
- Analyse process requirements, categorise operational modes and assess technology readiness;
- Develop a state-of-the-art review and open roadmap to accelerate development and adoption.

At the request of the roadway development task group, an interim project report was prepared and delivered in March, which summarised the review process, described major observations and findings so far through interviews and workshops. It also outlined a set of high impact areas that are important to advance the maturity level of roadway development over the next ten years. A set of high priority candidate projects were also specifically identified over three delivery time phases. The final report is now under preparation for completion shortly.
The project objectives are as follows:

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

Progress to date includes:

- A review was carried out of the findings from the 500 bolt underground trial held 2016 using an airtrack bolting rig with the retro-fitted prototype to install vertical, inclined and horizontal bolts;
- Design of the production standard prototype chemical pumping and delivery system is complete;
- Procurement and manufacture of all components is 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 conjunction with the intrinsically safe control system was delayed 12 months due to human resource availability from the supplier, however, it is now complete;
- All workshop testing is complete, the injection units are now stored, as are the bolters, E-boxes and HMI units until they are to be fitted to the continuous miner;
- The host miner has now been fitted out with the OKA equipment adapted to the LHS rib and vertical bolters;
- Calibration and commissioning of the equipment was not complete when COVID 19 restrictions were put in place. Calibration and commissioning completion and the underground trial have subsequently been delayed until restrictions are removed.
• Continuous batch feeding and acceptance of the system at the host mine site simulated operating gateroad (surface trial);
• Carryout modifications required to both Sizer Feeder and Premron CHS in readiness for underground trials (Stage 7 - 2020); and
• Installation and trial operation in a fully working underground panel (Stage 7 - 2020).

With the CV-19 restrictions, Premron was able to get most of the CHS trolley’s and enclosures off site, to enable work to continue back in their facility in Gladstone. Although this added additional none budgeted spending, it allowed the project to continue with adjustments made to the overall work program.

The Sizer Feeder machine modifications were finished as planned, but instead of performing the commissioning onsite at the host mine, Premron performed in-house in Gladstone, which was completed successfully and sent back to site in late April.

Both Premron CHS and the Sizer Feeder machine have undergone all the modifications necessary to ensure mine compliance and readiness for the underground trials. Premron have been given permission to complete a final two week shut down on the CHS surface testing machine, at the host mine. This will be performed mid May and will finalise all mine compliance issues electrically and mechanically.

Final surface trials will be completed early June, along with mine site acceptance, risk assessments and training package roll out. The COVID-19 restrictions have added about four to six weeks to the current plan, with underground trials now likely mid 2020.

### Strata Control and Windblasts

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<th>Project Code</th>
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<td>C25059</td>
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<td>C26063</td>
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<td>Peter Bergin</td>
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Stage one is complete, stage two will commence work in July.
C26064
Floor Stability: Comprehensive Investigation Into Failure Mechanisms and Controlling Factors

University of New South Wales
Serkan Saydam

Value: $298,940
Report Expected: May 2020
Industry Monitor/s: Adam Lines
Brian Vorster
Patrycja Sheffield
Peter Corbett

ACARP Contact: Peter Bergin

A draft report is being reviewed by the industry monitors.

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
Guangyao Si
Joung Oh
Najdat Aziz

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.

Laboratory investigation: The experimental part of the angle shear testing of cables is completed and full report is currently been fine-tuned and editorially checked. The full report will be ready for submission shortly.

Field data analysis: Three months of monitoring data of roof shear displacement have been collected from mine A. Roof shear displacement as longwall approaches was analysed against different faceline positions. The key layers causing horizontal roof displacement are identified (see figure below). These results have also been compared and reconciled with the tell-tale data collected at the same position.

Numerical modelling:
• USQ - Two-dimensional numerical simulation was completed. Local and global concepts were incorporated to model shear behaviour of angled cable bolts. Sensitivity analysis was conducted by considering various pertinent parameters including pretension values and installation angles. Local concept was subsequently extended into 3DEC, investigating in details shear behaviour of angled cable bolts in three-dimensional framework. Currently, research team is working to finalise the report and to prepare papers in quality journals and conferences for findings disseminations. It is envisaged to submit the report on time.
• University of New South Wales - As commented by our industry monitor in the project review meeting, the friction angle applied in numerical models need to be adjusted. We have retrieved coal and coal measure rocks in Mine A and remeasured the friction angles and cohesion on these samples to be used as the modelling input. The effects of pretension on cable bolt failure mechanism under different geological, in-situ stress and rock strength conditions were analysed. In addition, as suggested by the monitor, the project will investigate a more innovative way to simulate the coupling interaction between grout, cable and country rock. This will help cable bolt support design in the industry.

C27045
Assessment of Longwall Mining Induced Connective Fracturing

CSIRO
Deepak Adhikary

Value: $407,438
Report Expected: January 2022
Industry Monitor/s: Gift Makusha
Julian Potten
Peter Corbett

ACARP Contact: Peter Bergin

A draft report is being reviewed by the industry monitors.
**C27071**
**Intrinsically Safe Digital Networked 3D Roof Bolt**

**Holville**
Anne Wylie

**Value:** $140,000  
**Report Expected:** July 2020  
**Industry Monitor/s:** Mick Stadler, Paul Buddery, Roger Byrnes  
**ACARP Contact:** Peter Bergin

The project objective is to develop an intrinsically safe instrumented digital roof bolt that will:
- Accurately measure axial strain and bending in three dimensions;
- Interface to the Holville handheld terminal (project C25060), the wireless network of geotechnical sensors project C25059, and the IS certified (IECEx 12.0034X) Holville roofAlert™ communications and power backbone;
- Provide a cost-effective alternative to the routine monitoring of existing analogue ¼ bridge strain gauged roof bolts.

Currently working on building a test bolt with single slot, distributed, multiplexed circuit boards with strain and 3D inclination measurement to determine direction of bend. Progress on the project has slowed due to factors including the impact of COVID-19.

**C27073**
**Roadway Stability Monitoring System**

**CSIRO**
Chad Hargrave

**Value:** $239,565  
**Report Expected:** November 2020  
**Industry Monitor/s:** Jason Kim, Jim Sandford, Richard Porteous  
**ACARP Contact:** Patrick Tyrrell

This project is an extension to project C25062, which successfully demonstrated, in an underground field trial under realistic conditions, a new radar scanning technology that can detect millimetric changes in roadway structure. Project C27073 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.

The build for the radar-based change detection hardware has been successfully finalised, and the completed sensor has been delivered – a major step toward completion for the project. A mine site trial had been planned for the final week in April, but due to the COVID-19 lockdown this has been postponed indefinitely. The proposed sensor training with the system designers was unable to go ahead on delivery of the instrument. Instead, remote training and system commissioning has taken place between CSIRO staff and the system manufacturer. This process has successfully verified that the instrument is working correctly and that it is capable of detecting and measuring millimetric changes in distant targets.

The project has now moved into the trial phase, with initial testing demonstrating good sensitivity and repeatability of measurements of a remote target. The goals of the current project phase will be to identify the minimum reliable, repeatable change detection capability of the instrument, as well as its ability to operate continuously for a long period without significant measurement drift.

This in-house testing will deliver the key technical result of demonstrated continuous monitoring of a very slowly changing environment. These results will be supplemented by measurements of an external rock face or similar structure to demonstrate the spatial registration and practical deployment outcomes, enabling finalisation of the project outcomes and reporting.

**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 is due to commence June 2020.
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 outburst assessment methodology adopted in thousands of Chinese outburst coal mines, and its applicability to Australian low permeability coal seams. The final goal is to improve outburst assessment methods and control strategies mining in low permeability coal seams.

In the previous quarters, we had gathered and analysed data and information about Chinese outburst assessment methodology and engaged with a leading Chinese expert through a three month visit at CSIRO, including an underground visit at a Queensland coal mine. The test devices to measure Chinese outburst indices are also established at CSIRO.

We had previously planned to request/collect coal samples from project coal mines to test outburst indices of the Chinese methodology in this quarter. However, the plan was not able to be proceeded due to COVID-19. A planned visit of a Chinese researcher to CSIRO for 12 months is also delayed.

Instead of laboratory work, we shifted to desktop studies that can be conducted during the period of working from home. We had focused on the analysis of the mechanism leading to outburst incidents occurred in Australian coal mines, and the procedures used in Australian coal mines in assessing and predicting outburst risks and their differences from that adopted in Chinese coal mines.

C28019
Carbolt - Self Monitored, Yieldable Carbon Fibre Cable Bolt for Ground Control

Mining3
Karsten Hoehn

Value: $229,080
Report Expected: July 2020
Industry Monitor/s: Patrycja Sheffield
ACARP Contact: Patrick Tyrrell

The main objective of this project is to research, design and laboratory-test a ‘coilable’, carbon-fibre based rockbolt prototype, that includes:

- The ability to be installed similarly to a cable-bolt;
- A cable design that offers axial support and shear-load capacity and therefore provides support against lateral rock movement;
- The design of a ‘serviceable’ Carbolt locking mechanism with a load bearing plate; and
- An optical fibre sensor, integrated into the Carbolt during the manufacturing stage, to enable the ability for monitoring of rock movements.

The project will be considered successful if it can demonstrate the feasibility of a coilable carbon-fibre based rockbolt for underground roof support as an enabling technology for future automation of the roof support system, while achieving comparable specific tensile performance to a steel rebar roofbolt.

Following the assessment of several commercially available carbon fibre tows for manufacturing high strength cables and the selection of a suitable tow for the Carbolt the project progressed with the mechanical design of the Carbolt prototype cable, which comprises of multiple twisted carbon-fibre layers and a core.

The number of lays and the twist angle for the carbon-fibre tows to achieve a comparable specific tensile performance to a steel rebar roofbolt was confirmed through a series of tests. Then the design of the core could start as this had to match the lay twist angle. The flexibility of the core is a critical design parameter as it provides sufficient support for the cable structure while still allowing the Carbolt to be bent. Therefore, the core was modelled with several materials using Finite Element Analysis. Samples of the core are now being 3D printed for testing.

To ensure proper resin saturation of the carbon-fibre tows it was decided to pre-impregnate the Carbolt with a highly flexible resin. Potential resin candidates have been purchased from speciality chemical suppliers and are ready for testing.

Optical sensing fibres have been integrated into the 1st and 2nd Carbolt lays and field-serviceable connectors have been purchased. These connectors will be assembled with the prepared cores and pre-impregnated cables for the upcoming testing.
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, Peter Corbett
ACARP Contact: Peter Bergin

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

Progress to date:
- Parameters have been finalised subjected to any potential variation with on going experiments:
  - confining medium length: 1150mm,
  - confining medium width: 400mm,
  - confining medium (top) height: 1000mm,
  - confining medium (bottom) height: 1250mm,
  - plug height at the bottom of lower confining medium: 50mm,
  - lower embedment section: 1250-50: 1200mm,
  - confining medium strength: 40MPa,
  - grout strength: 60-80MPa,
  - borehole diameter: 42mm;
- Design of experiment program has been established: MB10 TTX will be tested under three different pre-tensioning levels being 0, 10, 20t;
- Experiment set-up has been designed and modelled: All the components of the experiment set-up has been created and assembled in the numerical modelling software ‘ABAQUS’ (see Fig 1). The dimensions and hole patterns of the testing facility ‘MAST’ were also analysed to aid in the experiment design (see Fig 2).

Fig 1 Experiment set up in ABAQUS

Feasibility study of the experiment design has been conducted aiding in the selection of the most suitable thickness of steel plate used in the test. The thickness was determined to be at least 10mm according to the modelling results seen in Fig 3.

Fig 2 Hole patterns and dimension

Fig 3 Numerical model results

- Suppliers and manufactures have been approached for ordering materials and mould casting.

C28026
Measuring the Height of Fracturing above Extracted Longwall Panels to Improve Reliability of Groundwater Impact Prediction

SCT Operations
Ken Mills

Value: $180,000
Report Expected: May 2020
Industry Monitor/s: Bob Coutts, Peter Corbett
ACARP Contact: Peter Bergin

A draft report is being reviewed by the industry monitors.
C29008
Modelling the Onset of Fracture Induced Instabilities for Underground Mining Applications

University of Newcastle
Anna Giacomini

Value: $203,820
Report Expected: March 2022
Industry Monitor/s: John Grieves, Paul O’Grady
ACARP Contact: Patrick Tyrrell

This project will deliver practical guidelines for designing bolt and cable roof support systems in anisotropic and jointed rock mass by developing and applying an efficient phase-field finite element code that is capable of computing stresses, displacements, and fracture paths. The code will incorporate a ‘Phase-field’ in addition to the usual displacement field, which allows cracks to be represented as smeared regions of damaged material within a continuum. The method has been used recently by the project investigators at the University of Newcastle to accurately reproduce both crack paths and load-displacement relationships in homogeneous and isotropic materials with or without structural features.

Over the last three months the team started the development of an efficient phase-field formulation to be implemented in the bespoke code. This step will extend in the coming months to its implementation in the bespoke computer code and the programming of additional finite elements required for simulating support measures used in underground mining applications.

C29012
Longwall Rock Mechanics in Massive Strata

Sigra
Tim Gibbons

Value: $245,000
Report Expected: July 2021
Industry Monitor/s: Bob Coutts, Brad Elvy, John Grieves
ACARP Contact: Patrick Tyrrell

This project will commence soon.

C29014
Definition and Quantification of Long Term Stability of Coal Pillar Systems

University of New South Wales
Ismet Canbulat, John Watson

Value: $230,000
Report Expected: April 2022
Industry Monitor/s: Dan Payne, Peter Corbett
ACARP Contact: Peter Bergin

The objective of this project is to define and quantify the long term stability of coal pillar systems. Work undertaken this quarter includes:

- Subsidence New South Wales has been contacted for any failed pillar cases. But a visit has not been possible due to current travelling restrictions.
- Coal pillar spalling rates are currently being observed at a mine site in New South Wales, where the pillar ages vary from two years to 40 years. But due to travel restrictions, the work will continue during next quarter.

The project is progressing within its anticipated timeframe.

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 the projects C25072 and 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 -
  - control program was installed and is undergoing fine tuning to ensure the required parameters are obtained during testing, this will be completed by the end of May;
- 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 is completed,
  - validation of a four channel GC for analysis of alkanes and VOCs is 95% completed. Only the work on the detection of propane needs to be completed. A channel in a third GC will be utilised for the detection of propane,
  - documentation of the analytical method for the gas chromatographs will be completed at the end of May;
- A literature survey of relevant reports and papers is in progress. Relevant Czech and Polish papers on spontaneous combustion indicators have been identified and sourced;
- It is envisaged to load 60 L of coal into the 2 m column during June. The coal will be sourced from a Queensland mine and will be the first of two tests to be conducted as part of this project.

C26058
Optimisation of the Coal Seam Gas Predrainage Process

Palaris Australia
Mark Blanch

Value: $293,220
Report Expected: May 2020
Industry Monitor/s: David Webb, Russell Thomas, Sharif Burra
ACARP Contact: Peter Bergin

A draft report is being reviewed by the industry monitors.

C27035
Automatic Leak Detection for Tube Bundle Systems

Simtars
Sean Muller, Snezana Bajic

Value: $220,000
Report Expected: January 2021
Industry Monitor/s: Bharath Belle, John Grieves
ACARP Contact: Patrick Tyrrell

The project objectives are to develop an intrinsically safe borehole survey tool that will:

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

Currently working on the real-time streaming of position data from the survey tool to the master controller in the roadway. Streaming of video data has been successfully achieved. Progress on the project has slowed due to factors including the impact of COVID-19.

