AUGUST 2023

CURRENT PROJECTS

This report is a summary of current projects for the months May, June and July 2023
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## UNDERGROUND

### Coal Burst

**C27020**  
Management of Coal Bursts and Pillar Burst in Deep Mines  

University of Adelaide  
Giang Nguyen  
Murat Karakus  

| Value: | $380,240  
| Report Expected: | August 2023  
| Industry Monitor/s: | Coal Burst Task Group  
| ACARP Contact: | Peter Bergin |

The draft final report has been submitted to the Industry Monitors for review.

**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: | August 2023  
| Industry Monitor/s: | Coal Burst Task Group  
| ACARP Contact: | Peter Bergin |

The draft final report has been submitted to the Industry Monitors for review.

**C28012**  
Microfracture Analysis as a Trigger for Coal Bursts  

SCT Operations  
Winton Gale  
Yvette Heritage  

| Value: | $498,000  
| Report Expected: | August 2024  
| Industry Monitor/s: | Coal Burst Task Group  
| ACARP Contact: | Peter Bergin |

The project aim 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 overall project objective is to define the zones around dykes and faults in which the coal is structurally modified and capable of generating sufficient gas related energy to initiate a coal burst. This will be achieved by:

- Digital CT scanning of coal block samples which have been selected at various distances from dykes and faults mapped in coal mines;
- Collation of results from project C28012 (characterising the volumetric porosity) with those from this micro fracture geometry study; and
- Assessment of the burst potential for the various geometries noted close and distant to dyke and fault structures.

Samples have been collected from the mine site and have been submitted for CT scanning. Initial samples have been scanned, and an approach for scanning of the bulk samples has been refined. This approach includes:

- Comparison of wet and dry CT images to provide easier identification of micro fractures; and
- Sub-core samples to 25mm diameter to obtain 14micron resolution.

Bulk scanning is underway. Initial results show a variety of fracture densities with less defined fracture sets to be analysed.

**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: | August 2023  
| Industry Monitor/s: | Coal Burst Task Group  
| ACARP Contact: | Peter Bergin |

The draft final report was submitted to the Industry Monitors for review and now being revised based on the feedback received. The final version of the revised report will be submitted in the first week of September 2023.

**C29010**  
In-situ Stress Measurements using Cored Coal/Rocks for Coal Burst Management  

University of Adelaide  
Giang Nguyen  
Murat Karakus  

| Value: | $228,600  
| Report Expected: | October 2023  
| Industry Monitor/s: | Coal Burst Task Group  
| ACARP Contact: | Peter Bergin |

It is challenging to measure in situ stress in areas at great depth when access is only available via exploration boreholes. It is also challenging to access the areas above longwall face where a high-stress concentration is expected. Knowing in situ stress magnitudes and their orientations are critical in managing coal burst. This project aims to develop a new method based on
deformation rate analysis and acoustic energy to calculate the magnitude and principal directions of in situ stresses from cored rocks.

The project work has been completed, a draft final report is being prepared for submission at the end of September.

C33014
Coal Burst Research Findings

SCT Operations
Winton Gale
Yvette Heritage

Value: $388,000
Report Expected: March 2024
Industry Monitor/s: Coal Burst Task Group
ACARP Contact: Peter Bergin

The project will examine and summarise the energy required to cause a coal burst in a range of seams. The energy may be derived from stored strain, seismic transmission and expansion of desorbed gas.

The objectives are to:
• Examine the threshold energy requirement to cause a coal burst for a number of coal seams cases based on a range of generic mined seams;
• Provide guidance as to the factors to be considered in a risk analysis; and
• Provide an estimate of the threshold values associated with dynamic bursts for a range of coal.

The project has been initiated and discussions and work has been undertaken to characterise the energy associated with those outlined above.

Modeling of both strain and gas induced bursts within a roadway has been assessed to determine the seismic signature of such an occurrence. The strain tensor of the seismic waveforms and energy of events has been determined. In general strain induced bursts are well reflected in the seismic transmission however gas related bursts are not well reflected.

Modeling and theoretical assessment of strain bursts has been undertaken. One of the key findings has been that the upper bound velocity of a strain burst associated with shear slip and overstressing can be defined. This allows burst severity and risk levels to be determined on the basis of stress conditions about the excavation.

The next stage has been to undertake simulations of bursts in a range of seam types. The main control for other seams is the rib resistance to a burst event. This is being assessed and known to be related to seam height, clay bands, structure and degree of rib fracture during development. This has been completed and indicates that rib strength is reduced by:
• An increase in rib height from 3m to 5m reduced rib strength;
• The occurrence of weak clay rich bands reduced the strength;
• The occurrence of two clay rich bands did not change the results markedly from that of only one band. However, it did significantly increase the velocity of ejection.

A full discussion of these results will be made at the next review meeting. One of the key outcomes is that most instances of seismic event recordings record a combination of modes of failure. This is due to the fact that one form of failure (say shear slip on bedding) allows additional failure in the surrounding area due to reduced confinement. In that way the overall strain tensor is one which reflects both events and associated displacement.

C34013
Listening for Bursts

Sigra
Ian Gray

Value: $60,000
Report Expected: September 2023
Industry Monitor/s: Coal Burst Task Group
ACARP Contact: Peter Bergin

This project’s purpose is primarily to examine the practicality of providing a means to enhance miner’s hearing so that the noise associated with dilation and pressurisation of coal prior to an outburst may be detected.

The draft final report has been submitted to the Industry Monitors for review.

C35014
Investigation of Pre-Installation of Optic Fibre Cable in Exploration Holes for Longwall Weighting and Coal Burst Monitoring

CSIRO
Baotang Shen
Joey Duan
Matt van de Werken

Value: $258,473
Report Expected: June 2025
Industry Monitor/s: Coal Burst Task Group
ACARP Contact: Peter Bergin

The goal of this project is to provide a new and more cost-effective approach for assessing the longwall caving progress and coal burst risk. It contains two objectives:
• To trial optic fibre cables pre-installed in geo-exploration holes for high accurate and cost efficiency longwall weighting and coal burst monitoring;
• To conduct a field demonstration using both distributed fibre optic sensors (DFOS) and geophones and investigate the optimal monitoring configuration,
data processing and interpretation methods for the DOFS system.

The main activities to date have been focused on finding and preparing for the field monitoring trial of the DFOS and geophone system in pre-drilled holes, which is a critical task of the project. With the help of key Industry Monitors, an underground mine in Bowen Basin (Mine A) has been identified as the site for the trial. The project staff have visited the mine and discussed with the mine engineers on the detailed arrangement of the monitoring. It is planned that the monitoring will utilise three pre-existing gas drainage holes across the current mining panel in the mine, and the period of monitoring will extend from the end of 2023 to early 2024 when this section of the longwall panel is mined. This task has now been brought forward by about six months compared with the original project plan to fit into the mining schedule of Mine A.

Detection and Prevention of Fires and Explosions

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

Mines Rescue
Alaster Wylie
Clive Hanrahan
Dave McLean
Matthew Fellowes

Value: $392,500
Report Expected: September 2023
Industry Monitor/s: Bharath Belle
David Webb
Owen Salisbury
Paul Wild
Peter Baker
Rae O’Brien
Sharif Burra
ACARP Contact: Patrick Tyrrell

The project aims to provide an additional spontaneous combustion control technique for use by industry and:

- To procure a full system ready for deployment in the Australian coal industry;
- To deploy the system in at least one underground longwall panel(s);
- To evaluate the cost and effectiveness of using CAFs to alter goaf ‘micro ventilation circuits’; and
- The system will be retained by NSW Mines Rescue and maintained similarly to the Mine Shield for use by the New South Wales and Queensland industry as a tool to assist manage accelerated oxidation of coal.

An initial first draft report was received by Mines Rescue 2nd May 2023, which has been forwarded to a second consultant for peer review. Subsequently, additional information has been received from the mine site which will allow further analysis by the abovementioned consultants and will assist in completion the final report.