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: Bharath Belle
David Webb
Paul Wild
Russell Thomas
Sharif Burra

ACARP Contact: Peter Bergin

The main objectives of this project include:
• 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;
• 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, intact core samples obtained from underground coal mines in the prior period have been subjected to various gas permeability vs applied stress experiments using the University of Wollongong Triaxial testing apparatus. In addition, -212um powdered samples obtained from the same sources, have been tested for sorption capacity using a range of gas compositions. Analysis is currently focused on the comparison of relationships between applied stress, coal geometry and gas composition characteristics with specific attention to particle size. Quantification of coal geometry in intact samples has been obtained using macro and micro-CT techniques.

While COVID-19 isolation requirements have impacted campus laboratory access and hence delayed some isotherm testing, several of the long-term sorption and desorption tests on intact core samples have been completed. Furthermore, as data from mine gas testing databases has been updated, this has been included for comparison with prior research completed at University of Wollongong. Experimental results further confirm laterally extensive and uniform floor-to-roof intra-seam coal character and gas emission response patterns that are more sensitive to the applied stress regime and coal material properties. These patterns, consistent with geochronological deposition sequence, may be used to reduce the apparent variability in observed gas emission behaviour regardless of reservoir gas composition.

We continued to conduct isotherm tests on samples collected from four mine sites. Samples are crushed to four groups of size fraction, e.g. particle size <212um, <1mm, 1-2.5 mm, 2.5-5mm, and subjected to isotherm sorption tests. Test results obtained to date show that coal particle size impacts the adsorption isotherm, the finer the size, the higher adsorption volume. Coal sorption varies between samples from different mines samples. CO2 adsorption volume is much larger than CO2/CH4 and CH4 the least.

Generalised relationships between increased applied confining stress and reduced gas permeability are again found to be consistent with prior research. However, in specific cores featuring bright horizontal bands, bedding planes, or other visible cleat fractures, the permeability response to increased stress load across a range of gas compositions was found to vary up to two orders of magnitude from those cores without such features. Results for Carbon Dioxide long-term sorption and desorption for intact samples demonstrate evidence of the swelling effect on applied stress and hence emission response. Otherwise, a high degree of intra-seam permeability variation and anisotropy is possible in Bulli Seam coal, even within relatively small lateral and vertical extents.

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

Capricorn Management
Dennis Black

Value: $69,750
Report Expected: June 2020
Industry Monitor/s: Bharath Belle
David Webb
Paul Wild
Sharif Burra

ACARP Contact: Peter Bergin

The main objectives of this project include:
• 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;
• Analysis of the data collected to date indicates there is no ‘loss of gas’ from core samples collected by UIS drilling where core recovery time exceeds 40 minutes.
In this quarter, mines that had previously indicated support for this project were contacted and requested to undertake site data collection to contribute to this project. Unfortunately, no additional data has been provided and the project report will be prepared using the data currently available. The literature review has been completed and the project report will be prepared using the results from the thirteen test locations provided by the four Australian mines. Preparation of the draft project report has commenced and will be submitted to monitors for review this coming quarter.

**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  
Paul Wild  
Peter Baker  
**ACARP Contact:** Patrick Tyrrell

The project aims at developing an equivalent goaf resistance model that can be incorporated into Ventsim to enable mine ventilation officers to model and assess goaf gas behaviours at a site level. The project is the first stage of the overall development of the goaf modelling functionality in Ventsim.

In previous quarters, we had developed fundamentals in translating parameters between flows in porous media and airways, and demonstrated good agreement between Ventsim and CFD methods in solving goaf gas flows through a 2D generic model.

This quarter we moved onto the development of the 3D resistance mode. We constructed a 3D goaf model in Ventsim based on an actual mine plan and ventilation parameters. Methane release from adjacent coal seams is also enabled in the model. We have run several simulations to calibrate the model with results produced by CFD. The calibration process is still ongoing, and we expect that reasonable agreement can be achieved in the next quarter.

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**C28022**  
**Rotary Steering System for Underground In Seam Drilling**

Sigra  
Andrew MacTaggart  
Ian Gray

**Value:** $574,404  
**Report Expected:** August 2020  
**Industry Monitor/s:** Malcolm Waterfall  
Owen Salisbury  
Paul O’Grady  
Russell Thomas  
**ACARP Contact:** Patrick Tyrrell

The objective is to build and test a simple rotary steering system (RSS) that is suitable for use in underground inseam and cross measure drilling. A rotary steering system provides directional control while maintaining rotation of the drillstring. This results in the ability to drill further with directional control at a higher rate of penetration, reduce hole tortuosity and increase hole cleaning performance. The increased drilling speed is expected to be a particularly important gain in cross measure drilling. Rotation of the drill string should enable better cuttings clearance and more effective directional drilling through boggy ground.

The first iteration of the Rotary Steerable System has been fabricated, assembled and tested under static conditions in Sigra’s workshop. The workshop testing has been a success with the RSS operating as expected.

The next stage of testing is now underway which involves conducting drilling trial with a borehole from surface. Sigra purchased a drill rig and have since conducted mechanical inspections and repairs to ensure the rig can meet the demands of the drilling program. Sigra have fitted the rig with their borehole survey system along with thrust, torque, flow rate and pump pressure logging to assist with analysis of the RSS drilling performance.
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;
• 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.

No significant progress has been made during this quarter due to COVID-19 constraints.

C29017
Appraisal of Gas Indicators from Goaf Drainage Holes for Spontaneous Combustion and Explosion Risk Management

University of New South Wales
Guangyao Si

Value: $119,750
Report Expected: April 2021
Industry Monitor/s: Bharath Belle, David Webb, John Grieves, Paul Wild, Peter Baker
ACARP Contact: Peter Bergin

The project objectives are to:
• Establish normal goaf gas profiles and identify trends of gas indicators (CO, CH4, O2 and CO2) by statistical analyses of goaf gas drainage data obtained from New South Wales and Queensland mines;
• Assess current TARPs applied in Australian goaf gas drainage systems and propose TARPs revision to maximise gas drainage performance without compromising sponcom and gas explosion risk; and to
• Develop instant feed-back control strategies for goaf gas drainage production and evaluate their effectiveness based on the established goaf gas tends, profiles, and ratios.

The initial data collection from three mines has been completed. The data received include goaf hole gas composition monitoring, suction pressure, flow rate, drainage plans in AutoCAD maps and goaf drainage TARPs. The project team has started working on analysing these data and will provide preliminary results in the next a couple of months.

C29023
Methodology for Efficient Design of the Pattern of Drainage Holes Based on Stress Variation and Gas Flow Behaviour in Coal Seams

University of New South Wales
Hamid Roshan, Hossein Masoumi

Value: $164,560
Report Expected: April 2022
Industry Monitor/s: Bharath Belle, Brad Elvy, Owen Salisbury, Paul Wild, Russell Thomas
ACARP Contact: Peter Bergin

In this project, researchers will identify the main parameters controlling the gas flow in a laboratory scale and develop a model across scales (laboratory and field scale) that can capture the major physical mechanisms of gas drainage. Tools will be recommended for the optimum design of drainage holes, based on available field data through geological-numerical exercises.

This project started during April.

C29024
Contamination - Ethylene from Timber Supports

Simtars
Snezana Bajic

Value: $94,750
Report Expected: December 2020
Industry Monitor/s: Bharath Belle, David Webb, John Grieves, Julian Potten, Paul Wild
ACARP Contact: Patrick Tyrrell

Ethylene is a key spontaneous combustion indicator used in underground coal mines. This project will deliver the understanding of the mechanism for atmosphere contamination with ethylene through temperature and humidity testing of timber used in the manufacture of underground supports. The tests will be performed in controlled environment, with special designed sampling equipment and regime. The project will also review reported instances at mines where ethylene trace levels have been found without the presence of increased carbon monoxide and hydrogen. The relationship
between atmosphere temperature and humidity and timber moisture content with regards to release of ethylene from timber supports will be established. The findings will be reported in a reference document to assist underground coal mines in preparing their Trigger Action Response Plans (TARPs), eliminating or avoiding contamination of gas samples with ethylene and planning timber support construction.

There was a slight delay in team set up to operate remotely due to current situation with COVID-19. Simtars is in the process of setting up experimental environmental chamber.

C29027
Review of the DRI Process and its Role in Setting Thresholds for Non Bulli Mines
CoalBed Energy Consultants
Scott Thomson

Value: $128,900
Report Expected: March 2021
Industry Monitor/s: Bharath Belle
David Webb
Paul Wild
Russell Thomas
Sharif Burra

ACARP Contact: Peter Bergin

This project aims to independently assess the variance in outburst thresholds at representative, participating sites across Australian coalfields and to compare this data with the fundamental reservoir properties at each site that drive outburst risk. The project plans to investigate the evidence regarding the setting of TLV’s and determine whether the current system is appropriate for mines other than those of the South Coast. Desorption rate is only one factor in many that affect outburst propensity. An objective of this project is to establish whether an alternative metric can be applied, and if not, improve the general understanding of how TLV’s should be applied in areas other than the Illawarra.

It is recognised that one of the challenges of this research is to overcome industry reluctance to change a system that is well established and clearly has had positive safety benefits to the industry. In addition, it requires the enlistment of support from enough non-Bulli mining operations to provide a meaningful database.

Work is currently underway gathering relevant data. To date, a reasonable response has been achieved, certainly enough to begin the process of analysing variance in TLV’s and investigating the relationship between reservoir factors and historical experience of outburst risk at the participating non-Bulli sites.

C29036
Direct Measurements of Effective Diffusion Coefficient of Coal
University of New South Wales
Peyman Mostaghimi

Value: $175,000
Report Expected: March 2021
Industry Monitor/s: Bharath Belle
David Webb
Paul Wild
Russell Thomas

ACARP Contact: Peter Bergin

This project aims to extend knowledge about diffusion processes and physics of gas flow in coal and to develop a method for direct measurement of the effective diffusion coefficient of coal. Diffusion of methane in coal is of complexity as several physical mechanisms including bulk diffusion and Knudsen diffusion are coupled. In addition, coal has high capacity for adsorbing methane and surface diffusion plays an important role in the diffusion process. A reliable estimation of the effective diffusion coefficient of coal and understanding its mechanisms are crucial for identifying the risk of outburst in coal mines. As a part of this project, we measure the effective diffusion coefficient from Australian coal mines and the obtained values can be used for future modelling to estimate the risk of outburst with the aim of increasing the safety of mining operations.

Work undertaken is as follows:
• Previous attempts for measurements of effective diffusion coefficient of coal in literature have been reviewed;
• The first round of samples has been received from industry;
• An experimental and computational framework for determination of coal diffusion coefficient was designed;
• The experimental setup for bulk measurement of gas diffusion has been assembled in our laboratories;
• Two cores have been considered, and gas samples have been collected. Due to COVID-19, there have been delays in further analysis of collected data required for determination of effective diffusion coefficient as the access to our laboratories is restricted. Following completion of this step, the data can be used in our computational framework for validation of our framework and prediction of diffusion coefficient.
OPEN CUT

Drilling and Blasting

C27023
Enhancing the Sleep Time of Hydrogen Peroxide Based Explosives

Mining3
Andrew Kettle
Ewan Sellers
Raphael Picorelli

Value: $333,747
Report Expected: October 2020
Industry Monitor/s: Andrew Lau
Benjamin Wood
Chris Bartley
Chris Davis
Ewen Mills
Lindsay Ford
Travis Zolnikov

ACARP Contact: Cam Davidson

The aim of this project is to enhance formulations of hydrogen peroxide-based explosives to meet sleep-time requirements in open-cut mining operations. The project seeks to identify inert-to-hydrogen peroxide materials, develop stabilised formula, and characterise the mixtures with unconfined detonation trials and laboratory-based tests.

Work undertaken:
• Conducted unconfined detonation tests of new 25-day sleep-time emulsion formulations in diameters (~230 mm) appropriate to open-cut blasting, to improve prediction of mining operation applications (Figure 1). Blasting performed at the Rurex Testing Range, Western New South Wales Analysis of the Velocity of Detonation (VoD) data from the H2O2-based emulsion formulations indicates a 5.0 and 5.4 km.sec-1 for 0.96 and 1.04 g.cm-3 density, respectively. This VoD result compares favourably to other bulk explosive performances. These tests were the largest unconfined mass detonations, at 60 kg, conducted to date.

• Conducted unconfined detonation tests of new 25-day sleep-time emulsion formulations at 24- and 36-days sleep-time, to confirm the blasting agent’s effectiveness. Blasting performed at the Mining3 Pinjarra Hills Blast chamber with a limit of 200 gram blasts. Analysis of the VoD data from the small diameter test cartridges of H2O2-based emulsion formulations indicates a 3.8 km.sec-1 for 0.93 g.cm-3 density at 24 days. These tests were the longest sleep-time of a H2O2-based formulation conducted to date, and far exceed the previous 48 hour tests. Laboratory density stability tests indicate sleep-time in excess of 40 days.

Next steps for the project are to:
• Continue testing of chemical stabilisers of hydrogen peroxide to enhance sleep-time and achieve unlined blast hole applications in lowly reactive mineralogical conditions for surface coal mining operations;
• Determine temperature stability over a range of conditions and formulations, and characterise auto-sensitisation conditions for formulations to define operational constraints.

Figure 1. Video images of unconfined detonation of a 239mm diameter cartridge (1m length) of novel hydrogen peroxide-based emulsion at a 0.96 g.cm⁻³ density (60 kg charge) at the Rurex testing range, Western New South Wales. Testing of emulsion formulations were repeated in triplicate, and further testing of varying densities were conducted.
C27034
Top of Coal Detection Phase 4

Mining3
Byron Wicks
Erik Isokangas

Value: $395,310
Report Expected: June 2020
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.

Field trial at mine site 1 has completed after twelve weeks. Data analysis from trial and final report is being concluded now.

C29053
Real Time Prediction of Coal Top Through Guided Borehole Radar Wave Imaging for Open Cut Blast Hole Drilling Phase 2

CSIRO
Binzhong Zhou

Value: $337,910
Report Expected: March 2022
Industry Monitor/s: Troy O’Reilly
Hugh Jennings
ACARP Contact: Patrick Tyrrell

This is a Phase II to the project C26022 for developing a borehole radar (BHR) based technique to predict the coal seam top in real-time, while drilling blast-holes, by seeing ahead of a drill-bit to improve blast hole drilling control, reduce coal top damage and subsequent loss of product, and increase production and profits for open cut coal mining. In project C26022, both numerical modelling and field trials simulating a drill rod as an antenna demonstrated the feasibility of the proposed technique for prediction of the coal top under typical open cut environments and paved the way for maturing this technology for the practical use for blast-hole drilling. This extension project aims to investigate and overcome various engineering and technical problems to make the guided BHR waves practical to use for coal top prediction during blast-hole drilling.

The project team are collecting drill-rig information, sourcing relevant drill components such as drill-bits and drill stabilisers from the support mine, conducting numerical modelling and preparing for field tests on drill-rod wireless communications, which is critical to transfer the downhole measurements to the driller in the cab on surface. We hope to provide some results on the wireless communication in the next quarterly report, providing the current COVID-19 restrictions will not prevent us conducting experiments in the near future.
Environment

C27009
Tailings Revegetation through the Vegetative Water Pump

CSER Research
Carmen Castor
Mike Cole

Value: $447,000
Report Expected: August 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 to be dried through the plant transpiration stream and make them safer and capable of being capped or used for other purposes. The monitors have agreed for the project to be delayed by six months to allow for COVID-19.