Preliminary findings from the first draft report suggest that the Compressed Air Foam (CAF), when injected into the goaf acted as an effective ‘dam’, stopping the ingress of oxygen into the goaf and allowing the mines seam gas to fill the void and no air ingress was possible.

A draft final project report is currently being prepared by NSW Mines Rescue in consultation with subject matter experts and the test underground mine. Presuming the peer review substantially supports the initial findings and is completed by the end of September, a draft final project report is expected to be completed for review within the next quarter and submitted to the Industry Monitors.

C29013
Evaluating GAG Docking Connections/Simulations

University of New South Wales
Duncan Chalmers
Guangyao Si

Value: $82,100
Report Expected: August 2023
Industry Monitor/s: Bharath Belle
John Grieves
Ken Singer
ACARP Contact: Peter Bergin

The draft final report has been submitted to the Industry Monitors for review.

C29026
Investigation into the Thermal Ignition Caused by IS Power Supplies

Simtars
Andre De Kock
Gareth Kennedy

Value: $153,700
Report Expected: October 2023
Industry Monitor/s: Brad Lucke
ACARP Contact: Patrick Tyrrell

The objectives of the project are to:

- Determine the fault conditions arising in an intrinsically safe electrical circuit that could ignite combustible material on a mining machine;
- Determine the role and extent that combustible material accumulation can cause or contribute to the risk of equipment fires, when ignited by intrinsically safe power supplies; and to
- Determine the parameters to be considered in installing an intrinsically safe circuit in an area where they could be an accumulation of flammable materials.
The fifth and final power supply was delivered on 26 May 2023. A few days after delivery (11 July) Simtars was informed the certification of the power supply had been revoked and Simtars is now in the process of addressing this and its influence on the project. Greases and oils selected to be used in the project are listed below.

The next steps are to resolve the IS certification matter, and then finalise the test setup and methodology.

### Table 1: Greases identified for testing

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<tr>
<th>Grease</th>
<th>Quantity</th>
<th>Serial #</th>
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<tbody>
<tr>
<td>Shell gastrop S7 V200/G</td>
<td>4</td>
<td>300011648</td>
</tr>
<tr>
<td>Greases gastrop S3 Highspeed CPU/G; pal Oil Grease; premium gear COUPLING,</td>
<td>2</td>
<td>300011715</td>
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<tr>
<td>Grease,BRG,SAPPHIRE ULTRAPLEX,CART</td>
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<tr>
<td>Spheronol 61P 00</td>
<td>2</td>
<td>3184626</td>
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<tr>
<td>Grease DP SPHEREX F6P,BLUE,flum</td>
<td>2</td>
<td>3414752</td>
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<tr>
<td>BLACKWOODS</td>
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</tr>
</tbody>
</table>

### Table 2: Oils identified for testing

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</thead>
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<tr>
<td>tekafl S2 M666</td>
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<td>310276243</td>
</tr>
<tr>
<td>oil PLANTIO; FUCHSULUB</td>
<td>1</td>
<td>1796801</td>
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<tr>
<td>Shell R3 15W 40</td>
<td>3</td>
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<tr>
<td>Shell Sred Osram 52 G320 oil</td>
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<td>300011451</td>
</tr>
<tr>
<td>oil HOY MOBE FLUID 424</td>
<td>3</td>
<td>971665024L</td>
</tr>
<tr>
<td>oil HYD Cowles ANVOL PE410 XH hydraulic fluid FLUIDOSYN; ESTER-bis;регвистик ЭССЫmüSü,ANSWER MATERIAL-DC40065-0</td>
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<td>3087128</td>
</tr>
<tr>
<td>Remol CST 300</td>
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### Environment - Subsidence and Mine Water

#### C28004

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

**Queensland University of Technology**

Andrew Fletcher

**Value:** $230,964

**Report Expected:** October 2023

**Industry Monitor/s:**

Gary Brassington

Peter Corbett

**ACARP Contact:**

Patrick Tyrrell

Regulators are concerned about the loss of listed communities in complex shrub swamp systems due to modified hydrology. Existing technology can detect dramatic changes in vegetation health, however new methods are needed to detect subtle, long term spatial and temporal changes to moisture patterns. This project aims to identify remote sensible signals for plant stress in these communities. Researchers will use calibrated thermal imaging on board small unmanned aerial service platforms to assess canopy water use through the day.

The project will commence final fieldwork in September. Long range weather forecast is positive with warmer and drier conditions predicted.

#### 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:** $444,055

**Report Expected:** November 2023

**Industry Monitor/s:**

David Gregory

Gary Brassington

Peter Corbett

**ACARP Contact:**

Patrick Tyrrell

The overarching project objective 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.

Data analysis and writing for the final report is ongoing.

#### 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:** August 2023

**Industry Monitor/s:**

Gary Brassington

Julian Potten

Rae O’Brien

**ACARP Contact:**

Patrick Tyrrell

The draft final report has been submitted to the Industry Monitors for review.
C33015
Regional Ground Movement on Bedding Planes and Potential Impacts on Groundwater

SCT Operations
Ken Mills

Value: $150,000
Report Expected: September 2023
Industry Monitor/s: Gary Brassington, John Watson, Peter Corbett
ACARP Contact: Peter Bergin

Bedding plane shears are features that define and control the magnitude of horizontal movements within the overburden strata adjacent to extracted longwall panels. Measurements and observations of the how the features influence horizontal stress relief and hydraulic conductivity of the overburden strata above and to the sides of extracted longwall panels have been made over the last two decades. These measurements are distributed across multiple sites and haven’t been collated into a cohesive form. This project aims to draw together existing information from multiple sites.

The report has been prepared and will be submitted shortly.

C33021
Pilot Scale Membrane Distillation Crystalliser (MDC) with Renewable Heat Source for Mine Water Brine Management

CSIRO
Ramesh Thirunekatarchari

Value: $969,195
Report Expected: December 2025
Industry Monitor/s: Michael Holzapfel, Paul O’Grady, Tim Kendrick
ACARP Contact: Patrick Tyrrell

This project aims to undertake a mine site demonstration of the MDC system for treating saline and acid mine drainage mine impacted water under actual mine site conditions. The main objectives are to develop a modular MDC water treatment plant to mine site specifications, install at the mine site by integrating with onsite infrastructure and to demonstrate the mine impacted water treatment performance. Through this study optimum operating process parameters for AMD treatment will be obtained in maximising reusable water recovery with reduced volume of saturated concentrate. Project planning is being carried out along with some preparations in onsite infrastructure. MDC site test unit development will commence from next quarter.

C33028
Fire Resilience of Temperate Highland Peat Swamps on Sandstone

University of Queensland
Mandana Shaygan

Value: $279,450
Report Expected: October 2023
Industry Monitor/s: Gary Brassington, Peter Corbett
ACARP Contact: Patrick Tyrrell

This project aims to assess the resilience of endangered Temperate Highland Peat Swamps on Sandstone (THPSS) to fire (both wildfire and controlled fire), and to evaluate how resilience varies between mine-impacted swamps and non-impacted swamps.

For mine sites one and two, the characterisation of chemical (pH, EC, soluble salts, exchangeable cations, CEC, organic matter content, Ash content, total nitrogen, phosphorous, trace elements) and physical (hydraulic conductivity, water retention characteristics, water repellency, bulk density, and particle size distribution) properties of all soil samples collected from swamps (in three fieldtrips) during the project has been completed. The obtained data from laboratory analysis have been statistically analysed and necessary graphs have been produced using R Studio. Remote sensing data and images, NDVI maps as well as Soil Moisture Index (SMI) maps have been produced for study swamps in mine sites one and two. For mine site one, the NDVI data of swamps obtained from remote sensing work has been validated using the historical vegetation data of swamps. For mine sites one and two swamps, the validation of Soil Moisture Index (SMI) data was completed using measured soil moisture data of study swamps. The next stage of project is writing the final report and submission.