Recently, survival was assessed after a March flood and follow-up rain events and 93% of all plants survived compared to the previous survey (photo below of plant selection experiment). This included 98% of the large *Eucalyptus camaldulensis* plants and 86% of large *E. robusta* plants that had been planted in 2019 (graph below). These data indicate that these plants have become more physiologically competent to be resilient to flooding. Current observations of *E. camaldulensis* show that the stem is becoming thickened from the soil up to the flood level, and to a greater extent than that expected from ‘woody growth’. This is consistent with known flood tolerance mechanisms where cortical cells expand and some break to form lysigenous aerenchyma that allows oxygen to diffuse from the air down to the root system. The characteristics of these species are now being more fully determined to provide further guidance for expectations in the flooding experiments to be conducted in C29041.

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

NSW Department of Planning, Industry and Environment
Harry Rose
Justine Cox

Value: $166,203
Report Expected: June 2020
Industry Monitor/s: Bill Baxter
Nigel Charnock
Stephen White
ACARP Contact: Patrick Tyrrell

A draft report is being reviewed by the industry monitors.

C27038
Self Sustaining Ecological Mine Rehabilitation that Achieves Recognised Ecological Communities

Umwelt (Australia)
Travis Peake

Value: $342,460
Report Expected: June 2020
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.
We have undertaken comprehensive review of the relevant literature, as well as legislation, policies and guidelines. Field sampling was completed in May 2019 where ecological data relating to composition, structure, and function was collected at rehabilitated areas and remnant woodland from five mine sites. A reassessment of the analysis approach and a major redirection was made (in consultation with industry monitors) during June-October 2019 in response to changing government policy and data which formed the framework against which the New South Wales component was being prepared. Analysis of this data has been completed, with the results supporting the hypothesis that mine rehabilitation can support recognisable ecological communities. The reporting is largely complete, and currently subject to review and then internal peer review.

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 2021
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 (eg 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.

Progress to date:
- The model has been developed now to where it is predicting realistic (albeit qualitatively correct) predictions. Testing and modification is now ongoing with the available data.

Mines 1 and 2 have been abandoned.

Mine 3:
- Has provided promising data;
- DEMs have been provided;
- We are now calibrating SSSPAM to match the gully form based on this DEM and are making good progress. Some very good results obtained but are only visually calibrated;
- Sites have been selected for field sampling and we await the field samples for calibration;
- Laboratory flume constructed and now being commissioned for parameter derivation;
- Samples have arrived at Newcastle and analysis about to commence.

Software development:
- Determining what components of the SSSPAM are necessary and focused efforts of speed up SSSPAM simulations is largely finished. This facilitate more thorough testing at the field sites because more simulations can be carried out.
- Software testing to determine the minimal data requirements that are needed to gain accurate results is currently underway. This will influence the type of laboratory testing to be done on field samples when they are collected.
- Some preliminary simulations using SIBERIA for the DEMs for Mines 2 and Mine 3 as well as other sites have been performed but they are not yet ground truthed so are only preliminary at this stage.
- SSSPAM is now being evaluated using the Newcastle teams existing data for other sites.
- Software developing now awaiting on laboratory data for calibration and validation.
- Software development considerably slowed as research fellow Dimuth Welivitiya was on leave overseas when the lockdown for COVID-19 occurred and he cannot return to Australia at present. Remote access to computing has been provided.

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: June 2020
Industry Monitor/s: Andrew Lau, John Watson, Ross Gooley, Stephen White
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 of 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:

1) 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.

2) 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 four rounds (February, May, August, November 2019) of pit lake sampling have been completed and the data is being analysed. The field experiment was completed in December 2019. Writing of the final report has commenced.

C27044
Testing the Resilience of Mine Site Rehabilitation with Fire

University of Queensland
Phill McKenna

Value: $239,537
Report Expected: March 2021
Industry Monitor/s: Craig Lockhart, Pieter Swart
ACARP Contact: Patrick Tyrrell

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:
- Field work at mine 2 for 18 month post-fire assessments;
- Field work at mine 4 for the 6 month post-fire assessment;
- Analysis of field data and remote sensing for mines 1, 2, 3, 4 and 5;
- Selection of a number of unmined control sites that have been burnt in the 2018-2019 fires;
- Multi-site trend analysis showing high association with daily rainfall (Fig 1).

Figure 2 Recovery trends for species richness at three mines following fire. Red-dashed line is the fire event and the blue bars are daily rainfall.
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.

The second samples (T= 3 months) for soil chemistry and microbial enzyme analysis were collected from the 42ha field site that compares varying amounts of topsoil (0, 10 and 20cm) and commercially available biological amendments (manure, compost, worm extract with Catapult™ microbial inoculant, and Troforte® slow release fertiliser with microbe mix). Method development for Fungi:Bacteria determination and soil proteome analysis is in progress.

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 release of salts from spoil piles affects surface and groundwater quality particularly the quality of water in final voids. With in-kind contributions from University of Queensland, a medium scale (1-1.5 tonnes) spoil leaching test facility was set up at UQ’s property in Pinarra Hills to bridge the gap between small -scale laboratory tests and field monitoring of real size spoil piles. The current project will deliver:

- A set of salt decay curves (with projections well into the future eg of the order of a 100 years) for a spectrum of spoil types based on ‘as-dumped’ structures with no artificial change to packing and internal structure;
- A consistent medium scale method for sampling such spoils; and
- A consistent procedure validated for a range of spoil types for medium-scale (1-1.5 tonnes) leaching to assess the long-term release of salts and trace elements.

For the medium scale leaching tanks (IBCs), 20th Leach cycle for rock-like and soil-like samples from site 1 completed and 13th leach cycle for saturated soil-like and rock-like samples from site 1 completed. 6th leach cycle of new Permian soil-like from site 2 and rock-like sample from site 3 completed. These last two IBCs are instrumented with moisture and conductivity sensors and are leached by rainfall simulator. A Tertiary sample from site 2 was leached but challenged by very low hydraulic conductivity. Therefore, a new packing design will be trialled in the next few weeks to encourage better water flow. 4th leach cycle of site 4 was completed.

The focus of the laboratory column leach experiments is prediction of salt release under different water/rock ratios and residence times and also to differentiate between salinity from sulfide oxidation processes and the release of intrinsic salts from spoils geology (Fig 1). In the last quarter leachate chemistry data collected to date were analysed.
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.

Detailed site assessments have been undertaken across seven mines spanning Queensland and New South Wales. The assessments capture 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. The assessments 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 have been used to derive secondary data layers for each pixel across the sites surveyed, including slope, slope length, contributing catchment and vegetation cover. Erosion was assessed by mapping the occurrence of gullying from high-resolution drone photogrammetry. The surveys have generated millions of data points for each site and are being used to:

- Develop reliable correlations between point soil data and proximal/remote sensing data to spatialise the soil data;
- Compare differences in erosion performance and site characteristics between experimental treatments;
- Develop regressions of site characteristics explaining variation in erosion; and
- Populate revised conditional probability tables informing the Bayesian Decision Support Model to improve estimation of the likelihood of erosion for any given set of site conditions and management practices.

In parallel with model updates, the data input interface to the Mine Spoil Rehabilitation 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 by video-conference.

C29041
Preconditioning Plants to Withstand Flood on a Tailings Dam

CSER Research
Mike Cole

Value: $114,000
Report Expected: August 2021
Industry Monitor/s: Chris Urzua, Shaun Booth, Trent Cini
ACARP Contact: Patrick Tyrrell

This project has a primary objective of developing plant preconditioning methods to enable species used in the 'vegetative water pump' to better survive flooding on tailings dams.

As has been shown in earlier project C27009 many of the plants, including those of well-known flood tolerant species such as Eucalyptus camaldulensis (River Red Gum) failed to survive when nursery grown tube stock were grown on a tailings dam and flooded. This is believed, in part, to be due to a lack of physiological capacity to initiate the flood tolerance mechanisms of that species.

Activities in the first phase of this grant have, therefore, been to grow healthy plants more likely to withstand flooding than standard nursery stock. The plants are being grown in a higher nutrient environment which is expected to increase their capacity to initiate flood tolerance mechanisms. From this it is anticipated that guidance would be available to nurseries of how to grow plants for use on tailings dams. The current cohort of plants are being grown so that different aged plants can be exposed to flooding in containers, with flooding up to 20cm above the soil. Due to the COVID-19 issues, the flooding experiments will now commence in September this year.

Variation in contributing catchment affecting erosion.

Analysis to date has indicated statistically significant differences between erosion (0.9% v’s 12.8% surface area affected); vegetation cover (82% v’s 43%) and ESP (5.5% v’s 21% in spoil at 150-500m) for gypsum treated and rock mulched rehabilitation. Using regression analysis, vegetation cover, exchangeable sodium percentage, contributing catchment area and slope length explain most of the variation in erosion area.
**Exploration**

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

*University of Queensland*  
*Joan Esterle*

- **Value:** $141,050  
- **Report Expected:** June 2020  
- **Industry Monitor/s:** Peter Handley, Richard Ruddock, Tim Buddle  
- **ACARP Contact:** Patrick Tyrrell

We are in the write up phase for the project.

**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:** July 2020  
- **Industry Monitor/s:** De Nicholls, Gareth Johnson, Mark Laycock  
- **ACARP Contact:** Patrick Tyrrell

This project is on hold.

**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 will be used in different hyperspectral core scanning devices. Currently no spectral library for coal is available. 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 Visible and Near through Short Wave, Mid and Thermal Infrared (VNIR, SWIR, MIR and TIR), covering a wavelength range from 450 to 14300 nm. The concept of a ‘standard coal series’ will also be explored, using crushed samples at different size ranges, which will also assist in testing the robustness of the system. This would also help in upscaling issues from the core to the highwall, where the target is to determine the bulk variation between plies.

With the support of the coal industry we were able to collect 17 samples with different rank and lithotype for this project. Currently, all the core samples are scanned using the SWIR, MIR and TIR sensors. The scanning work was conducted at the Corescan and CSIRO facilities in Western Australia. The core samples (except one that was not core) were scanned on both curved and slabbed surfaces to test the effect of the curvature of the core on the spectrum results. The results showed that slabbed surface produced better results. In order to obtain a spectrum that was not influenced by the coal banding (lithotype), the coal core was crushed to a fine powder to produce compressed pellets. In the case of the bright lithotype core samples, bright coal layers (assumed to be vitrinite-rich) were also handpicked from the core to produce compressed pellets. The compressed pellets were scanned in the SWIR, MIR and TIR ranges. MIR dataset showed significant differences between the different coal samples. Scalars are currently being produced to evaluate those spectral differences. Petrographic analysis (reflectance and maceral analysis) are being conducted at UQ. Chemical analysis, including proximate and ultimate analysis, were performed at ALSCoal lab in Brisbane following standard procedures for coal analysis.

Currently, the project team is not seeking for more new core samples. The team is now integrating and interpreting the data to create the hyperspectral library for coal samples with different rank and composition.

**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 an earlier 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.
The stronger metallic enclosure to house the radar system in the harsh environment directly behind the blade of a dozer has commenced. The fabrication of the enclosure has now been completed. The research team are currently undertaking tests and fine tuning to ensure that the method to attach the enclosure to the blade of a dozer is suitable such that there is sufficient range of motion so the enclosure tracks the ground level correctly when scanning, but also lifts up out of the way when required. Once this is complete over the coming weeks, the enclosure will be installed on a dozer at the host site so the survivability evaluation trial can commence. A photo of the heavy duty enclosure is shown below.

![Photo of heavy duty enclosure](image)

Figure: Photo of heavy duty enclosure to house a radar antenna for mounting behind a dozer blade.

**C27011**

**Predicting the Impact of Complex Joint Structures on Mine Operations**

University of Newcastle

Anna Giacomini

Marc Elmouttie

**Value:** $273,711

**Report Expected:** July 2020

**Industry Monitor/s:** Gift Makusha, Leonie Bradfield, Warren Hitchcock

**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 by applying statistical techniques based on random field theory (RFT). The approach will be used to extrapolate the geo-structural characteristics of previous strips to infer the probabilistic geo-structural characteristics of future strips. DFN simulations are used to ground-truth the Random Field Theory method. 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.

A refined analysis of structural data acquired from Site 1 has been conducted. A new algorithm to compute spacing statistics was implemented to estimate the appropriate parameters upon which the random fields could be defined. Discrete fracture network analysis (DFN) of Site 1 has also been undertaken to provide the 3D structural data for five strips based on completed structural mapping. Available production data from Site 1 have been analysed. A rock engineering systems (RES) based model has been created for both interpolation of data as well as assisting with the data interpretation. Additional spatial and temporal data have been requested to Site 1 in order to complete the correlation between geotechnical and production data. Recently provided hazard data from Site 1 is intended to be used as a proxy for production problems and this analysis is currently ongoing.

New subroutines have been developed to combine a Gaussian random field model to another type of random field model, namely a binary random field. The challenging ongoing process aim to produce a code that can predict the probability of fracture intensity at any given location of the rock mass, for different joint sets, given the information we get from the wall.

**C28038**

**Groundwater Pressures and Flows Within Spoil Dumps**

University of Newcastle

Stephen Fityus

**Value:** $365,200

**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 to 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.

Development of a model to account for the role of cracking in dumps as a mechanism for water ingress continued. The focus of this aspect of the research has shifted to using satellite data to estimate the residence time for water on dump surfaces, which will be used to estimate the proportions that are captured and lost by the dump.

The large, high capacity cell in which samples of mine waste will be loaded prior to measurement of directional hydraulic conductivity has been constructed, and the first
test samples have now been prepared. Testing will commence as soon as the pressure transducers arrive. A second instrumented borehole in a waste dump has been achieved on a second partner site. This hole is complemented by additional piezometer holes installed in the waste dump by the mine, to give data with the potential to understand the hydraulic surface transverse to the pit axis. One year of data is now available from the first instrumented hole at the first site, and only recently the readings from all four VWPs appears to have stabilised.

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, Thomas Hahn
ACARP Contact: Cam Davidson

The main objective of the project is to expand on the application of geophysical data (inspired by Geophysical Strata Rating) to open cut coal mines for developing a robust and determinist rock mass strength model that can lead to a more accurate numerical analysis based on advanced Machine Learning algorithms.

Geophysical and geotechnical data for all mines have been investigated to identify the potential sites for both training and prediction steps in machine learning. To this end, available logs and geotechnical data for all boreholes in each site were extracted and arranged. Good geological information, five essential logs including Sonic, density, resistivity, neutron and gamma, and quality geotechnical data were considered as a criterion for selection of appropriate sites and one site was specified for correlation development.

The next step includes, evaluation of sensitivity of different geophysical log data to each geotechnical parameter and discovering some possible patterns. This will provide a valuable aid in training downhole log data with geotechnical parameters in machine learning.

C28041
Guidelines to Improve Blasting Geotech Outcomes

University of Queensland
Italo Onederra
Sarma Kanchibotla

Value: $242,266
Report Expected: June 2021
Industry Monitor/s: Dan Stolberg, 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 focuses on site specific issues to understand the impact of adopted blasting strategies with the support of advanced modelling techniques and on-site monitoring.

In this quarter, the research team has been able to advance the blast modelling capability by developing and implementing specific codes and scripts to automatically extract data from several simulations. We now have the ability to configure and run multiple scenarios to calibrate models much faster than before, as well as perform a number of sensitivity analyses simultaneously; expanding the range of blast configuration parameters and geometries that can be studied. The new codes allow for the automatic generation of input files (via Python) and the batching of these via R. The input files are the executed in a virtual PowerShell environment and subsequently stored using a script written in LISP. A separate program also allows for the automatic generation of output graphs from each model as well as comparisons considering basic statistics.

Due to the COVID-19 restrictions agreement has been reached that the advanced modelling testing should initially focus on existing and historical mine based data; to this end the team has developed and submitted a list of input data requirements. One set of data associated with floor disruption blasting has been received and reviewed; and the research team has requested complementary information to enhance the analysis. A second set of data from a different operation will also be available to the team over the coming weeks to test the upgraded modelling capability.
**C29005**

**System for Rock Fall Analysis: Scoping Study**

**CSIRO**  
Marc Elmouttie  
Peter Dean  
Xun Luo

**Value:** $81,200  
**Report Expected:** February 2021  
**Industry Monitor/s:** Gavin Lowing  
Steven Gale  
**ACARP Contact:** Cam Davidson

Systems to detect, monitor and analyse rock-falls in open pit mining operations have the potential to improve operational safety, improve calibration of rock fall simulators (restitution coefficients), and importantly provide quantitative data to justify current standoff designs. A monitoring system that can accumulate a large database of rock fall events across the full strike length of highwalls is required. The use of existing monitoring systems (radar, vision, lidar) as well as knowledge of the wall geometry, geology (rock mass types) and structural characteristics (defect orientations and intensities) has potential to support detection of events (potentially in real-time) and detect rock fall movements accurately enough for determination of trajectories (bounce kinematics), impact locations and final resting positions.

To achieve this goal, a scoping study is being undertaken to define the technical specifications and system design for a fused sensor system to support the analysis of rock falls on highwalls. The technologies required will include computer vision and other image processing algorithms (rock mass characterisation, rock-fall detection, tracking and trajectory calculations), in combination with new rockfall-specific radar systems, acoustic (seismic) monitoring (identification of potential rock fall candidates, support trajectory calculations) and computational statistics including machine learning (automated structure mapping, rock mass characterisation). To achieve these objectives, collaborations with mine software and radar companies will be used to ensure the latest demonstrated technology solutions are drawn upon as much as possible. This project started in February, with the Requirements Analysis to define the technical system requirements being developed with the monitors and circulated for feedback. Meetings with radar providers have been conducted to highlight project objectives and discuss technical details relevant to supporting the integrated system. Analysis of capabilities of computer vision and microseismic monitoring systems has begun using CSIRO expertise in these fields.

In the next quarter, analysis of theoretical performance of the various sensors for detection and monitoring along (1km) strike distances will be undertaken. An initial system design will also be developed and discussed with the monitors and third-party technology providers.

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**C29044**

**Baseline Data for the Development of Automated Characterisation of Waste Materials**

**University of Newcastle**  
Simit Raval  
Stephen Fityus

**Value:** $197,850  
**Report Expected:** February 2022  
**Industry Monitor/s:** Adrienna Robotham  
Kim Peckett  
Leonie Bradfield  
Ned Stephenson  
**ACARP Contact:** Patrick Tyrrell

Good waste drum design and analysis requires accurate physical models of the distribution of waste types throughout the dump. The detailed mapping of spoil types in the evolving dump is an arduous task, and the high variability of spoils makes automatic categorisation difficult. Machine learning from large data has the potential to facilitate automated categorisation, however large data on categorised spoils does not yet exist. This project will carry out a series of detailed spoil mapping studies across many different mine sites, in the Sydney and the Bowen Basins, where a range of spoils from each studied site are classified in detail according to the BMA framework. This will provide thousands of data in support of project C29048, which aims to demonstrate that machine learning can be used to infer spoil strength from spectral analysis of multispectral data. In conjunction with project C29048, the greater aim is to prove that real time, automated spoil categorisation through multispectral analysis is a feasible concept.

This project entails a large amount of field work and although preliminary approaches were underway to secure sites to commence this work, the onset of COVID-19 has meant that any plans for fieldwork have been delayed. However, to commence some work on this project, a pilot study involving laboratory-based photography of a range of spoils of known but different fabrics has commenced. The results from some preliminary attempts to recognise different spoil fabrics shows promise. As the pandemic subsides, planning to undertake fieldwork will resume.
Health and Safety

C25026
Reducing Risk Taking Among Australian Coal Miners

University of Newcastle
Anna Giacomini
Mark Rubin

Value: $302,235
Report Expected: April 2021
Industry Monitor/s: Doug Kennedy, Robyn Masters
ACARP Contact: Patrick Tyrrell

This multi phase project aims to investigate the cause of risk-taking behaviour in Australian open cut and underground coal mines (Phase 1) as well as develop and deliver 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 effectiveness of the intervention over time.

The research team has commenced data collection for the Phase 2 intervention. Data collection has been completed at two sites: one open cut mine and one underground coal mine, both in the Hunter Valley. Signed consent has been received from an additional two mine sites (one Hunter Valley underground mine and one mid-western New South Wales underground mine). Participation at these sites is due to commence post COVID-19 once site access restrictions have been lifted. The research team is also continuing discussion with a further three sites (open cut mines in the Hunter Valley, and north Queensland, and an underground mine in mid-western New South Wales) regarding participation with a view to securing consent. Wider recruitment also continues through direct emails, social media and industry discussion.

COVID-19 has temporarily ceased data collection for this project. During this time of inactive data collection, the research team are remaining in contact with participating mines (and the industry) to keep lines of communication open and explore options and timelines to recommence data collection at each respective site.

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 project 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.

Hardware involving a miniature accelerometer located in the seat and on the vehicle floor, and utilising a Raspberry Pi microcomputer has been designed and software coded. Data inspection and analysis software has been completed.

Data are now being obtained from accelerometers mounted in both floor and seat of trucks at a central Queensland coal mine. A dozer has also been instrumented. The analysis software is largely complete and analysis of the data is underway. The data have been demonstrated to be effective in identifying potential opportunities for control measures to be implemented. Additional modules are awaiting installation by the mine. A site visit was undertaken in January.

Additional hardware was constructed and 30 sets of sensors and processors were sent to the site in April and are awaiting installation.
C26028
Proximity Detection System Performance Testing Framework

Mining3
Chris Essebier
Isaac Dzakpata
Susan Grandone

Value: $653,594
Report Expected: July 2020
Industry Monitor/s: Matt Clements
Tony Egan

ACARP Contact: Cam Davidson

This phase follows on directly from the earlier stage with the goal is to combine the best elements of existing PDS research, developed by Mining3, the University of Pretoria, New South Wales Department of Industry (mine safety) Australia, CSIRO, and others, into a single, unified industry guideline for testing PDS.

Due to COVID-19 a decision was made to submit a scope variation which includes an update of the PDS Sensing Capability Assessment/tool published in Phase 2. The intent is to release the document prior to the completion of the verification testing as it would have immediate benefit to users. Mining3 requires the preliminary website created for demonstration purposes in Phase 2 be converted to a fully operational, supported and branded website that is compliant with Mining3 mandated standards.

In mid-April, Mining3 management implemented a process to enable this project and other critical projects work to be undertaken onsite. The project team is planning a return to site in early May to assess the test pad and document the ground preparation work required in readiness for testing. If no other delays are experienced due to COVID-19 restrictions, testing will commence in July.

C27013
Evaluating Risk Control Performance

University of Queensland
Maureen Hassall

Value: $135,000
Report Expected: May 2020
Industry Monitor/s: Kevin Rowe
Kylie ah Wong
Stephen Broad
Tony Egan

ACARP Contact: Cam Davidson

This project is on hold.

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 coal mines. Three focus group workshops were undertaken involving 17 surface mine operators and maintainers, as well as task observations at each site. Information gained has been used to populate 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; and
- 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. Additional examples were observed during a site visit undertaken to a New South Wales surface mine in September 2019, and two Queensland surface coal mines in January 2020. A draft final report is currently being prepared.

C28048
Information Sharing System for Vehicle Interactions

University of Queensland
David Cliff
Jill Harris

Value: $174,207
Report Expected: August 2020
Industry Monitor/s: Tim Gray
Tony Egan

ACARP Contact: Cam Davidson

This project is aimed at verifying the transition of RISKGATE Collisions knowledge to a new online knowledge hub for Vehicle Interactions (VI). In so doing,
RISKGATE’s bow-tie arranged data has been disaggregated to fit a new taxonomy, termed the Control Framework that takes into account the industries new focus on control verification activities. As well as a more flexible user platform.

The transfer of RISKGATE Tyres information has followed the successful transfer of RISKGATE Collisions information. A review of this remapping is underway as well as a business case for the similar transfer of other non-VI RISKGATE topics to other industry supported knowledge bases.

This project offers a re-working of the valuable data stored in RISKGATE by utilising a promising new format; and so widen its use to new users.

**C29001**

**Human Aspects of Mining Automation: Scoping Study**

University of Queensland
Robin Burgess-Limerick

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The objective of this project is to identify questions related to the human aspects of automation and define a framework that will encompass a program of work to answer these questions in relation to other industry work.

Interviews with critical informants/subject matter experts were undertaken, and a database of international mining automation installations, and planned installations, compiled. A multi-disciplinary international research team was assembled to collaborate on the planned projects. A paper was presented at the US Society for Mining Engineering in Phoenix in February 2020 and a visit to The University of Pittsburgh and the NIOSH Pittsburgh Research Mining Research Division was undertaken. Industry stakeholders and research collaborators attended a workshop in late March. Presentations from the workshop are available at: [ergonomics.uq.edu.au/HAAM](ergonomics.uq.edu.au/HAAM). A draft final report has been submitted for review by the industry monitors.

**Maintenance and Equipment**

**C26020**

**Preventing Fatigue Cracking Via Proactive Surface Dressing**

Bureau Veritas AIRS
Simon Krismer

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No report received.

**C26021**

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

CSIRO
Jeremy Thompson

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Stage one is complete and stage two is yet to commence.

**C28036**

**Wireless Health Monitoring Mine Equipment Using RFID and Machine Learning**

Monash University
Nemai Karmakar

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The project aims to develop RFID based sensing systems with machine learning techniques to predict and monitor the health condition of conveyor belts.

The research team has designed and fabricated a UHF RFID sensing device and a dielectric resonator for conveyor belt characterisation. The commercial RFID chips have been integrated into the fabricated sensor prototypes and their laboratory tests are conducted to analyse their ability in detecting cracks on conveyor belts. The fabricated dielectric resonators are utilised to characterise the conveyor belts in UHF frequency bands. Such characterisation enables to obtain the dielectric constant and dissipation factor of the belt which would be critical for any future simulation regarding the sensor
performance in the belt environment. The team also
developed a new graphical user interface (GUI) for UHF
RFID reader that uses multiple antennas to interrogate
and extract sensing information from the UHF sensor
nodes in real-time. The new GUI can detect a crack on the
conveyor belt for a belt motion of up to 4 m/s. The
experimental results from combining the UHF sensors
with the developed GUI have revealed promising
to adapt such an integrated technology for the
health monitoring of conveyor belts.

The team is currently working on the design and
development of chipless RFID based crack detection
sensors. The performance analysis of such sensors will be
conducted via simulation and practical experiments. The
development of another GUI for chipless RFID reader is
also on progress which will enable the measurement of
variation in electromagnetic (EM) or radio frequency (RF)
parameters due to the change in belt’s physical
properties or condition. The proposed GUI will also be
updated to integrate multiple antennas into the chipless
reader system for the health monitoring of conveyor
belt.

C28049
On-board Energy Recovery and Battery Storage
Systems for Diesel-Electric Haul Trucks: Scoping
Study

Enterprise Improvement Solutions
Craig Hurkett

Value: $50,000
Report Expected: June 2020
Industry Monitor/s: Maintenance Task Group
ACARP Contact: Patrick Tyrrell

No report received.

C29043
Develop Skid Mounted Tyre Handler Testing Rig

University of Queensland
Michael Heitzmann
Peter Knights

Value: $313,850
Report Expected: March 2021
Industry Monitor/s: Robert Fraser
Stephen Broad
Tim Gray
ACARP Contact: Cam Davidson

The project objectives are to design, construct, and
commission a skid-mounted tyre handling testing rig. The
testing rig will be manufactured, assembled and
functional tested at Cascade Australia’s Brisbane
manufacturing facilities. Initial performance testing will
be carried out at the Bridgestone Mining Solution
Australia Service Centres in the Hunter Valley. The testing
rig will enable the frictional force between tyre handler
pad and tyre to be quantified for a range of OTR tyres,
wear, and surface wetting conditions. The test rig will be
transportable to enable onsite testing.

COVID-19 restrictions have affected many business
functions both within and outside of UQ. In the next
quarterly period the following activities are scheduled:
- Meeting to be held to review conceptual design;
- Detailed engineering of rig (in conjunction with
  Cascade Australia);
- Design of instrumentation package for handler arms;
- Conduct critical design review.

C29051
Predicting Failure of Hydraulic Pumps and Motors

GEM Innovations
Graham Manuel

Value: $72,358
Report Expected: November 2020
Industry Monitor/s: Brendan Wilkins
Tim Gray
ACARP Contact: Cam Davidson

The objective of this project is to install case drain flow
meters and monitoring equipment on the hydraulic
pumps on an excavator. The monitoring equipment will
send a daily email to the maintenance planner with the
average daily case drain flow recordings. From the daily
flow readings, the maintenance planner will be able to
change hydraulic pumps prior to failure, during a service
interval.

After initial meeting with key stake holders, sensors and
flow meters were purchased. These were set up to
simulate a working excavator with the data monitoring
of flow, pressure and temperature. After testing, the
sensors have been installed one pump of the chosen
machine. Initial data was as expected and more sensors
and flow meters have been purchased.

The data acquisition system is still being tested, and once
done the system will be installed on the machine with the
extra sensors and flow meters.
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<th>Overburden Removal</th>
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<td><strong>C28039</strong>&lt;br&gt;Low Frequency Noise Prediction and Validation Study</td>
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<td>ERM Australia Pacific&lt;br&gt;Aaron McKenzie</td>
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No report received.

**C28046**<br>Broader Contribution of Coal Sector Employment to Indigenous Individuals, Families and Communities

Myuma<br>Michael Limerick

**Value:** $199,472

**Report Expected:** December 2020

**Industry Monitor/s:** Anthony Galante<br>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 – 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 first 7 of the 30 interviews with Indigenous coal company employees in Brisbane were arranged with an employer in March 2020. However, only 1 interview was able to be conducted before the COVID-19 restrictions prevented face to face meetings. The research team also negotiated access to 3 employees at a Bowen Basin coal mine, but it has not been possible to undertake these due to travel restrictions and mine site access restrictions.

The fieldwork for this project has now been put on hold pending a lifting of the COVID-19 travel and workplace access restrictions. The alternative of doing interviews by videoconference or phone was considered, but it was determined that this was not appropriate for the in-depth qualitative interviews required for the research. It is hoped that the face to face interviews can be resumed in the second half of the year. The timeframes for completion of the project have been extended accordingly.