C35016
Rehabilitation Options for Ponded Areas Due to Longwall Coal Mining

University of Queensland
Louisa Rochford

Value: $397,200
Report Expected: May 2026
Industry Monitor/s: Jason Fittler, Ned Stephenson, Raymond Howard
ACARP Contact: Patrick Tyrrell

Little research has been undertaken into the most appropriate options for rehabilitating land subsided by longwall mining in Australia. This project will investigate the implications of retaining ponded areas from longwall mining, including their contribution to environmental values. Researchers will analyse the impacts on site topography and drainage, surface hydrology,
geomorphology, soil hydrology, water quality and geochemistry, fauna and flora.

This project very recently commenced.

Maintenance and Equipment

C25063
Photocatalytic Destruction of Diesel Particulate Matter
CSIRO
Yonggang Jin

Value: $527,192
Report Expected: August 2023
Industry Monitor/s: Brad Lucke, Dave Young
ACARP Contact: Patrick Tyrrell

This 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 draft final report has been submitted to the Industry Monitors for review.

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

Value: $1,268,500
Report Expected: August 2023
Industry Monitor/s: Brad Lucke, Dave Young, Paul Wyatt, Sharif Burra
ACARP Contact: Patrick Tyrrell

The draft final report has been submitted to the Industry Monitors for review.

C28010
Towards Better, Safer Mines - Optical Technologies for Software Defined Instrumentation

University of New South Wales
Francois Ladouceur
Lucy Chen

Value: $704,974
Report Expected: February 2024
Industry Monitor/s: Ben McCamley, Dave Young, Ernest Baafi
ACARP Contact: Peter Bergin

This stage of the project is the continuation of the prior stage where the participants have completed the design of an optically powered, intrinsically safe gas monitoring station (CH4, CO, CO2, O2). This certified system has been successfully deployed in situ and reliably collected data over a period of two months. The project seeks to:

- Fix identified technical issues with the current system and proceed with its testing;
- Develop an improved system design, focussing on design for manufacture; and
- Providing the resources needed for its deployment and testing.

Work undertaken in the quarter includes:

- Fabrication of intrinsically safe PCBs for gas monitoring stations (see Fig.1);
- The first prototype enclosure is machined, and all fitting parts are fabricated including battery holder, touchpad, display cover, LED light pipes, filters and O-rings (see Fig.2). This prototype is used to test the mechanical fitting and dust / water ingress;
- Progress has been made on Android APP and will be tested with the fabricated PCB.

Fig. 1. PCB for gas monitoring station (including Bluetooth module and embed alarm LEDs)

Fig. 2. Enclosure prototype (ABS) with battery holder, displays cover, touch pad and LED light pipes

Work planned for the next quarter:

- PCB firmware development and Android APP development;
• Ingress test (part of Intrinsic safety test) on the prototype enclosure;
• Fabrication of the final version of enclosures based on the test result of the prototype;
• System assembly and testing; and
• Final report on the project.

We foresee no important technical holdups but the final stage (fabrication and testing) may take longer than expected and field trial decision needs to be made. We are seeking advice from the Industry Monitors while endeavouring to produce quality deliverables efficiently.

C29009
Control of Touch Potential Transients During Switching

ResTech
Peter Stepien

Value: $114,000
Report Expected: September 2023
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 voltage transients when switchgear closed or opened. There were no faults present in the equipment of the earth fault limited supply, yet touch voltages occurred. The aim of this project is to understand the method by which these touch voltages occur and determine a method to eliminate them to improve mine safety. An ELV hardware equivalent model has been developed for convenient experimentation. Solutions to eliminate touch voltage will be demonstrated on typical mining equipment at normal system voltage as a find proof of concept.

Some continuing ELV hardware simulator experiments. Form factor for a solution has been developed to allow testing on typical mining equipment. The final report is being prepared.

C33009
Ceramic Wall Flow Filter Commercialisation

PPK Mining Equipment
Bradley Drury
Greg Briggs

Value: $888,778
Report Expected: December 2023
Industry Monitor/s: Andrew Esdaile, Bharath Belle, Steve Coffee, Trevor Hartley
ACARP Contact: Patrick Tyrrell

This project builds on work undertaken in projects C25073 and C26070. An industrialised filter was developed under C26070 and requires the following to be commercially available:
• Technical refinements to allow retro-fit to existing Diesel Engine Systems; and
• Testing against certification and regulatory requirements – emissions and Ex-protection.

The focus during the quarter has been on finalisation of supporting documentation. Explosion-protection and emissions testing are complete and MDG43 and AS/NZS 3584.2 test reports have been received. NSW Mining Design Registration alteration will be sought pending 3rd party verification. Site trials are scheduled following Design Registration.

C33017
Specialised Instrumentation and Data Processing for Real Time FEA Condition Monitoring of AFC Chain

Vayeron
Ryan Norris

Value: $185,000
Report Expected: September 2023
Industry Monitor/s: Brad Lucke, Jarrod Sampson
ACARP Contact: Patrick Tyrrell

Armoured face conveyor (AFC) chain failure causes serious production delays and associated costs for longwall operators, accounting for up to 27% of longwall failures. This project will develop a closed loop quasi real time prototype AFC chain link to model real time stress and strain monitoring.

Progress over the quarter is as follows:
• Firmware has now been finalised and tested;
• Ex Certification process recommenced with close-off occurring in August;
• 3rd Party Strain gauge consultant has been engaged for final fitments;
• Batch certification of units to occur in late August;
• Project industry handover expected in late August early September.
C33026
Prototype Battery Electric Load Haul Dump

3ME Technology
Justin Bain
Martin Kime
Lewis Grainger

Value: $1,431,295
Report Expected: July 2024
Industry Monitor/s: Brad Lucke
Dave Young
Paul Wyatt
Sharif Burra

ACARP Contact: Patrick Tyrrell

The objective of this project is to design, build, and certify a high-performance battery for use in an Electric Vehicle (EV) system that meets Australian Hazardous Area requirements. Achieve Hazardous Area certification of an Ex battery and then integrate into an underground rubber tyred vehicle to operate in a hazardous area of an underground coal mine.

Key activities conducted to date:
- Preliminary presentation delivered to Certifying body with feedback provided on future requirement to enable testing to be conducted;
- Design evolved including type of protection method/s and internal and external component selection;
- Further audits conducted against relevant Standards and submitted to Certifying body for review.

Key tasks to be conducted next quarter include:
- Submit final documentation, drawings and audits to Certifying body;
- Build, test and commission battery;
- Progress to Stage Gate 2 of the project.

C20033
Development of a Safer Underground Explosive

University of New South Wales
Andres Castro
Duncan Chalmers

Value: $468,000
Report Expected: March 2024
Industry Monitor/s: Bharath Belle
Brad Elvy
Paul Wild
Russell Thomas

ACARP Contact: Patrick Tyrrell

Three of the research team have returned to Dhanbad Test Facility in India to conduct a full suite of P5 tests under Australian supervision. Two new formulations of potential P5 explosives have been provided to Dhanbad and will be subjected to a full set of Series I tests. If it had passed Series I it would be subjected to Series II and then Series III. These three series are the Incendivity tests that are required.

Series IV - deflagration series: Ideally this series should be completed in sequence. However, it was mutually agreed to run the deflagration cannon in parallel with Series I. This allows the Australian team to speed up the testing time and reduces the time required for the Australian team to be in India.

Discussions have been held with the supplier to obtain these new formulations.

Further test work has been conducted in Gore, Queensland to commission the new type II cannon and a collection tube has been placed at the discharge of the cannon to try and trap some of the ejection. The initial tests have shown that some of the ejected material is deposited and subsequently collected for testing, however there was insufficient material recovered for any meaningful results. This line of inquiry will continue once the work in Dhanbad is completed.

C28018
Longwall Floor Horizon Sensing

CSIRO
Andrew Strange
Zak Jecny

Value: $269,680
Report Expected: October 2023
Industry Monitor/s: Jarod Chadwick

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 of the seam floor. 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 to enable a long-term trial of this sensor on a production longwall. This includes the development of a suitable non-metallic explosion protected enclosure.