This project follows directly from project C25041, DynaCut fundamental development and scalability testing for high capacity mining of coal overburden. This revised scope retains the key objective of element 3 of the phase 2 with an emphasis on the Super Surface Mobile System (SSMS). This completion work will build on the results of the work completed so far in phase 2 to define minimum success criteria for potential high-value concepts to inform the modification, design and development of a prototype up-scaled test machine, capable of validating up-scaled performance in line with the requirements for commercial adoption. This aligns with the end goal of de-risking the path for the development of technology towards a commercially viable and operationally acceptable system for overburden removal. Three project key tasks are involved. The first aims to develop system concepts and perform opportunity and trade-off assessment for the concepts. The second aims to study constrained and unconstrained Up-scaling potentials for the DynaCut System and the third will use the findings of the first two elements, combined with potential mining system concepts, to inform an up-scaled test machine.

Since the rescoped project kicked-off in November 2019, the three key tasks have progressed steadily. A high-level scenario modelling of potential single and multiple Super Surface Mobile Systems has been performed, leading to the identification and assessment of current engineering, operational and technical constraints. Next steps of task 3 will investigate the feasibility of coupling the current UG Design (HRCM) of the SSMS with suitable material handling systems and support equipment as well as the assessment of selective mining capabilities of an upscale DynaCut system.
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 missions autonomously and choreographing a fleet of dozers performing pivot-push operation.

Work completed in this includes completion of the MineStar interface and testing of the system on the Caterpillar Dozer simulation environment. Work planned for the next quarter includes physical system testing at Caterpillar’s proving grounds on a D11 dozer. This work is expected to prove correct functional behaviour and de-risk planned field trials. However, these proving ground tests will not allow for evaluation of performance improvements that are expected to accrue from mission planning.

To evaluate these performance improvements, site trials are required. It is hoped that these trials will be possible during 2020.

C28047
Dragline Excavation Sequencing - Phase 3 (Towards a Benefit)

University of Queensland
Kevin Austin
Matthew Green
Ross McAree

Value: $507,011
Report Expected: July 2020
Industry Monitor/s: Andrew Denman
Chase Wright
Daryl Myles
Matt Graham

ACARP Contact: Cam Davidson

This project is developing and testing an operator assist technology with the potential for improving the efficiency of dragline operations and providing an operational productivity benefit of 10+. The main objective of the project is to demonstrate a benefit to operation from the use of the technology in providing operators guidance on tub position sequencing and material movement. Site trialling of the system is being supported by Anglo American mine.

System hardware is deployed on two draglines at the test site. The presence of COVID-19 has prohibited travel and site access, and testing plans are being reworked to manage testing remotely. The dragline team at the test site continue to support project activities.

System development has progressed with the Pegasys Client ready for deployment once operation is verified through bench testing using a bench simulator configured with test site operation data. Recent client updates have included a finalisation of database table structure, system report generation, and system health monitoring. The decision tree framework used to sequence the dragline activities now incorporates sequences extending over multiple blocks and more efficiently explores the excavation options across the extended horizon. These updates also allow block-level decisions such as block length to be considered.

The next phase of work will complete the bench testing of the sequencing system and conduct remote testing of the system operation on the target draglines. This will progress to trialling the sequencing system through guided operation of the excavation tasks required within a block. The process for conducting the guided operation will be negotiated with site, and will likely progress with close involvement and oversight by the Dawson team.
COAL PREPARATION

Dewatering

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

QCC Resources
Andrew Swanson
Bob Drummond

Value: $437,393
Report Expected: June 2020
Industry Monitor/s: Mario Salazar
Rod Fox
ACARP Contact: Nerrida Scott

No report received.

C25018
Improving Solids Recovery and Moisture Reduction in Ultafine Coal Dewatering

University of Queensland
Liguang Wang

Value: $184,000
Report Expected: June 2020
Industry Monitor/s: Rahul Patel
Steve Vaughan
ACARP Contact: Nerrida Scott

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

Pilot scale SBC trials were completed. A draft report has been prepared and is being internally reviewed prior to submission to the industry monitors.

C27016
Eriez HydroFloat in Plant Evaluation

Eriez Magnetics
Darren Mathewson
Liam Davis

Value: $155,600
Report Expected: July 2020
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 (eg. -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.

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 factions 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 Whiten equation was curve fitted and showed cutpoints between 1.80 and 2.40 RD with overall Eps of between 0.10 and 0.22. Due to the higher than expected cutpoints, there is often only one, or zero, float-sink fraction above the calculated cutpoint, so the curve-fit is significantly overestimating the cutpoint and the Ep. Being the first Australian HydroFloat trial, it was also expected that some results would be sub-optimal. The main purpose of the trial was to identify the optimal operating conditions. Nevertheless, the overall Ep of 0.10 is thought to be superior to any other hindered bed separator technology when fed with a feed top:bottom size ratio of >16:1 (ie 2.0 mm/0.125 mm).

Testing at the second site (on a flotation tails stream) is delayed due to the COVID-19 restrictions.

C27064
Dry Beneficiation Using FGX and X-Ray Sorters

A&B Mylec
Glenn Sherritt

Value: $112,000
Report Expected: June 2020
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 processing option improves the overall resource economics through reduced haulage of rejects. Dry processing, at a suitable throughput and metallurgical efficiency may also assist some projects in cold climate areas or remote locations which are being considered by Australian mining houses. The low capital cost profile and quick site establishment of an FGX plus XSS-T operation is likely to be a better capital fit for junior to mid-tier mining houses seeking to establish a cash flow from their resource.

Following are some of the key project milestones and status to date:
- A 3-tonne sample of ROM coal has been collected;
- Mining location, working section, bore core data and predicted product qualities and yields for the collected sample have been collated;
- The bulk sample was then transported to ALS Maitland for initial crushing and sizing;
- FGX test work including sizing and float-sink of product, middlings and reject has been completed;
- The samples for the FGX middlings test procedure were then progressed through the XSS-T sorting process in individual and combined size fractions;
- The product and reject samples from the middlings test procedure have undergone float/sink testing at ALS to complete the program; and
- A final report is being compiled.

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 (floculants and surfactants) on the coal tailings concerning the dual functionality of capturing fine clay particles and reducing the final moisture of dewatered tailings.

Studies on the settling rate of tailings thickener underflow samples showed that treating smectite-rich tailings with the two-step (coagulation-then-flocculation) procedure and a new salt-resistant modified anionic polyacrylamide (mPAM) obtained a high settling rate in compared with the conventional anionic PAM. Dewatering performance of the mPAM and the two-step procedure was evaluated on three mine-site tailing samples. These optimum conditions were applied in a two-step procedure on the tailings samples dewatering using pilot-scale solid bowl centrifuge. It confirmed that treating the tailings with the two-step procedure in which the tailings were coagulated by the Al³⁺ coagulant and then flocculated by mPAM significantly enhanced the solid recovery and lowered the cake moisture in both lab-scale centribaric and pilot-scale solid bowl centrifuge dewatering. In the next phase, all data are collecting and analysing to write the final report.

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, Luke Dimech, 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, insuring the extra yield does not result in excessive moisture. It is also anticipated that there will be further reduction in the product ash.

Strong progress has been made on this project to build the ground work for quantifying any improvement that arises from the application of the novel binder agglomeration. The initial work was focussed on distinguishing the basic components of the flotation product into firstly (i) a portion of clean coal product containing no slimes and (ii) varying portions derived from the -38 micron portion of the tailings. The Reflux Flotation Cell provided a simple way to generate an ultra-clean flotation product. The ultra-clean flotation product was separated into different size portions covering (i) the full RFC product (ii) +38 micron (iii) +45 micron etc. The overall clean coal RFC product was then modified by introducing different portions of the tailings to simulate different conventional flotation products. This initial work has shown that the final moisture content is a very strong, and almost unique function of the Sauter mean, and shows that one way to target a lower product moisture is to introduce sharp desliming or size
classification. Moistures well below 20% were achieved by simply removing some of the finest coal. This approach was only effective when the product was slimes-free.

Other work has also shown that relatively small portions of entrained slimes included with the clean RFC product can result in excessive moistures, above 30%. Interestingly, the rate of filtration was reduced almost exponentially by this material. This means that for a fixed filtration capacity, high moistures may be produced due to incomplete filtration. Observation of the cake revealed a thin layer of the slimes in the upper crust of the filter cake.

If a conventional flotation product is subjected to the novel agglomeration it should be possible to reject the ultrafine slimes from the product, in turn forming a basis for reducing the product moisture. This has now been quantified. It should be noted however that such a state can also be formed using the Reflux Flotation Cell. For this reason, recent work involved applying the agglomeration to the clean coal product, completely free of ultrafine slimes, to examine the genuine impact of the agglomeration.

The above systematic approach has provided clear evidence on the precise reductions in product moisture that can be achieved using the novel emulsion binder. It is clear the limitations in the reduction are due to the very fine coal particles present in the RFC product, which is slimes free, and that further gains would be possible by deliberately limiting the final particle recovery. The report is now ready to be written.

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.

The design of devices for fixing the auxiliary tool of the system has been finalised. The manufacturing of the devices, however, has been delayed, due to COVID-19. An extended literature review on the current techniques of particle size measurement and deep learning has been conducted.

This literature review work has inspired us to further advance the algorithm with previously obtained slurry images. Meanwhile, a new approach was tested with previous data and a higher accuracy of model prediction on solids concentration has been achieved. Furthermore, a preliminary hybrid neural network has been built for particle size distribution measurement.

In the following quarter, devices for fixing the auxiliary tool of the system will be built and experiments will be carried out to have more representative slurry recordings. The focus of our work is then to test and advance the hybrid neural network for the measurement of particle size distribution.

Environmental Improvement

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 CHPP. Detailed water quality is being analysed fortnightly to monthly for each of clarified water and ‘fresh’ makeup water.

The project is aiming to 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 regular water collection and analysis is continuing. It is intended that the corrosion coupons will be recovered from each site during May 2020, and this will enable the corrosion rates to be calculated after 12 months exposure at each site.

The project is scheduled to conclude data collection in December 2020, with reporting to follow.
**Fine Coal**

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

University of Newcastle  
Kevin Galvin

| Value: | $294,820 |
| Report Expected: | August 2020 |
| Industry Monitor/s: | Clinton Vanderkruk, Kevin Rowe, Luke Dimech, Penny Walker |
| ACARP Contact: | Nerrida Scott |

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

Early experiments involved 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 m³/h in a 2.0 m diameter unit.

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. Following the most recent tender budget, it was necessary to review the design to bring the project into budget. The main conclusion, following laboratory experiments, is that a single RFC unit will now be ideal to achieve both high throughput, recovery, and high-level product cleaning. It will still be possible to undertake a rougher trial at rates approaching 1000 m³/h, with a rougher-cleaner combination in the one cell at 500 m³/h.

The final design for this full-scale facility has been completed, along with the full design and Hazop reviews. The Reflux Flotation Cell (RFC) modular system has since been constructed and reviewed, and the on-site installation has largely been completed following some delays with the electrical equipment during December and January. Other safety and risk documentation have been prepared.

Due to COVID-19 access to the site has been limited to essential purposes only. The facility will very soon be ready for wet commissioning once the access becomes possible.

**C26001**  
**Impact of Sub Optimal Operation: Stage 2**

CSIRO  
Mike O’Brien

| Value: | $41,500 |
| Report Expected: | June 2020 |
| Industry Monitor/s: | Luke Dimech, 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.

Update of spreadsheet is completed, a final report is being prepared.

**C27012**  
**Towards Better Fine Coal Classification**

QCC Resources  
Andrew Swanson, Mike O’Brien

| Value: | $99,920 |
| Report Expected: | May 2020 |
| Industry Monitor/s: | Mario Salazar, Rod Fox, Tom Wilson |
| ACARP Contact: | Nerrida Scott |

A draft report is being reviewed by the industry monitors.
C27021
Model Informed Control Strategy for Coal Flotation
University of Queensland
Kym Runge

Value: $199,571
Report Expected: July 2021
Industry Monitor/s: Clinton Vanderkruk, Majid Ejtemaei
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 (right) and a froth vision system.

University of Queensland and CSIRO researchers were deployed to a coal handling and processing plant (CHPP) in Queensland in September and October 2019 for a six week phase of on-site test work. They installed a series of sensors, including the CSIRO InterFloat™ sensor, on a Jameson cell and conducted a comprehensive sampling campaign to determine the effects of operating conditions, especially the supplied air rate, on both coal flotation performance and froth behaviour.

Since returning from this deployment, CSIRO has analysed all of the data collected using their InterFloat™ sensor and compared their results with manual measurements performed in-parallel by University of Queensland researchers. CSIRO has produced a full report on their findings, including recommendations for how the InterFloat™ sensor might be modified and improved for future use in coal flotation control. However, based on the minimum resolution achievable with the InterFloat™ (~25mm compared to the required ~10mm) the decision was taken not to include the InterFloat™ sensor in the planned second phase of on-site test work to be conducted by University of Queensland later this year.

University of Queensland is currently processing the large amount of data collected during the first phase of site work and, as assay results become available, building statistical models that link changes in operating conditions and froth behaviour with the performance of the Jameson cell under investigation, in terms of combustible yield and ash content. The results of this analysis are being used to inform an experimental design for the second phase of on site test work planned for the second half of 2020.

C27025
Quantifying the Step Change Benefit of Reflux Flotation Cell Circuits
University of Newcastle
Kevin Galvin

Value: $167,020
Report Expected: May 2020
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 maximising 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 to arrive at the best configuration.

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. There appear to be significant benefits in
minimising the gas flux, provided the flux is sufficient to achieve full recovery.

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.

Numerous other experiments conducted over the past quarter delivered similar findings, with the RFC recovery relatively high, product ashes substantially lower than predicted by the tree curve, with the throughput varied typically at up to 5 cm/s, and in one case pushed to 7 cm/s and beyond. The work shows conclusively that the optimal circuit from a performance, engineering, and cost perspective involves conducting the rougher-cleaner combination in the one cell. The project work is now complete.

A draft report is being reviewed by the industry monitors.

C27026
Ultralow Ash Coal by 3D Binder Flotation

University of Newcastle
Kevin Galvin

Value: $152,020
Report Expected: June 2020
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.

Following earlier problems associated with using iron-based grinding media, we moved to a ceramic milling arrangement. We also chose to use a binder that contained no salt. A coarser feed was sourced from New South Wales, offering prospects for a lower ash through liberation. 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 higher than expected at 19% ash. Thus, the strong liberation only reduced the ash to 14%.

Surprisingly, the fine grinding continued to produce poor quality results, contrary to expectations, with only modest reductions in the ash observed. We suspected that the mineral matter was being crushed and effectively smeared into the surface of the coal macerals, and that the fine coal formed was similarly being contaminated by the ultrafine mineral matter. The point is that this technology will “grab” any particle that contains almost any level of hydrophobicity, so the results are suggesting that high ash particles contaminated by the fine coal are being recovered. With this hypothesis in mind, new experiments were conducted for the purpose of cleaning and dispersing the particles, ahead of the agglomeration. A teepol dispersant was added, while ultrasonic cleaning was applied to the ground material. Moreover, the emulsion binder that was added was reduced to ideally target the most hydrophobic of the particles. The product ash was still only 6.2%. It is suspected that the coals being used are less than ideal, so others will be sourced.