The tests of the new bracket and skid base using a forklift were successful. Therefore the entire system was returned to the host mine site for reinstallation and pilot trial. A field trip to the host mine site was recently undertaken and the LW GPR system and bracket / skid base were installed and operated in a supervised manner for several push/advance cycles. This result was successful such that the skid base and bracket performed as expected and the LW GPR produced subsurface GPR data of the seam floor. Ground truth validation data was also obtained by drilling into the exposed seam floor of the path the GPR followed.
The LW GPR system was removed from service but the bracket and skid base were left in place to ascertain if the system can survive in that location. Once it has been demonstrated that the skid base and bracket do not sustain damage, the LW GPR will be reinstalled into the skid base and the production pilot trial will resume at which point more data will be acquired. Processing and analysis of the GPR data already collected has commenced.

C29033
Alternative Flameproof Enclosure Protection Techniques

CSIRO
Peter Reid

Value: $272,000
Report Expected: September 2023
Industry Monitor/s: Brad Lucke, Colin Hoyle
ACARP Contact: Patrick Tyrrell

The aim of this project is to design and manufacture a certified pressure sensing module which will be able to be certified as Ex ia/ib. This module will be designed to automatically and safely de-energise the payload quickly if the atmosphere inside the enclosure has been compromised. This module can then be incorporated inside a wide range of existing enclosures to help them to be certified as Ex P and achieve a higher protection level.

This project extension aims to achieve the following:
- Reduce the dependence on specific (now hard to procure) semiconductors;
- Combine the two separate pressure switches into a single board;
- Address all the other modifications that were required to allow the current design to meet the requirements of 60079.2 and 60079.11;
- Redesign with a focus on manufacturability and cost;
- Select a suitable manufacturer to manufacture these modules;
- Addition of a differential pressure sensing configuration.

During this quarter, we engaged in consultations with various potential industry partners to identify a suitable supplier/manufacturer for the proposed module. Unfortunately, none of the parties expressed interest in manufacturing the new protection module derived from this project. As a result, a decision was made for CSIRO to directly collaborate with local design and manufacturing experts to facilitate the production of the IS Ex.P pressure switch. Regrettably, this entire process caused an approximate three month delay to the project schedule. Despite this setback, we anticipate substantial progress in the upcoming quarter as we work closely with the chosen experts to advance the project.

C29037
Intrinsically Safe RFID Sensors for Underground Coal Mining

CSIRO
Lance Munday

Value: $136,050
Report Expected: September 2023
Industry Monitor/s: Brad Lucke, Flemming Nissen
ACARP Contact: Patrick Tyrrell

The project objectives are to:
- Develop a Radio Frequency Identification (RFID) platform that will enable the installation of a range of powerful sensors onto longwalls and other underground mining equipment with minimal effort and cost;
- Gain Ex.ia Group I certification for the RFID sensors;
- Trial the system in an underground coal mine and evaluate performance.

The goal of the project is to fulfil these objectives to deliver a pre-commercial system that can be rapidly brought to market by a commercial partner. Key benefits of the system are:
- Low installation cost and negligible maintenance cost, since the RFID sensors are cheap, wireless, and do not contain batteries;
- Increased safety and reduced cost for a range of mining processes including longwall control, roof bolting, personnel tracking, equipment localisation, machine condition monitoring and asset management;
- At-face measurement of machine and environmental parameters, even where there is a continuous presence of an explosive gas mixture.

Activities during the quarter:
- Testing of the dual-antenna tag design continued. This antenna topology proved to be more efficient at energy harvesting and data communication in the 915MHz band. It exhibited about twice the performance of the single-antenna design in terms of tag read-distance versus tag read time. Tag read time was defined as the time taken for the tag to sample its sensor data, write the data to its memory, then send the data to the reader via the RFID link.
- At tag-to-reader distances of less than 0.5m, the read time was acceptable (2-4 seconds). At 1m, the read time was approximately 8 seconds. At the maximum reliable read distance of 2.5m, read time was 70 seconds. This performance was deemed insufficient for the intended application, as the reader would typically be moving, and would need to interrogate multiple tags in 2-4 seconds at distances of several metres.
- A review meeting was held in July. It was agreed that the limitations of the 915MHz passive RFID technology had been reached, and that the technology was not sufficient for project purposes. It
was agreed to halt any further R&D on the project, and that CSIRO would write the final report and submit it to ACARP in Q3.

To improve performance, it was decided to change to a two-antenna topology, with one 915 MHz antenna used for data and the other for energy harvesting. Several RFID energy-harvesting evaluation kits were purchased; these integrate the rectifier circuit, energy storage and power management into a single module. These kits are currently being tested to determine the best candidate to integrate into the system.

C34003
Self-Drilling Bolt Automation: Bolt Design and Manufacture Method, and Chemical Canister Concept Development

OKA Rock Bolt Technologies
Mark Levey

| Value:                           | $1,857,744          |
| Report Expected:                | August 2023         |
| Industry Monitor/s:             | Roadway Development |
| ACARP Contact:                  | Patrick Tyrrell     |

The project objectives are as follow:
- Complete development of the Chemicals, Capsule and Self Drill Bolt;
- Complete the development of the Adaptor/modified drill-head, headplate and software such that an underground trial can take place; and
- Carry out an underground trial.

Progress during the quarter is noted as follows.

The Chemicals:
- Have locked in the chemical formulae for use in the canister;
- The capsule, after treatment retains the styrene content within the resins.

The Adaptor:
- The water sequence valve has been manufactured and tested okay;
- The adaptor IFC drawings are awaiting final dimensioning of the capsule which can’t be completed until the capsule is functioning correctly in the injection plastics.

The Canister:
- The capsule body and nozzle molds were completed five weeks later than expected in May. Sample capsules have been received, tested and modifications made twice so far to the dyes. The turnaround time is 3.5 weeks, and the third set of capsule test samples arrived at the end of July.
- The other four components in the capsule are being manufactured in Australia. The dyes have been designed and 90% manufactured, awaiting dimensioning once final samples of the body and nozzle lid are available.

The Bolt:
- 250 hollow bars are complete ready for trialling.
- We have prepared 125 x 6’ and 125 x 7’ bolts for the workshop and underground outbye trial.
- Six sample bars were sent to Bureau Veritas for testing. They have met the standards required for the host mine for the second trial.

Headplate:
- The headplate design and manufacture (for use in the New South Wales mine outbye trial) is complete and stored at our workshop.

Next steps are:
- Continue trialling plastic variations until the hoop strength (capsule wall flexing) is adequate and the capsule body is performing as required. Turn-around times for samples to be manufactured is 3.5 weeks.
- Complete the manufacture of the four internal component dyes and make samples of the parts. Then carry out the iterative process of dimensioning all components in hdpe such that the capsule performs satisfactorily in the test receptacle.
- In parallel with the above, manufacturing the adaptor (3d printed in metal) and test it.
- The drilling test rig is set up in the workshop so that all elements and components of the system can be tested prior to trialling underground.
- Studies on the final plastic type and magnets used in the system can be carried out when we are at this stage.

C34015
Assistive Shuttle Car: Development of an Industry Ready Guidance System: Stage 3

CSIRO
Andrew Strange
Mark Dunn

| Value:                           | $205,395           |
| Report Expected:                | November 2023      |
| Industry Monitor/s:             | Roadway Development |
| ACARP Contact:                  | Patrick Tyrrell    |

Most development operations in Australia utilise manual line-of-sight radio-controlled miners to cut roadways, and operator driven shuttle cars to transfer coal from the working face. These levels of technology are not able to achieve the Roadway Development Task Group (RDTG) goal of safe remote operation of roadway development. Two issues have been identified that inhibit progress in the domain of remote development:
- Continuous miner self-steering technology to maintain desired roadway headings has not yet reached the required level of performance required for sustained remote operation;
• No automated options currently exist to guide shuttle cars while tramming through roadway systems and whilst avoiding ribs, cut-through corners and other infrastructure.

The sensor pack initially developed in this project for the shuttle car assistive guidance system consisted of two ExScan sensors where one was to be mounted on the front and the other on the rear of the shuttle car. This approach was pursued because these units are already certified for production use in the target environment and have previously been demonstrated in a related application. However, upon physical inspection of a shuttle car at the host mine site and in consultation with the industry contact, the task of identifying an appropriate mounting location where the sensor is expected to survive appears more challenging than originally expected.

The team is now revisiting the sensor and subsequent explosion protection methods available. This is a complex three-fold problem which involves identifying a:
• Suitable mounting location where an enclosure survives whilst providing the required field of view;
• Suitable enclosure that can fit in the chosen mounting location; and
• Suitable LIDAR sensor that provides an adequate level of performance that fits inside the identified enclosure without drawing power level that exceeds the rating of the enclosure and power available on the shuttle car.

C34017
Self Cleaning ExScan and Underground Reflectors

CSIRO
Matt van de Werken

Value: $141,995
Report Expected: August 2023
Industry Monitor/s: Brad Lucke, Brian Wesley, Mick Condie

ACARP Contact: Patrick Tyrrell

The aim of this project is to investigate coatings and other methods to improve the dust mitigation on reflectors, particularly signage and ExScan laser reflectors, as well as the ExScan itself, in underground coal mines.

The draft final report has been submitted to the Industry Monitors for review.

C34019
Longwall Bretby Cable Handling Monitoring with Fibre Optics

CSIRO
Karsten Hoehn

Value: $237,940
Report Expected: September 2023
Industry Monitor/s: Brad Lucke, Nick Belton, Shane McDowall

ACARP Contact: Patrick Tyrrell

The objective of the research is to explore the possibilities of utilising fibre optic sensing technologies to improve monitoring and maintenance of subsystems for underground longwall mines, specifically, the shape and condition of the Bretby Cable Handler.

Secondary objectives are to use the same fibre optic cable as a sensor and record audio signals that allow modelling the operation from an acoustic or vibration point and then detecting anomalies. Using this technology this project aims to:
• Demonstrate the feasibility of monitoring the condition of the Bretby Cable handling system, through distributed fibre optic sensing, to detect failures, such as Bretby dislocations;
• Determine how early the detection can be made to provide an operator with sufficient time to intervene;
• Evaluate the feasibility of listening to the shearer and to detect operational anomalies, e.g. cutting into rock rather than coal;
• Introducing a novel measurement technology that improves the automation and safety of underground coal mining operations; and to
• Provide recommendations on a potential commercialisation strategy for the Bretby Cable Handling Monitoring system.

The Bretby test rig assembly at Mining3 was utilised to complete five sets of experiments consisting of varying parameters including, static strain loading, dynamic strain loading, lodgements, dislocations and type of interrogator. The processing algorithm has been optimised to adapt to the model created for the helically wound optic fibre cable embedded inside the provided HV cable.

The results are beginning to highlight the capabilities of the interrogator and processing algorithm.
The current results show that the interrogator has the potential to measure the induced strains from the Bretby cable. The characterisation of the specific signals from lodgements however are to be further developed using more representative simulations at larger lengths in the laboratory experiments (using the test rig assembly or otherwise). A meeting is to be scheduled with the Industry Monitors to review updates from the experiment results and to determine the next phase.

**C34024**
Effects of Rock Weathering on Life-of-mine Roadway Stability

University of Queensland
Zhongwei Chen

- **Value:** $312,534
- **Report Expected:** September 2024
- **Industry Monitor/s:** Brian Vorster, Matt Tsang
- **ACARP Contact:** Patrick Tyrrell

The main objectives are to:
- Identify the relevant weathering testing standards for assessing the process of rock degradation;
- Experimentally characterise and quantify the responses of rock properties to the weathering; and to
- Apply the laboratory results to assess the weathering impact on CMRR de-rating and its implications to support design practices.

The team is sourcing the suitable drill cores, and the lab testing will commence once the cores are available.

**C35004**
Advancing Remote and Automated Capability for Longwall and Roadway Development

CSIRO
Andrew Strange
Jonathon Ralston

- **Value:** $2,517,000
- **Report Expected:** May 2025
- **Industry Monitor/s:** Roadway Development Task Group
- **ACARP Contact:** Patrick Tyrrell

This project responds to the industry need to accelerate remote and automated longwall and roadway development capability. This is of major importance to the underground coal industry to meet ongoing safety, productivity, operational and sustainability issues.

The project utilises the flexible industry-directed project model to deliver research impacts to industry. This model involves project delivery being conducted through well-scoped work packages which provides the stakeholders the opportunity to select work package topics and direct and monitor progress throughout the project.

The first work package, entitled “Offline Drivage Monitoring”, progressed over the past quarter. The purpose of WP1 was to advance the Miner Position Measurement System (MPMS) so that it can reliably estimate the position of a continuous miner to enable the measurement of offline drivage in real-time. The offline drivage system was developed and performance evaluated using the CSIRO test track facility with satisfactory results. Whilst the original end goal was to trial the offline drivage system on both a Sandvik and Komatsu miner bolter over a complete sequence (approximately 100m retreat), no Sandvik miners were available with the necessary hardware during this time. Therefore, the efficacy of this offline drivage system was evaluated for a Sandvik miner using pre-existing data.

The system was trialled in production on a Komatsu miner, however, a bug in the miner firmware prevented the stationary interlock from functioning correctly. This issue degraded the system performance for this case. Technical development of this activity through WP1 has been finished and a mini-report is being prepared. However, it is anticipated that offline drivage will resume in future when a Sandvik miner becomes available for testing and the stationary interlock issue on the Komatsu miner has been resolved.

The industry working group also met to discuss ideas for WP2. The topic of “Longwall Gate End Face Alignment” was selected and has since been supported by the project monitors. WP2 has now commenced.
**C35009**  
**Longwall Remote Operations – Face Mapping Robot – Phase 1**  
**Quantum Engineering and Consulting Group**  
Luke Dyer  

Value: $170,000  
Report Expected: November 2023  
Industry Monitor/s: Mick Condie  
ACARP Contact: Patrick Tyrrell

This project aims to create a significant improvement to remote operations in underground mining by designing and executing a mobile face scanning system (the “Face Mapping Robot”). The robot would contain inertial navigation hardware, forward (coal face), rear-facing (goaf), and traverse (walkway) cameras and laser scanners. The robot would be mounted onto the rear of the AFC pans and be able to move up and down the face independently of the shearer.

The primary objectives of the robot are to:  
- Enable face-wide visual images of the coal face and roof supports;  
- Enable face-wide 3D laser scans of the coal face and roof supports; and to  
- Enable a fast remap of the position of the AFC panline at any time, particularly at a point in time after the AFC push has occurred.

Phase 1 aims to design, build, and perform on-face tests with a manually propelled prototype robot to determine if the data captured is suitable for the various automation systems currently in use.

Discussions and work undertaken includes:  
- An project review meeting has been held to discuss project objectives and any additional requirements or limitations from a variety of sites to consider in robot design concepts;  
- Information, imagery, and specs have been provided by trial mine site 1 and assessed for prototype design and function considerations based on mine site 1 infrastructure;  
- Design concept 1 has been drafted, requirements determined and is now progresses to the development of prototype 1;  
- Prototype 1 has been scheduled for fabrication/assembly, then will be tested in a workshop environment prior to being tested on mine site 1.

**Health and Safety**

**C24010**  
**Proximity Detection Systems Specification for Underground Coal Mining Machines**  
**Simtars**  
Andre De Kock

Value: $565,988  
Report Expected: October 2023  
Industry Monitor/s: Brad Lucke  
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 to  
- Determine if future developments by the proximity detection manufacturers will address the specification from the coal mining industry.

To date we have interviewed 13 people. We still need to complete another seven interviews, to reach the 20 people as planned. We are in contact with the mining companies to schedule additional interviews. The 13 people interviewed included two Inspectors from Queensland. We have reached out to the New South Wales Inspectors to provide people to interview.