This work has so far demonstrated that the agglomeration can be used to efficiently recover and concentrate a fine coal tailings stream to achieve a low product ash. However, further grinding of the concentrate product followed by application of the novel agglomeration does not yield a further reduction in the product ash. In order to assess whether this result was due to the coals selected for the study, an alternative series of experiments was conducted. Product generated from the Reflux Flotation Cell (RFC) was subjected to fine grinding to achieve liberation. This material was then subjected to (i) agglomeration to achieve product upgrade and (ii) flotation using the RFC. The original tailings stream generated a product ash of 7% following application of the RFC. The ground product then achieved a product ash of 2.5% following application of the RFC and 7% following the agglomeration. Clearly, the coal used is capable of delivering liberation and reduction in the ash.

The experimental program has been completed, and the draft final report is now being prepared.

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;
- Guide plant engineers to identify the best frother for their coal preparation plants.
In the last three months, the two phase characterisations of 18 frothers in fresh water and process water with different salinity have been completed. The results show that critical coalescence concentration (CCC) and dynamic foamability index (DFI) can be used to quickly classify frothers. From the 18 frothers, weak frothers with similar characteristics with MIBC but with a higher flash point were identified. Stronger frothers which may be more suitable for oxidized coal and coarse particles were also identified. Besides, it was found that water salinity changes frother characteristics and therefore should be considered when evaluating frothers.

Three phase characterisation of frothers is currently being conducted on different coal samples and water samples collected from participating plants. The measurement include bubble size and frothability. The three phase characterisation will help identify the roles of different coal properties in the selection of frothers.

C28051
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
Rahul Patel
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 (eg static mixers, rotor-stator mixers) in diesel emulsification in saline water;
• Develop a new continuous emulsification technique (eg 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;
• Comprehensively evaluate the benefits of diesel emulsification for coal preparation plants.

In the last three months, diesel emulsification using a power ultrasound was conducted in water with different salinity. It was found that power ultrasound produces a significantly finer droplet size than static mixer and rotor-stator mixer. Ultrasound power intensity, treatment time and diesel to oil ratio are the main factors that affect the emulsification efficiency. Besides, power ultrasound can also produce fine diesel emulsions in high salinity water, which cannot be achieved by using a static mixer and rotor-stator mixer.

Flotation tests are conducted to identify the effect of emulsification on flotation performance. Preliminary results have shown that diesel emulsification can improve flotation performance and reduce diesel consumption. These benefits are mainly dependent on the droplet size. More tests are being conducted to identify the critical droplet size and also the effects of different coal types and water salinity.

C28053
New Approach to Simultaneously Improving Flotation and Subsequent Froth Breakdown

University of Queensland
Liguang Wang

Value: $192,600
Report Expected: November 2020
Industry Monitor/s: Clinton Vanderkruk
Luke Dimech
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; and to
• Provide a fundamental understanding of this new approach.

The proposed new approach was used to improve the flotation performance via inhibition of bubble coalescence in the froth phase and pulp phase of a flotation system. Improvements in coking coal flotation in a flotation column and a bottom-driven mechanical flotation cell have been demonstrated previously. In the last quarter, the experimental system was upgraded to address the potential occupational safety issue of the proposed approach. Lab-scale experiments were carried out to test the upgraded system for inhibiting bubble coalescence in flotation column and mechanical flotation. The results showed pronounced improvement in foam stability at certain operating conditions. The foam stability tests were also carried out at pilot-scale and improvement in foam stability was observed.

Preparation of the feed for pilot-scale flotation trials and construction of a holder for multiple devices of interest are ongoing. Pilot-scale flotation tests will be carried out in the following quarter. Procurement of equipment suitable for industrial trials is also under way.
The objective of this project is to investigate the effect of chemical additives on handling and post-processing of coal tailings after dewatering. Rheology properties of thickened coal tailings together with their interaction forces are examined for dewatered samples of different particle size, salinity, clay mineralogy, moisture content, and dewatering technology. Various polymers (natural and synthetic) and other chemical additives will be investigated to quantify their suitability for improving coal tailings handling for disposal. Mathematical models will then be established to relate rheological properties with mineralogy and moisture content of the tailing to provide a predictive tool for tailings disposal. The knowledge gained from this project will help developing simple on site tools to assess the consistency of tailings that suitable for stable disposal and to support decision making on the allocation of the current tailing stream.

This progress report covers the activities and outcomes of the project from February to April. In the previous phase of this project, the experiments on quantifying the particle size distributions, surface charges, and the clay type and mineralogy have been done as planned. A method of screening chemicals for tailing disposal has been established. Different types of both conventional and modified flocculants were tested using the new method. In this process, the stickiness and yield stress of dewatered fine tailings by a lab-scale press filter were measured and assessed. The results showed that modified flocculants reduce the stickiness and enhance yield stress of dewatered fine tailings due to its unique structure and functional groups. In the next phase of this project, the bucket rheometer for the sliding test of fine tailings (dewatered by a pilot-scale solid bowl centrifuge - SBC) has been developed. The developing and testing bucket rheometers for co-disposal of fine-coarse coal rejects are progressing as planned. Activities of the next research quarter will be on completing the bucket rheometers for co-disposal coarse and dewatered fine reject from pilot-scale SBC and establishing a predictive model to correlate rheological properties with mineralogy and moisture of tailings.

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, then to use their reported results to determine the variation within the data obtained.

The identical samples sourced from two separate CPPs were sent to commercial laboratories and research institutions to perform Basic Froth Flotation test (A54156.2.1) and Sequential Froth Flotation test (A54156.2.2). The results were statistically analysed. It was found that the yield obtained in the basic test are consistent, however, the ash analysis resulted in greater variations. Overall, greater variations were recorded with the results of the sequential procedure.

The project aims to develop a prototype analytical tool to profile coal and mineral particles in the fine circuit of a coal preparation plant (-2+0.1mm). This second stage involves integration of the profiler components (optical cell, sampling system, camera operations, software particle tracking and statistical analysis). The optical cell/sampling system have been developed in parallel to the software integration activities. We have also tested the tracking software on ultrafine (-100um) coal samples and coarse (-50+2mm) coal samples. Both test suites suggested that tracking software could be utilised in other particle ranges if the hardware was optimised. The ultrafine coal testing suggested that better optics were required to resolve particles below 50um. The coarse particle tests revealed a need for better solids handling to introduce the sample. The current status is that the sampling system control circuit is operational and the software is now capable of processing a video and outputting statistics and summary data. The next stage
will involve calibration with a commercially float/sunk test coal and final coupling of software to hardware.

**C28060**

*Measuring and Correlating CGA Data at Particle Topsize*

Basacon Services
Bruce Atkinson

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<td>Chris Urzaa, Tim Manton</td>
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<tr>
<td>ACARP Contact:</td>
<td>Nerrida Scott</td>
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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 grain analysis is in progress and report submission is scheduled for late in the second half of 2020.

**C29065**

*Wash Plant Fines Testing Methods Enhancement*

McMahon Coal Quality Resources
Chris McMahon

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<td>Frank Mercuri</td>
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<td>Nerrida Scott</td>
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This project very recently commenced.

**C26010**

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

CSIRO
Mike O'Brien

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<td>Industry Monitor/s:</td>
<td>Clinton Vanderkruk, Rod Fox</td>
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<tr>
<td>ACARP Contact:</td>
<td>Nerrida Scott</td>
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This project aims to provide the coal industry with usable data from a pilot scale multi-sloped screen that can be used to maximise screening efficiency while providing the lowest possible forces on the screen, screen components and screen structures.

To date fifty-four experiments have been completed with strokes ranging from 6.1 mm to 14.1 mm, frequencies from 8 to 16 Hz, solids contents of 30% and 40%w/w and feed rates of 20l/s, 30l/s and 40 l/s (27tph/m²). A normal plant screen treating 600 t/h is approximately 25 tph/m².

Figure 1 shows the effect of changing the g force by changing the weights on the mass rate of minus 1.0 mm material in the oversize and Figure 2 by changing frequency.

![Figure 4 Effect of changing the g-force by adjusting the weights at 30% solids.](image-url)
The project has the 50% solids and 60% solids to complete at the three feed rates but due to site restrictions as a result of COVID-19 pilot plant activities have been reduced for health and safety reasons as the site is in afterhours mode. Return to normal activity is a little while off as of yet but a staged return to site is underway.

C26011
CSIRO Instruments at Multiple Plants

CSIRO
Mike O’Brien

Value: $427,798
Report Expected: August 2020
Industry Monitor/s: Naomi Pritchard, Rebecca Fleming
ACARP Contact: Nerrida Scott

To maintain the momentum of industry access to the CSIRO technology, this 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 optimise 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 new Instrument has been updated to a smaller more compact unit with molded electrodes and electrode holders as shown in Figure 1.

Figure 1. Effect of changing the g force by adjusting the frequency of operation.

Expected to be delivered to the mine site in the Bowen Basin in June and installed in July. Hunter valley mine site installation delayed due to travel ban.

C26012
Improved Flotation Recovery Via Controlling Froth Behaviour - Stage 2

University of Queensland
Liguang Wang

Value: $100,000
Report Expected: May 2020
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; and to
- Demonstrate and evaluate a simple and fast tool for measuring the concentration of frother in flotation cells and water circuits.

A draft report is being reviewed by the industry monitors.
**C26016**  
**Benefits of Online Thickener Underflow Rheology Measurements**  
Clean Process Technologies  
Alexander Everitt  
Noel Lambert

**Value:** $251,000  
**Report Expected:** June 2020  
**Industry Monitor/s:** Mario Salazar  
Naomi Pritchard  
**ACARP Contact:** Nerrida Scott

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

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

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

Due to current COVID-19 pandemic, access to sites has been restricted for non-essential contractors and visitors. This has unfortunately delayed the opportunity to install the unit on site.

During this time, additional instrumentation has been added to the unit to increase its viscosity measuring range, so as to achieve a more complete rheological profile with on-line analysis. Preliminary testing and calibration of the new system has been carried out at our facility and integration of the additional equipment with the existing instruments has been optimised.

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

**Value:** $217,000  
**Report Expected:** June 2020  
**Industry Monitor/s:** Kevin Rowe  
**ACARP Contact:** Nerrida Scott

The objectives of this project are to:

- Demonstrate and evaluate coal flotation with oscillatory air supply at pilot scale;
- Evaluate energy and reagent savings of oscillatory air flotation.

A draft report has been sent to the industry monitors for review.

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

**Value:** $29,820  
**Report Expected:** May 2020  
**Industry Monitor/s:** John Kelly  
**ACARP Contact:** Nerrida Scott

A draft report is being reviewed by the industry monitors.

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**C27032**  
**Methodologies for Applications of CGA: Handbook**  
Basacon Services  
Bruce Atkinson  
Graham O'Brien

**Value:** $51,422  
**Report Expected:** May 2020  
**Industry Monitor/s:** Chris Urzaa  
Morgan Blake  
Pam White  
**ACARP Contact:** Nerrida Scott

A draft report is being reviewed by the industry monitors.
C27050
Detection of Non-Ferrous Broken Pick Tips and Clay Balls in the DMC

CSIRO
Mike O’Brien

Value: $61,280
Report Expected: August 2020
Industry Monitor/s: Clinton Vanderkruk
ACARP Contact: Nerrida Scott

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.

Delays have been encountered due to COVID-19. Until mine site access can be granted researchers are setting up the pilot scale DMC to run with the sensors in place and inserting both hard objects and clay balls.

C28061
Quantitative Based Structural Integrity Evaluations Using Modal Parameters Estimation

Mincka Engineering
Fidel Gonzalez

Value: $363,651
Report Expected: June 2020
Industry Monitor/s: Kevin Rowe
Peter Shumack
Phillip Enderby
ACARP Contact: Nerrida Scott

The wireless hardware system purchased for the instrumentation had to be returned to the OEM in light of heavy coal dust makeup at the ROM area. A new wire-based data acquisition architecture had been purchased and the ETD is on the third week of June. This hardware will be installed with a direct feed from the available site power. Additional failure modes of the structure had been identified after the simulation done to it and also field evidence from previous inspections. These failure modes are the object of the research in light of being detectable with modal parameter changes.
### Process Control

**C26013**  
**Effect of Flotation Water Chemistry on Coal Chemistry, Fluidity and Coke Quality**  
University of New South Wales  
Noel Lambert  
Seher Ata

- **Value:** $337,986  
- **Report Expected:** September 2021  
- **Industry Monitor/s:** Clinton Vanderkruk  
  Rebecca Fleming  
- **ACARP Contact:** Nerrida Scott

A draft report is being reviewed by the industry monitors.

**C28073**  
**Novel Processing to Reduce the Cost of Generating Dry Stackable Tailings**  
University of Newcastle  
Kevin Galvin

- **Value:** $141,342  
- **Report Expected:** June 2021  
- **Industry Monitor/s:** Andrea Crawford  
  Clinton Vanderkruk  
  Kevin Rowe  
  Penny Walker  
- **ACARP Contact:** 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.

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.

Due to COVID-19 Monash University had closed its laboratories with reopening expected end May at which time work on this project will resume.
**TECHNICAL MARKET SUPPORT**

**Future Technologies**

**C28068**

**Utilisation of CHPP Waste in Value-Added Products**

CSIRO

Ian Porter

Philip Ofori

- **Value:** $250,000
- **Report Expected:** January 2021
- **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.

In the last quarter, tailings-based geopolymer binder formulations and curing conditions have been optimised and geopolymer concrete specimens have been produced with 7 day compressive strengths equal to or higher than equivalent ordinary Portland cement concrete. The workability and mechanical strength of geopolymer concrete mixes using tailings from four other sources will be optimised in the next quarter. Tests have been performed in which fine and coarse washery rejects have been used as substitute for sand and conventional aggregates in geopolymer mixes, resulting in moderate reductions in mechanical strength. These tests will be completed in the next quarter.

A total of 14 coal reject-filled tubular columns, including 12 FRP tubular columns and 2 reference specimens, were tested for compressive strength using a 5000 kN compression testing machine with displacement control. The effects of infilled coal reject particle sizes (i.e., unscreened and sieved +26.5 - 63mm), the type of FRP composites, the thickness of FRP tube (i.e., 1.5 mm and 3.0 mm) and the number of fibre sheet plies (i.e., 1, 3 and 5) on the axial load carrying capacity and deformation ability of these columns were examined. Compared with the unconfined infill material made of coal reject and cementitious grout material, both the compressive strength and the deformation capacity of FRP confined columns have been significantly enhanced, verifying its expected advantages in high strength and high stiffness. Based on the experimental test results, the theoretical analysis has progressed to obtain an in-depth understanding of the confining action of FRP composite to infill material made of coal reject and cementitious grout material. Due to the impact of COVID-19 pandemic, some previously planned tests to validate the numerical modelling have not been conducted, which may affect the determination of the final design of the standing support system.

In using BOS slag as a binder in pasting, the experiments have been extended to isolate a single variable for each trial, for comparison with a reference concrete, made to a 20 MPa specification. This is being carried out by firstly doing a series of trials, with the same amount of sand, aggregate and water as the reference concrete, but progressively replacing part of the cement with pulverised BOS slag. A limitation has been that, with the available equipment, the BOS slag can only be pulverised to less than 312 microns, whereas the cement has a maximum particle size of 212 microns. Similarly, a series of tests where the standard amounts of cement, aggregate and water are used and the amount of sand progressively replaced with fine coal wash with a similar size distribution is planned.