The following steps need to be completed:  
- Complete and process industry interviews;  
- Obtain input from the New South Wales Mines Inspectorate;  
- Complete the transcription of the interviews and prepare the data to be used in the processing software;  
- Develop a proximity detection specification, based on the analysis of the data; and  
- Interview proximity detection suppliers to gauge their ability to fulfil the specifications.

**C27049**  
**Mine Rescue Vehicle Radar Sensing Integration**  
**CSIRO**  
Eleonora Widzyk-Capehart  
Gareth Kennedy  
Lance Munday

Value: $254,405  
Report Expected: September 2023  
Industry Monitor/s: Brad Lucke  
ACARP Contact: Patrick Tyrrell

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

The goal of the project is to fulfil these objectives in order to deliver a pre-commercial prototype system that can be rapidly brought to market by a commercial partner. Key benefits of the system are:
• Improved health and safety, whereby persons in any part of a mine, who are subject to disorientation or severely impaired visibility, are able to find their way out of the mine;
• Enhanced productivity for mining machinery, where operation is impaired due to dust, smoke or water vapour.

The draft report is being prepared and internally reviewed before submission next quarter.

C28023
Developing Suitable Gas Separation Membrane for Breathing Apparatus

Monash University
Victor Chang

Value: $196,500
Report Expected: August 2023
Industry Monitor/s: Bharath Belle, Ken Singer, Lee Earnshaw, Paul Wild
ACARP Contact: Patrick Tyrrell

The draft final report has been submitted to the Industry Monitors for review.

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

Lear Siegler Australasia
Peter Phaedonos

Value: $152,1730
Report Expected: June 2024
Industry Monitor/s: Bharath Belle, Brad Lucke, Glenn Owens, Ian Marshall
ACARP Contact: Patrick Tyrrell

The PDM Real time dust monitor is a safety tool and a safety companion to the miner. At any point in the miner’s working shift the PDM will display the 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, the PDM will provide the miner with the means to monitor and manage such exposure. 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.

The project status is as follows:
• Vast progress has been achieved these past three months with all the required redesign of the various PCBs completed and submitted to Simtars for evaluation, to allow us to move to the prototype stage;
• Most of the components for the manufacture of the PCBAs have been purchased and on hand;
• The WiFi module is being evaluated for IECEx verification;
• The prototypes for the Certification process need to be as the final manufactured and ready for field use PDM instrument, LSA is working towards finalising the mould supplier/manufacturer; and
• It is anticipated that over the next three months we’ll see a clearer end point of the project and final certification of the PDM.

C29002
ACARP Dust Program Technical Support Coordination

Gillies Wu Mining Technology
Hsin Wei Wu

Value: $100,000
Report Expected: December 2023
Industry Monitor/s: Andrew Lau, Bharath Belle, Brad Lucke, Kevin Rowe, Sharif Burra, Tony Egan
ACARP Contact: Patrick Tyrrell

The purpose of the project is to provide a coordination of technical inputs and supports to dust, silica and DPM related ACARP projects that are monitored by the Dust Steering Working Group (DSWG). It would offer a point of reference for the research project monitors and the DSWG. Assistance would be provided to seek out potential researchers in the relevant fields and help them build research submissions.

Tasks as advised and assigned by the DSWG include:
• Review the past and current work undertaken, highlight the gaps in knowledge and guide the current work programs as needed;
• Develop discrete packages of research work to be undertaken by targeted researchers;
• Visit researchers to ensure the technical side of the program is running well;
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Underground Projects

- Organising periodical task group meetings for review of current projects;
- Organising visits for DSWG members to researchers’ facilities to view progress; and
- Following up researchers for their guidance as required by project monitors or DSWG.

C33001
Methodology Development of Free Silica Analysis of Dust on PDM Filters: Phases 1A&B

CSIRO
Hsin Wei Wu
Yonggang Jin

Value: $249,200
Report Expected: September 2023
Industry Monitor/s: Andrew Lau
Bharath Belle
Brad Lucke
Kevin Rowe
Sharif Burra
Tony Egan

ACARP Contact: Patrick Tyrrell

The latest personal dust monitor (PDM) is a real-time mass-based respirable dust monitor in the coal mines. The objective of the project is to develop a methodology to enable silica analysis of the PDM-collected respirable coal dust.

In the quarter, work focused on data analysis of silica measurement results and drafting the final report which will be submitted to the Industry Monitors shortly.

C33006
Breathing Zone Exposure Quantification and Respirators Performance – Review of Exposure Control Strategies

CSIRO
Rao Balusu

Value: $329,450
Report Expected: November 2023
Industry Monitor/s: Andrew Lau
Bharath Belle
Brad Lucke
Kevin Rowe
Sharif Burra
Tony Egan

ACARP Contact: Patrick Tyrrell

The project work will involve extensive laboratory investigations and some field studies. The project studies will provide a better understanding of the effectiveness of respirators and integrated unit performance of full-face PAPRs in protecting workers working under high dust concentration zones as well as the actual personal dust exposure levels of workers wearing full face PAPRs.

In the quarter, work focused on tests and evaluation of the performance of P2 masks. Two types of P2 masks with and without an exhaling valve were tested by fitting the mask on the mannequin inside the dust chamber. A vacuum line was installed throughout the mannequin head to pump the dusty air through the mask at controlled air flowrates. Two PDM3700 units were used to monitor the dust concentrations in real-time of both the dusty air outside the mask around the mannequin’s nose area and the filtered air through the mask. The mask protection factor was determined by comparing both inside and outside dust concentrations. The pressure levels at the P2 mask were also continuously measured to obtain variations of the pressure drop during testing. The effect of the air leak during mask wearing was also tested by creating different levels of controlled gaps between the mask seal and the mannequin’s face profile. A range of tests were carried out to evaluate the performance of two types of P2 masks under various dust concentration conditions inside the dust chamber and under different air leak conditions.

C33011
Coal Mine Dust Lung Disease: What Happens Once the Dust Settles? A Longitudinal Study of a Latent Disease

I-MED Queensland
Katrina Kildey

Value: $167,925
Report Expected: August 2023
Industry Monitor/s: Bharath Belle
Brad Lucke
Sharif Burra

ACARP Contact: Patrick Tyrrell

The draft final report has been submitted to the Industry Monitors for review.
C33012
Respirable Dust Reference Testing Method and Dust Chamber Facility

Simtars
Gareth Kennedy

Value: $215,950
Report Expected: July 2024
Industry Monitor/s: Andrew Lau, Bharath Belle, Brad Lucke, Kevin Rowe, Sharif Burra, Tony Egan

ACARP Contact: Patrick Tyrrell

The aim of this project is to establish the methodology for the respirable dust chamber as a reference tool for cyclones and devices used in the coal mining industry. This will be achieved through three objectives:

• Establish that the respirable dust chamber conforms to international testing methodology and accuracy;
• Verify the methodology utilising a selection of respirable dust cyclones and impactor plate devices currently used in underground coal mines.; and
• Compare the accuracy of the devices when using a different dust types and dust mixtures (stone dust, coal dust, silica).

The final commissioning including installation of the control system for the chamber is still progressing with expected completion date of October. The reference test dust (Arizona dust) has been confirmed and purchased. The next steps are:

• Complete the commissioning;
• Finalise the comparison testing with NIOSH;
• Purchase the cyclone dust samplers;
• Obtain coal samples from an Australian mine site for testing, including sample preparation.

C33069
New PDM filter for Direct-on-Filter Silica Analysis of Coal Mine Dust

CSIRO
Yonggang Jin

Value: $298240
Report Expected: October 2023
Industry Monitor/s: Andrew Lau, Bharath Belle, Brad Lucke, Kevin Rowe, Sharif Burra, Tony Egan

ACARP Contact: Patrick Tyrrell

The main objective of this project is to develop a new type of Personal Dust Monitor (PDM) filter with a non-silica filter material and a novel filter assembly structure to enable the direct-on-filter silica analysis of the PDM collected dust sample with a field-based FTIR method. The project work will involve extensive laboratory studies for development, evaluation and prototyping of the new PDM filter. Expected outcomes from this project include a novel type of filter for use in PDM to achieve both real-time respirable dust monitoring throughout the sampling shift and silica content measurement at the end of the sampling shift, and a rapid reliable field-based approach to be developed for optimal monitoring of personal exposure levels of respirable coal dust and respirable crystalline silica with one single PDM unit.

In the quarter, important progress has been made for the fabrication of prototype filter holders with a good mechanical strength and very small mass around 100 mg. It enables the newly developed filter to meet the filter mass limit required by the PDM3700. The prototype filter holder was fitted with the new filter membrane and the obtained new filter assembly was mounted onto a PDM3700 for dust sampling tests. Parallel dust sampling tests at the laboratory were carried out using the commercial glass fibre filter and our newly developed filters. The results showed that the real-time sampling concentrations with both filters were close. The project is currently progressing well, and the results are quite promising. Further optimisation of filter holder fabrication and more detailed parallel dust sampling tests will be carried out to finalise the prototype in the next quarter.

C34006
Resilience and Mental Health in Mining Pilot Program

Macquarie University
Rebecca Mitchell

Value: $476,099
Report Expected: March 2025
Industry Monitor/s: Rae O'Brien, Sharif Burra

ACARP Contact: Patrick Tyrrell

The primary objective of this project is to investigate the work-related factors that influence the resilience of coal mining employees. Using the results from a two-phase data collection process, we are currently designing interventions to bolster the resilience of these employees. Our goal is to improve work practices and experiences that directly contribute to employee resilience and mental well-being in the Australian Coal Mining sector, while also identifying and addressing any practices that might negatively impact resilience and mental health.

Over the last quarter, we made significant progress in several areas. We completed a thematic analysis of the survey and interview data, providing insight into the specific activities that affect resilience both positively and negatively. This step has been bolstered through the application of an intervention design framework, the British Design Council’s Double Diamond, which will be
instrumental for our upcoming design of pilot resilience interventions. Utilising the data from the surveys and interviews, we have developed distinct personas that represent the varying elements that challenge worker resilience in the workplace. Additionally, our team has conducted a thorough literature review, identifying current resilience-strengthening activities both in relevant industries and the academic literature. Based on these findings, we have initiated the development of resilience-strengthening activities specifically targeted for the coal mining sector.

Focus will now shift to the development phase of the Double Diamond intervention framework. This entails engaging with stakeholders to facilitate discussions and workshops, where we will collectively refine and plan the most effective implementation of the resilience-strengthening pilot interventions.

C34007
Evaluating Toxicity of Different Types of Respirable Crystalline Silica Particles to Lung Cells and Tissues

University of Queensland
Gordon Xu

Value: $207,950
Report Expected: October 2023
Industry Monitor/s: Andrew Lau, Bharath Belle, Brad Lucke, Kevin Rowe, Sharif Burra, Tony Egan
ACARP Contact: Patrick Tyrrell

The project aim is to evaluate the toxicity and potential hazards of respirable crystalline silica (RCS) particles to lung cells and tissues. By developing three typical RCS particles (freshly generated, hydrated and aged) that the coal mine workers are typically exposed to, we investigate their biological impact on lung cells and tissues in vitro and examine their toxicity and potential hazards to lung tissues in a mouse model. The project outcomes will provide a comprehensive understanding of the varying levels of toxicity and risk posed by different RCS particle types to mine workers and help inform and direct health and safety strategies to reduce exposure to the most dangerous RCS particle types.

In this quarter, our focus was on examining freshly generated, hydrated, and aged RCS particles where freshly generated RCS were made via a ball mill with the particle size from a few to several hundreds of micrometres when suspended in water. We compared their impacts on lung cells, intestinal cells, and macrophages to these RCS particles and iron-containing RCS particles (Fe-RCS). Our data revealed that freshly generated Fe-RCS particles showed some cytotoxicity across all three cell lines in comparison with non-Fe-containing RCS particles. Similarly, hydrated and aged Fe-RCS particles were also more cytotoxic than the corresponding RCS particles. To further investigate the mechanism, we will examine the surface reactive oxygen species (ROS) present on these samples (three types), with the aim of uncovering their roles in various conditions.

C34023
Advanced Breathing Apparatus with Gas Membrane Modules

Monash University
Victor Chang

Value: $298,436
Report Expected: January 2025
Industry Monitor/s: Bharath Belle, Ken Singer, Lee Earnshaw, Paul Wild
ACARP Contact: Peter Bergin

The main objective of the project is to develop a prototype for breathing apparatus which will replace the CO2 adsorption module with a light weight gas separation module.

The new hollow fiber spinning machine for the membrane prototype development arrived with commissioning done in June and the first batch of CO2/O2 membrane is targeted by the end of August. This addition will greatly assist the development of gas separation module and also help to establish the local capability in in-depth knowhow. In addition, the team has started in designing the membrane housing module to be integrated into the Drager’s BG4.

C35017
Is Exposure to Illite Dust Linked to Pneumoconiosis?

University of Tasmania
Basil Beamish, Graeme Zosky

Value: $302,428
Report Expected: October 2024
Industry Monitor/s: Andrew Lau, Bharath Belle, Brad Lucke, Frank Fulham, Kevin Rowe, Shane Apps, Sharif Burra, Tony Egan
ACARP Contact: Patrick Tyrrell

Previous ACARP projects conducted by our group have identified illite in coal dusts as a potential driver of lung cell toxicity, which may be related to the risk of developing Coal Workers’ Pneumoconiosis (CWP). The overarching aim of this project is to explore this
relationship in more detail. The two key objectives for this project are to:
• Conduct an extensive, systematic review of the literature as it pertains to potassium alumino-silicates and pneumoconiosis; and to
• Determine whether the illite content of coal is directly correlated with the detrimental lung cell response.

For the past few months we have been focussing on Aim 1 of the project and have made considerable progress. Using a well-established protocol for conducting systematic reviews, we identified 4625 articles that were potentially relevant to the research question. Using two independent reviewers, we triaged the initial article list by initially assessing relevance based on the title and abstract of the manuscripts which eliminated 3765 of these articles. The remaining articles were read in full for relevance generating a final list of 133 articles for inclusion in the systematic review. We are currently in the process of collating data from these articles in preparation for drafting a manuscript. We have also developed a database of fresh coal samples from around NSW and Qld has been developed based on ash analysis results that covers an appropriate spectrum of potassium-alumino silicates. A selection of these samples will be identified for the laboratory studies to be conducted in the project.

Roadway Development

C27076
Underground Coal Mine Gateroad Development Continuous Haulage System

Premron
Mick Whelan

Value: $8,344,838
Report Expected: March 2024
Industry Monitor/s: Roadway Development Task Group
ACARP Contact: Patrick Tyrrell

This project aims to develop a Continuous Haulage System for mine gateroad development, utilising the closed conveyor system of the “Premron CHS”.

The project encompass the following key objectives:
• Perform modifications to the Premron CHS to allow a more compact machine operating window, allowing additional components to be fitted to the machine (Ventilation) – completed;
• Provide a customised fully onboard Services and Ventilation System within the Premron CHS – completed;
• Perform modifications to the Sizer Feeder machine, to reduce width and height allowing clearance for LHD and other equipment – completed;
• Perform a mini build to test functionality of the modifications provided and a full systemisation of the entire Roadway Development – partially completed;
• Installation and trial in a fully operational underground panel.

Post the Factory Acceptance Testing (FAT) at Premron’s facility, we required additional modifications to be performed, namely due to Monorail tolerances that had been increased. These included:
• Head and Tail Trolley modifications – to allow increase in Mine Monorail Tolerance;
• SDT Traction System (x9) mods - to allow increase in Mine Monorail Tolerance;
• New Monorail Wheel Assembly (x950) - to allow increase in Monorail Tolerance;
• Additional Code D Overhaul on ExD Brake Packs (x6);
• Additional Hydraulic Modifications on Sizer Feeder Machine;
• Recommission Sizer Feeder Machine.

The above works has all been completed and the Sizer Feeder machine will be re-commissioned early August, before finally sending to host mine site.