**General**

**C25053**

**Coal Sample Bank**

CSIRO

Lauren Williamson

- **Value:** $279,329
- **Report Expected:** October 2021
- **Industry Monitor/s:** 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, 39 coal samples have been delivered, stored at -18°C and their details recorded in a database. Of the 39 samples stored coal quality data has been provided by coal producers for 33 of the samples. Request for coal and/or coke samples have been received from the researchers leading six projects that have commenced in 2020 (C29067, C29070, C29071, C29072, C29076 and C29077). One coal and three cokes have been added to the coal bank so far this year with a further coal coals being sourced from coal producers to refresh depleted samples. Coal and/or Coke samples have been supplied to for project C28071 and C29077 this year.
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, and SA Committee MN/1/2, Coal Preparation both held separate meetings in March by videoconferencing, because of the current pandemic. Attendance for each meeting was somewhat down on usual and agenda items reduced due to current circumstances.

A number of ISO ballots were considered as well as SA withdrawal ballots for a number older and outdated Standards.

During the period, Barry Isherwood assisted SA in preparing and drafting its ACARP support proposal, and arranging the necessary discussions concerning delegates to be nominated and endorsed, to attend the ISO TC27 meeting to be held next year.

ISO Central Secretariat has allowed extension of deadlines where necessary and particularly where planned Round Robin testing programs are involved and the difficulty in circulating samples globally.

C26037

Standards Australia
Emilie Mortgensen

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

SA support for Australian Mirror Committee—Schedule of meetings.

MN-001-01 (Coal analysis) —Mirror Committee for ISO/TC27/SC3 and SC5:
- Chairman: Barry Isherwood;
- Last meeting: 19th March 2020, Converted to Zoom Meeting (due to COVID-19 situation);
- Next meeting: 16th July 2020 (SA Office Sydney/Zoom);
- Meeting objective: Review ISO/TC27/SC5 & SC3 documents including systematic reviews and finalise Australian mirror Committee position on ISO ballot (and comments).

MN-001-02 (Coal Preparation) —Mirror Committee for ISO/TC27/SC1 and SC4:
- Chairman: Dave Osborne;
- Last meeting: 25th March 2020 (Converted to Zoom Meeting (due to COVID-19 situation);
- Next meeting: 23rd September 2020 (NIER Newcastle/Zoom Meeting);

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: June 2020
Industry Monitor/s: Jay Zheng, Sean Flanagan
ACARP Contact: Ashley Conroy

This project aims 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 requires five coal samples, three for concentrating inertinite-rich particles, including two different sized particles, 0.25-0.5 mm and 1.6-2.0 mm, and two coals for blending purpose. We have completed inertinite concentrates separation, CATA tests for swelling and permeability, and DETA tests for volatiles (C and H release) for their blends with another two different rank coals and fluidity tests for selected samples. We are currently delayed for preparing large coke samples for strength tests and fused carbon analysis, we are expecting to get this done and a draft report prepared next quarter.

**Major Projects**

**C27001**  
**Maritime Regulation Project**

Goodwin Port Solutions  
Ash Goodwin

- **Value:** $2,922,49  
- **Report Expected:** December 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.

AMSA subsequently issued Exemption 5739 allowing Australian shippers of solid bulk cargoes to use the Refined MHB(CR) Corrosivity Test.

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. Experimental work continues towards confirmation of a refined testing method.

AMSA have issued Certificate of approval AP5620 allowing coals meeting specified criteria to be classified as MHB.


**Metallurgical Coal**

**C26039**  
**Nanoporosity in Cokes: Their Origin and Influence on CO2 Reactivity**

CSIRO  
Mihaela Grigore

- **Value:** $149,756  
- **Report Expected:** April 2020  
- **Industry Monitor/s:** Kim Hockings, Nick Andriopoulos, Oliver Scholes  
- **ACARP Contact:** Anne Mabardi

A draft report is being reviewed by the industry monitors.

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

CSIRO  
Karryn Warren, Merrick Mahoney

- **Value:** $161,640  
- **Report Expected:** June 2020  
- **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 feed 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 project C24057 into the links between the size distribution of fusible and infusible macerals and minerals, associations of macerals structures in coke oven feed coal and resultant coke structure and strength;
- Further understand the mechanisms behind why coals from the Rangal Coal Measures have unexpected coking behaviour.

In the last quarter chapters of the draft final report were prepared and the last of the CGA size data extraction from each of the size fractions of the coke oven feed progressed. In the next quarter we expect to submit the draft final report.
**ACARP Current Projects Report May 2020**

### C26046
**Relevance of Maceral Concentrates to Whole Coal Coking Predictions**

**University of Newcastle**  
Wei Xie

- **Value:** $69,500  
- **Report Expected:** May 2020  
- **Industry Monitor/s:** Graeme Harris, Kim Hockings, Oliver Scholes  
- **ACARP Contact:** Ashley Conroy

A draft report is being reviewed by the industry monitors.

### 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:** July 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, using samples tested at room temperature in an epoxy resin mounting medium. In a typical tribological test on coke, a ruby ball indenter is used to apply a force to a rotating polished coke sample. In this current project we have demonstrated that tribological testing can be applied to coke samples at temperatures of up to 950°C in both inert and carbon dioxide atmospheres without the necessity to use a mounting medium for the coke.

The aim of these experiments is 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 then aim to use this information to identify steps to help improve coke strength prediction and its resistance to abrasion in the furnace.

We have completed all experimental work and the majority of post-test imaging and quantification of the data. In the last quarter, we continued the writing of the final report. In the next quarter, we intend to relate the quantified data to traditional coke strength measures, including the coke strength after reaction (CSR) index, and submit the final report for this project.

### 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:** June 2020  
- **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 completed all of the proposed work for this project and are in the reporting phase. The report consists of two parts. The first part contains our research outcomes on the effect of force and inertinite on pore structure and the second part contains our research outcomes on preferential pathways in the pore structure. The second part is complete and we are currently completing the first part now that we have a complete set of results.

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

**CSIRO**  
Karryn Warren, Merrick Mahoney

- **Value:** $173,196  
- **Report Expected:** August 2020  
- **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?
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?

The FTIR data for vitrinite and inertinite has been processed for each of the coals and differences observed between the percentage of alkenes to alkanes present in these macerals (by peak area). Peak height differences have also been observed. Figure 1 shows the difference in alkene percentage between vitrinite (orange) and inertinite (yellow) by maceral reflectance for Coal G. Analysing the data in this way will enable the relationship between reflectance and alkene percent to be assessed.

Figure 1: Percentage of alkene present by FTIR analysis in vitrinite and inertinite regions of a particle of a single coal, showing the increase of alkenes in this coal present in the inertinite and potential relationship to reflectance.

In the next quarter we anticipate completion of the FTIR data analysis, CGA size and reflectance data extraction for all coals, data analysis and commencing of the final report draft.

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: June 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 Australian coking coals supplied by the coal bank have been used on the coking tests using the 4kg lab-scale coke oven at the NIER prescient of University of Newcastle. A number of plastic layer samples have been produced with different ranks, and vitrinite contents, and these samples have been analysed using Synchrotron IR and XPS. TEM analysis of these plastic samples has been partially done from which carbon domain structural parameters will be derived. The TEM results will be combined with IR and XPS analysis to define carbon structures. The carbon structures of the coke from TEM analysis will be correlated to coke quality, including CRI/CSR, and also the coal properties. Clear correlations between carbon structures between carbon structure parameters and coke quality and coal properties, although limited by the number of coals tested. Further research should expand the coverage of coals in terms of rank and vitrinite contents to provide more reliable data.

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

University of New South Wales
Pramod Koshy

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

This project has focussed on the high-temperature strengths and performance of coke blends prepared using different fabrication facilities, namely a lab-scale oven and pilot oven. This is a follow up on prior work (C25045) on the high-temperature testing of single-coal cokes of varying CSR values.

The objectives of the current work are to:

- Determine the high-temperature and room temperature strengths for two blends made using a lab-scale oven and using a lab coking oven before after gasification,
- Develop correlations between the mineralogical, microstructural, and fracture characteristics of coke blends with strength evolution, and
- Validate the effectiveness of the laboratory coke oven by comparing its properties with those from the conventional pilot-scale oven for the same compositions.
A binary (C1) and a ternary (C2) coal blend were prepared and lab-scale coke samples were prepared at University of Newcastle (~4 kg for each blend - C1L, C2L), while the same blends were produced in a pilot oven (C1P, C2P) to produce ~40 kg for each blend. All cokes were cored into cylindrical samples and then gasified under simulated blast furnace conditions. The resultant samples were end polished to produce cylinders with parallel ends and then subjected to room- and high-temperature mechanical tests. The room temperature strengths were similar for C1P and C1L samples while those of C2P were significantly lower than the values for C2L. This could be related to the C2L sample not undergoing sufficient coal-to-coke transformation in the lab-scale oven. High-temperature tests at 1400°C and 1100°C (figure shown below) showed that C1P showed the highest strengths among all samples while C2P showed the lowest. Further, fractography showed that C1L showed stronger RMDC and IMDC compared to C1P samples.

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 analyses of closed and open nanoporosity in unreacted cokes using neutron scattering at ANSTO are underway. The neutron scattering data obtained from the first session at ANSTO have been processed. The NSC tests on cokes have been completed. The reactivity tests of cokes with CO2 using a Fixed-Bed reactor and the petrographic analyses are underway. Low-temperature ashing of the cokes is required prior XRD analyses. The ashing process is in progress.

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 by:

- Using an inertinite analogue to elucidate the influence of particular inertinite attributes; and
- Examining the impact of maceral associations on laboratory carbonising tests as a step towards improving predictions of coking performance from these tests.

In the quarter, polished mounts have been prepared for two of the coals for coal grain analysis (CGA). A replacement third coal has been selected, due to ageing and supply issues with the initially selected third coal. In the next quarter, this coal will be separated into vitrinite-rich (VRF) and inertinite-rich (IRF) components using a bench-scale washery at the University of Newcastle. Following petrographic analysis of the washed coal fractions, we intend to:

- Form small-scale cokes from blends of the coal with the selected inertinite analogue materials, including charcoal, graphite and a 50:50 mixture of the two.
- Use fractographic analysis to examine the breakage surfaces of the fractured coke specimens, focussing on the strength of the interfaces between the inertinite analogues and the reactive maceral derived components (RMDC), and the influence of their inclusion in the blend on the interface between the coke inertinites and the RMDC.
- Prepare five grinds from the blend comprising coal inertinites (ie no additives), whereby the grinds of the VRF and IRF will be adjusted separately before recombining to produce samples with different grain
composition for the same overall composition. The vitrinite-rich and inertinite-rich material in each sample will be characterised by CGA, and subsamples of each sample will also be crushed to size for both the Gieseler fluidity test and the dilatation test, with the prepared reserve of each to be examined by CGA.

C29066
Evaluation of Australian PCI Coals Under Industry Scale Blast Furnace Conditions using a 3D Computer Modelling - Stage 3 Under Overseas Blast Furnaces Conditions

University of New South Wales
Yansong Shen

Value: $150,000
Report Expected: April 2021
Industry Monitor/s: Cameron Tasker, Chris Urzaa, Morgan Blake
ACARP Contact: Ashley Conroy

This project follows on from two previous projects which modelled the PCI behaviour of single coals and binary coal blends respectively, under Bluescope Steel’s blast furnace and PCI conditions. The overarching objective of this current project is to evaluate Australian PCI coals under overseas industry-scale blast furnace conditions (specifically those found in Baosteel and Tata Steel blast furnaces) using an improved 3D computer model.

During this quarter:
- Coal selection - following the discussion between the project team and industry monitors, it was suggested that the project would use coal data of up to six Australian PCI coals, covering typical PCI coals of LV, MV and HV. The properties of five out of six Australian coals have been received from industry monitors;
- BF data - The detailed Baosteel operating conditions have been collected from the published paper. The Tata Steel data is not available for now. Industry monitors and CI Shen are chasing them up.
- Model improvement - Significant effort has been made to further develop the PCI model under industry-scale conditions at Baosteel. Initial tests have been conducted.

C29067
Oxidation Rate in Reducing Coking Propensity of Individual Maceral Grains Residing Naturally in Lump Coal using FTIR Microscopy

University of Newcastle
Quang Anh Tran

Value: $99,800
Report Expected: April 2021
Industry Monitor/s: Graeme Harris, Steve Lempereur
ACARP Contact: Ashley Conroy

This project aims to employ FTIR microscopy to relate the oxidation of maceral grains in coal to its fluidity reduction. This technique combines the advantages of FTIR and microscopy with respect to oxidation studies. While the microscopic component allows the determination of vitrinite and inertinite grains, the FTIR component provides information on the structural change of maceral grains without the need of destroying/pelletizing the sample. The structural change of macerals acquired from this non-destructive test will then be linked to the change in fluidity between unoxidised and oxidised samples to understand their individual contribution to the coal oxidation.

The project started in April but has experienced mild delay due to COVID-19. In the next quarter, coal samples will be acquired and development and preparation of analysis methods suitable for FTIR microscopic technique will be conducted.

C29068
In-Situ Study of the Permeability of the Plastic Layers of Australian Coking Coals Using an Advanced Permeability Test Apparatus

University of Newcastle
Jianglong Yu

Value: $154,000
Report Expected: October 2021
Industry Monitor/s: Cameron Tasker, Nick Andriopoulos
ACARP Contact: Ashley Conroy

This project aims to carry out comprehensive research on instantaneous permeability of the plastic layer formed during coking of Australian coking coals using an advanced permeability in-situ measurement apparatus to be built at the NIER precinct of the University of Newcastle, meanwhile to establish a methodology to better evaluate the coking capacity of Australian coking coals. This research aims to achieve a better understanding on how the plastic layer is formed during coking of Australian coking coals, how the chemistry and permeability of the plastic layer affect the coking behaviour, and how these processes further influence the formation of coke structures and coke quality that if formed through the plastic layer.
A suite of Australian coking coals from the ACARP coal bank will be used in this research. The tests will be carried out in two parts on a small in-situ permeability rig and the existing 4kg lab-scale coke oven, respectively. Currently, the small in-situ permeability rig is under construction. The key part of the small in-situ permeability rig is a coke reactor, which will be heated using an electric furnace. The test rig allows in-situ pressure drop of a coal bed from which the permeability can be calculated. The data from different coals will be compared. The in-situ measure of pressure changes inside the coal bed will also be carried out on the 4 kg lab-scale coke oven, and the data will be compared with that from the small permeability rig.

**C29070**  
**Effect of Coke Properties on High Temperature Strength and Hot Metal Reactivity Under Blast Furnace Conditions**

**University of New South Wales**  
Pramod Koshy

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<td>Industry Monitor/s:</td>
<td>Jay Zheng, Nick Andriopoulos, Stephen Brant</td>
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Prior work focussed on the impact of blast furnace conditions such as high-temperatures and gasification conditions on the strength development and associated microstructural, microtextural, and mineralogical characteristics of single-coal and blended cokes. This project follows on from this research with additional focus on slag-metal-coke interactions at high temperatures and their dependency on coke and coal properties. The project aims to:

- Compare high-temperature and room temperature mechanical strengths of two single-coal cokes and two blends derived from these cokes (from the pilot oven);
- Develop fundamental understanding of key material/compositional factors affecting carbon dissolution into hot metal in the presence of slag under BF conditions; and
- Gain understanding about the associations between strength development and reactions with metal/slag with the mineralogical, microstructural, and fracture characteristics of the coke and ultimately with coal blend properties.

It was decided at the start-up meeting that all samples should be produced using the pilot oven to ensure sample consistency. The two coke blends required are available from prior projects while the two single coal cokes are being prepared currently in the pilot oven. Preliminary corrosion tests of coke with steel (2 wt% carbon) are currently being conducted under static conditions at 1350°C, 1450°C, and 1550°C in order to understand the impact of temperature on coke reactions and carbon pickup by the hot metal. A primary slag composition has been prepared and tests are planned on slag-metal-coke reactions.

**C29071**  
**Source of Variability of Reactivity of Coke in the NSC Test (CSR Test)**

**CSIRO**  
Lauren Williamson

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The main objective of this project is to determine if the variability in reactivity of the coke particles used in the NSC test is due to the crushing procedure used to prepare the sample or inherent variability in coke at the 20mm size.

The following activities are currently in progress:

- Coal selection and souring is being finalised in agreement with industry monitors;
- Development of coke preparation (mounting and polishing) and imaging processes to work with large +50mm cokes;
- CSIRO is finalising subcontracting agreements with the University of Wollongong for the supply of Coke Analogue for this project.

**C29073**  
**Correlating the Distribution of Multiscale Structural Features with Coke Quality Indicators by Combining Advanced Datamining Approaches with 3D Visualisation**

**University of Newcastle**  
Keith Nesbitt

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<td>Graeme Harris, Lauren North</td>
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<td>Ashley Conroy</td>
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The project addresses:

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

The project aims to leverage previous experience in machine learning, modelling, 3D visualisation, statistical characterisation to enhance characterisation of coke based on the distribution of microstructures, by:
Further development of manifold learning and clustering approaches to automatically detect structural features of interest in an increased range of cokes;

Refinement of 3D statistical characterisation approaches for classifying coke strength based on the distribution of microstructure classes; and

Validation and communication of all outcomes with experts using the previously developed interactive 3D visualisation tool.

A software engineer/scientist for 2 days a week to support the project has been selected, commencing April 4 through to 30 October 2020.

The first phase of the project has commenced with work focusing on:

- Select blocks of structural features, from different cokes as basis of isomap;
- Refining isomap generation with alternative distance metrics (autencoding).

There has been some initial delay in gathering all datasets due to COVID-19. However, this is not expected to cause any significant delay in meeting project timeline. The project has began with the datasets currently available.

C29076
Understanding of the Mechanism of Chemical Interaction Between Vitrinite and Inertinite

University of Newcastle
Wei Xie

Value: $149,500
Report Expected: February 2021
Industry Monitor/s: Kim Hockings, Sean Flanagan
ACARP Contact: Ashley Conroy

This project attempts to obtain fundamentally understand of the chemical interaction of vitrinite with inertinite particles. The objectives are to:

- Investigate chemical interactions of volatiles from vitrinite with inertinite on altering the thermostability;
- Evaluate the chemical structure alteration of inertinite during coking with and without volatiles and condensable tar released from vitrinite;
- Clarify how volatiles and condensable tar from vitrinite interact with inertinite to alter coking of inertinite, and to what degree the alteration could be.

To achieve the goals, we use Reflux Classifier (RC) for concentrating inertinite particles, 0.2-0.5 mm, Computer Aided Thermal Analysis (CATA) for swelling and permeability; Dynamic Elemental Thermal Analysis (DETA) for volatile (C, H) release, Attenuated total reflectance-Fourier-transform infrared spectroscopy (ATR-FTIR) for identifying structure features of inertinite and coal tar, Thermogravimetric analysis (TGA) for coal tar boiling point and Pearson Petrography for fused carbon and structures.

In the first quarter, we have requested coal samples, however, this project requests a large amount coal samples that need to be delivered from coal producers, at this stage, we are still waiting for coal samples. Next quarter, we are expecting to receive the coal samples, carry out coal maceral separation and start CATA tests.

C29077
Effects of Ash Minerals on Coke Reactivity at High Temperatures

University of Wollongong
Brian Monaghan

Value: $207,654
Report Expected: April 2021
Industry Monitor/s: Jay Zheng, Jeremy Byrnes, Kim Hockings
ACARP Contact: Ashley Conroy

The primary objective of this project is to quantify the impact of mineralogy and carbon structure on the reactivity of metallurgical coke using a coke analogue at temperatures >>1100°C in a pseudo CRI test. It represents the first phase (year 1) of a broader topic that deals with high temperature performance of Australian metallurgical coals in use in the steel industry.

Progress during the quarter:

- Employed research associate to work on project;
- CSIRO contract for carbon structure and grain analysis in progress;
- Pseudo CRI test furnace and coke analogue production equipment commissioned;
- Purchased of raw materials for preparation of the coke analogue samples;
- Prepared a trial batch of coke analogue, and characterised the porosity as a QC check. The porosity and pore size distributions fit within the acceptable limits;
- Cokes to be studied identified from the ACARP coal bank. This was done in consultation with industry monitors.
C29078
High Resolution Micro CT 3D Assessment of Coke Gasification

University of Wollongong
Brian Monaghan

Value: $64,590
Report Expected: April 2021
Industry Monitor/s: Nick Andriopoulos, Tim Manton
ACARP Contact: Ashley Conroy

The overall aim of this work is to understand the mineral effects on porosity evolution during CO₂ gasification of coke with a view to extending the application of CRI/CSR data. The primary objective of the proposed work is to obtain high resolution micro CT measurements of metallurgical coke and coke analogue to address the resolution/voxel size limitations on quantitative assessment of coke pore connectivity, porosity distribution and mineral size distribution, and their changes on coke gasification.

Progress during this quarter:
• Employed research assistant to work on project;
• CSIRO contract for MicroCT in progress;
• Pseudo CRI test furnace and coke analogue production equipment commissioned;
• Purchased of raw materials for preparation of the coke analogue samples;
• Access to Geodict Software from CSIRO established;
• Coke analogue production underway.

Thermal Coal

C27022
Slagging and Fouling During Co-Combustion in HELE Boilers

University of Newcastle
Liza Elliot

Value: $164,350
Report Expected: January 2021
Industry Monitor/s: Chris Urzaa, Jason Nunn, Shaun Booth
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. Additionally, a sample of coal and economiser ash have been obtained from a Chinese power station. SEM analysis of the deposits show significant differences in crystalline nature of the deposits depending on the deposit location within the boiler. Deposits from both boiler A and B were fused (slagged), with Boiler A deposits initiating from a small layer of micron sized particles. Boiler B’s initiation layer contained particles ranging from 4 to 130 µm (a dusty layer).

Drop tube furnace combustion of the feed coals and TMA analysis of the ash collected in two cyclones has been completed. Further drop tube experiments with a combination of feed coal and a range of proportions of biomass (bagasse and spotted gum) have started.

Drop tube furnace combustion of the samples was delayed due to broken furnace elements, the discovery of historic not-to-code electrical alterations, failure of the pump in the water cooling circuit and hospitalisation of key personnel. Each of these problems has been overcome, though additional element failures occurred again and it was very difficult to obtain replacement parts. Replacement elements were obtained after a six month delay. The furnace is now functional and testing has restarted. Issues associated with sudden changes in TMA readings have been overcome. Investigation of possible contamination in the drop tube furnace are currently being investigated.

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: May 2020
Industry Monitor/s: Greg Wickman
ACARP Contact: Ashley Conroy

Comments have been sent back to the Researcher regarding the industry monitor review of the draft final report.
C28063

University of Newcastle
Jianglong Yu

Value: $79,900
Report Expected: May 2020
Industry Monitor/s: Brenda Hutchinson
Greg Wickman
Shaun Booth
ACARP Contact: Ashley Conroy

A draft report is being reviewed by the industry monitors.

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 main 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; and to
• 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
Task 1; Planning and sample selection:
• Five coking coals and five thermal coals with wider range of reflectance to test for complex coal blends;
• Thermal coals rich in minerals for the second objective of the project.

Task 2; Sample preparation and image acquisition:
• Sample preparation completed for complex coal blends;
• CGA analysis of individual coal samples for compositional information to use for complex coal blend analysis.

Task 3; Enhancement of CGA system to characterise complex coal blends
• Various binary and multinomial classification algorithms and techniques were applied to classification tasks for coal blends comprised of two to six individual coals. Algorithm input consists of a collection of particle images exported from CSIRO’s commercially licensed Particle Imaging Software (ParIS). Algorithm output is a label for each input particle indicating its source coal, effectively partitioning the blend into its constituent coals; on going.

Next Quarter:
Task 3: CGA and SEM analysis:
• CGA analysis 28 samples (15 coking coals and 13 thermal coal samples);
• SEM analysis for selected thermal coal samples to obtain overall mineral composition of samples; For this task, I have to visit JKMRC, University of Queensland to use Scanning Electron Microscope. At this stage uncertainty due to the COVID situation this task may need to postpone for the next quarter (yet no access for visitors);
• Testing complex coal blends with CGA software for complex coal blend enhancements;
• Mineral analysis using Scanning Electron Microscopy to use for the of phase diagrams to characterise thermal coals;
• In parallel task 4 (Validate modifications to the CGA software to characterise coal blends); will be carried on based on the software development.

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
Shaun Booth
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.

Four coal samples have been obtained and crushing and sizing of three have been completed. Crushing of the fourth is underway. New plates for the reflux classifier have been produced creating smaller channels over which separation occurs. An algal bloom occurred within the reflux classifier requiring small doses of a biocide. This was followed by corrosion of the plates which caused blockages to form which have been overcome by the addition of an enamel coating. Significant agglomeration of the fine particles is being managed until an ultrasonic plate can be obtained.

Separation of three samples on the reflux classifier is complete. Characterisation of the splits is complete for two of these coals and drop tube combustion studies have started.

COVID-19 has had minimal impact on this project, with staff required to take two weeks leave. Our laboratory has been able to continue most preparation, experimentation and analysis during the extended physical distancing restrictions.

**C28072**

**Mineral Redistribution from PF Coal to Ash in Commercial Power Stations**

University of Newcastle  
Rohan Stanger

| Value:  | $153,270 |
| Report Expected: | June 2020 |
| Industry Monitor/s: | Morgan Blake  
Shaun Booth |
| ACARP Contact: | Ashley Conroy |

This project aims to characterise the changes to mineral matter within coal as it passes through a power station. A SEM-based technique has been used to analyse pulverised coal (as power station feed) and fly ash. The technique, a variant of Mineral Liberation Analysis, has been found to allow identification of both vitrinite and inertinite as well as common minerals in coal. In the fly ash, a number of phases were identified that were consistent with the feed minerals (such as quartz and alumino-silicates) or heat treated variants (iron-bearing amorphous material). This program has been affected by COVID-19 in reducing the number of power stations that may be sampled. As such, the final section of the project will involve a deeper analysis of power station variables (steam cycle, load, mill).
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
Andrew Maddocks
Behdad Moghtaderi

Value: $1,219,962
Report Expected: July 2020
Industry Monitor/s: Bharath Belle, 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 funded projects on this topic designated as Phase-I to Phase-III primarily focused on prototype development and pilot-scale demonstration of the SDL process without the option for regeneration of stone dust particles. However, the vision in Phase-IV is to furnish the SDL process with the necessary means for in-situ regeneration of these particles. This is driven by the fact that additional heat is released when the CO₂ formed by the oxidation of VAM reacts with the calcium oxide particles undergoing the in-situ regeneration. This in turn, enables the SDL process to reach the state of auto-thermal operation (ie self-sustaining) at methane concentrations as low as 0.2 Vol%. 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.
- 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. Modifications to the pilot-plant were completed in Q3 2019 to improve the performance and operability of the process. 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: June 2020
Industry Monitor/s: Ben Klaassen, Bharath Belle, Trevor Stay
ACARP Contact: Patrick Tyrrell

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

This project aims to optimise the VAMMIT thermal oxidiser through design calculations and CFD simulations to achieve lower pressure drop, higher methane oxidation efficiency, and stronger dust deposition and corrosion resistance. The project will also investigate the feasibility of a catalytic VAM mitigator to operate at much lower temperatures (~450-700 oC) to completely avoid stone dust decomposition and at lower methane concentrations (≥0.2%). The specific objectives are:

- Optimisation of the honeycomb bed structure of VAMMIT;
- Optimisation of operating parameters of VAMMIT;
- Feasibility study of a new catalytic version VAMMIT; and
- Investigation of safety management associated with VAMMIT.

The project work has been successfully completed and the draft final report has been prepared and is under internal review. Once reviewed, the revised report will be submitted to ACARP for review.
C28075
Application and Optimisation of Hybrid Chequer-Bricks in Regenerative Thermal Oxidisers for VAM Abatement

University of Newcastle
Behdad Moghtaderi
Jafar Zanganeh

Value:    $255,480
Report Expected:    June 2020
Industry Monitor/s:    Bharath Belle
                        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 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, most of essential and key tasks of the project have been achieved:
- A comprehensive experimental study conducted on different brick flame arrester configurations in both small-scale propagation tube and pilot-scale detonation tube;
- It was determined that the stabilised combustion at the face of the brick flame arrester (ie upstream side) plays a detrimental role on the performance of the brick flame arrester causing its failure;
- The performance of the brick made flame arrester highly depends on the length to diameter (L/D) ratio of the arrester. The best performance was achieved for the brick flame arresters with L/D> 8;
- The pilot-scale detonation tube experimental work showed the presence of fine coal dust particles increases the chance of brick flame arrester failure.

Figure: Footage of the flame propagation through the brick flame arrester (CH₄= 9.5%, L/D=1).

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

University of Newcastle
Andrew Maddocks
Behdad Moghtaderi

Value:    $190,320
Report Expected:    June 2020
Industry Monitor/s:    Ben Klaassen
                        Bharath Belle
                        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
- Developing mass transfer models for the absorption and desorption of methane in ionic liquids.

A commercial rotating packed bed reactor was modified to allow for the experimental program. Standard operating procedures, a risk assessment and safety reviews were prepared and internal safety clearance was granted. Analysis of the experimental data has been completed and the draft report is undergoing internal review.
C28077
Progress in Developing Ventilation Air Methane Abatement Technologies

CSIRO
Shi Su

Value: $90,000
Report Expected: July 2020
Industry Monitor/s: Ben Klaassen
Bharath Belle
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
• Develop a technology roadmap for the development of a suitable reactor.

The project report is being revised according to the comments from the industry monitors.

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

University of Newcastle
Michael Stockenhuber

Value: $258,672
Report Expected: June 2020
Industry Monitor/s: Bharath Belle
Jim Sandford
Trevor Stay
ACARP Contact: Patrick Tyrrell

With a growing pressure to reduce emissions, there is an increased importance in the need to oxidise methane present in VAM (ventilation air methane), the largest greenhouse emission associated with mining. To this end, catalytic processes are an attractive option, with the methane able to be oxidised to reduce the overall greenhouse potential by a factor of 23. There are two key deactivation mechanisms which need to be understood to make the process commercially viable; deactivation caused by water vapour (present in the VAM stream) and via the formation of carbonaceous species, both of which block active sites. The current project investigates the use of regular air pulses for in situ regeneration and removal of these species for continued operation.

Recent experiments have shown that exposure of a partially deactivated catalyst to regenerative gas results in reactivation and extended catalyst life. It was determined that the removal of carbonaceous species occurs rapidly, with regeneration favouring shorter, more frequent pulses. A draft report highlighting the positive effects of in situ regeneration on a commercial oxidation catalyst has been presented to industry monitors, with some limited additional experiments to be completed. These are currently underway and expected to be included in the final report.