Premron have completed all O&M Manuals, Safety Dossier and Training Manuals, which are now all submitted to host mine.

We are awaiting some changes to the host mine plan and options for the mini-build site. It is expected to trial on the surface at the host mine site later this year and commence underground trials in 2024.

C33013
Light Weight Composite Conveyor Support Structures

University of New South Wales
Ganga Prusty
Serkan Saydam

Value: $280,440
Report Expected: August 2023
Industry Monitor/s: Roadway Development Task Group
ACARP Contact: Patrick Tyrrell

The draft final report has been submitted to the Industry Monitors for review.
C33020
Floor Horizon Control for Roadway Development
CSIRO
Andrew Strange

Value: $80,000
Report Expected: January 2024
Industry Monitor/s: Roadway Development Task Group
ACARP Contact: Patrick Tyrrell

The overarching objective of this project is to develop a floor horizon control sensor suitable for installation on a production miner-bolter. The key outcome of this project is to install an enclosure that is capable of housing a floor horizon sensor (ground penetrating radar) on a production miner-bolter to ascertain how well a new non-metallic enclosure, along with the corresponding mounting bracket, can survive the roadway environment. The enclosure will not require certification because it will not contain a sensing payload.

The enclosure and bracket assembly were sent to the host mine site and installed on a Sandvik MB650 miner on the surface. Standard operating manoeuvres were executed on the surface such as sump in and out, when the apron was both up and in contact with the floor. The enclosure and bracket handled that mock operating scenario satisfactorily.

After the initial tests were successfully completed, the cutter head, apron and stab jacks were lowered to the ground to raise the body of the miner to enable adjustment of the tracks. This action resulted in the miner canopy foot lifting up and colliding with enclosure flange. This in turn sheared the U spring from the bracket and the enclosure became detached from the miner. Post-analysis of this event revealed that the U spring was partially squashed and most likely became elastically deformed during the previous manoeuvres which forced the enclosure backwards into the path of the canopy foot. Whilst this procedure was not previously considered, the enclosure and bracket must be able to handle this activity. This bracket configuration was deemed incompatible for the production environment. During discussions after the trial between the research team and mine site personnel, an alternative location and mounting method has been identified for a future design.

This trial was the final technical activity for this project.

Strata Control and Windblast

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: September 2023
Industry Monitor/s: Lesley Munsamy Patrycja Sheffield Peter Corbett
ACARP Contact: Peter Bergin

The main objectives of the project are to develop:
- Prevention techniques, e.g., anti-microbial coating, as a long-lasting controlling technique to mitigate against SCC in underground coal mines;
- Guidelines for preventing SCC, which is consistent across the industry.

In this quarter, the following tasks have been carried out:
- Completed design of guidelines for characterising the corrosion failure of the bolt and prevention method as a poster;
- Full-scale in-situ rock and cable bolt coupons have been installed to validate the developed coating;
- Finalising the final report.

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: September 2023
Industry Monitor/s: Brian Vorster Patrycja Sheffield Peter Corbett
ACARP Contact: Peter Bergin

The project objective is to investigate the cable bolt pre-tensioning practice as followed by Australian coal industry through large-scale testing. The selected level of pre-tensioning and the technical reasons associated with such a selection are to be further studied.

Numerical study and report writing are both ongoing and expected to finish within next quarter. Numerical work completed up to now entails axial performance of the cable bolt system (relative joint separation), and model development for the shear case (relative joint shear sliding). Report writing completed to date entails details on the conducted experiments and results, key details from the collected mining sites data regarding pretension practice, and details on the numerical study regarding the relative joint separation case.
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: September 2023
Industry Monitor/s: Peter Corbett, Russell Thomas
ACARP Contact: Peter Bergin

This project aims to define and quantify the long-term stability of coal pillar systems.

The work undertaken this quarter includes:
- Mathematical models for assessing the long-term stability of coal pillars have been developed for pillar and roof spalling modes;
- A detailed study has been completed into the stability of pillar foundations (i.e., floor);
- A model for a height of failure was developed based on underground measurements; and
- The final models are currently being combined.

The final report is currently being compiled.

C29019
Mechanical Assessment of Time Dependent (Creep) Behaviour of Coal and Coal Measure Rocks Under Uniaxial and Triaxial Conditions Based on Experimental and Analytical Methodologies

Monash University
Amin Heidarpour

Value: $205,000
Report Expected: March 2024
Industry Monitor/s: Brian Vorster, Elliot Tembo
ACARP Contact: Peter Bergin

The objective of this project is to investigate the time-dependent behaviour of coal and coal measure rocks by conducting experiments under various timeframes ranging from a month to a year or more. Researchers will use creep loading frames in temperature and humidity-controlled conditions which replicate the underground mining environment.

The team has made significant advancements in the setup and operation of creep rigs equipped with precise extensometers. All ten creep rigs are now operational, enabling both conventional and multistage creep experiments at various stress levels. Uniaxial and triaxial creep testing has commenced, facilitated by the successful modification of the temperature control system to maintain a constant room temperature during tests. In conjunction with these significant achievements, a predictive model has been developed based on the comprehensive set of experimental results. This model aims to predict the time-to-failure under various loading conditions.

Furthermore, a notable investigation into the effect of slenderness ratio and sample diameter on the time-dependent properties of the specimens has been undertaken. Additionally, preparations for creep experiments on coal and marble samples are currently underway, reflecting the project's breadth and depth in exploring the time-dependent behaviour of different materials. Overall, the achievements made so far lay a strong foundation for further advancements in understanding and characterising the creep behaviour of the studied materials.

C29022
Mechanical Investigation of Two Critical Standing Support Systems (Timber Chock and Pumpable Crib) in Underground Coal Mines

Monash University
Hossein Masoumi
Javad Hashemi

Value: $295,000
Report Expected: March 2024
Industry Monitor/s: Bob Coutts, Brian Vorster, Dan Payne, Gift Makusha, Patrycja Sheffield
ACARP Contact: Peter Bergin

The main objective of the project is to characterise the mechanical behaviour of two standing support systems including timber chock and pumpable crib which are commonly utilised in underground coal mines in Australia.

To investigate the mechanical behaviour of timber chock structures, the study has been categorised into three levels: component, contact, and global levels. At the component level, static bending and compression perpendicular to the grain tests have been conducted on small and clean samples. Additionally, the numerical model has been calibrated based on the experimental results. To study the effect of notch corner shapes on timber components' load-bearing capacity and stiffness, three types of notches were prepared and tested under three-point bending tests. The notch corner shapes are categorised as follows: type A - rectangular notch-round notch corners, type B - double rectangular notch corners, and type C - double rounded corners. Furthermore, the effect of moisture content on the mechanical properties of timber elements has been clarified. For the contact level tests, all the timber components have been prepared, and a loading frame with a capacity of 5MN has been installed to conduct the compression test on the timber chock in the contact level, which is made of two rows of timber components.
One of the main objectives of this research is to develop a numerical model that can simulate the mechanical behaviour of pumpable cribs. In this period, a review of the potential material models available in the literature and that can represent the mechanical behaviour of pumpable cribs has been conducted. The main aim of this review was to select a material model that can be used in the numerical simulations of pumpable cribs representing the grout behaviour and confinement effect. Grouts used in pumpable cribs are cement-based materials. Several constitutive models for concrete and rock materials exist in the literature. The current focus is to have a more refined study of some of these models (such as the concrete damage plasticity) with the aim to select a model that can be potentially calibrated using experimental data. Moreover, numerical simulation techniques have also been reviewed in this period.

C29025  
Effectiveness of Shotcrete in Underground Coal Mines  
University of New South Wales  
Chengguo Zhang  
Joung Oh  

**Value:** $185,000  
**Report Expected:** August 2023  
**Industry Monitor/s:** Ben Forrest, Brian Vorster, Julian Potten  
**ACARP Contact:** Peter Bergin  

The draft final report has been submitted to the Industry Monitors for review.

C33019  
Monitoring While Drilling Concept on Characterising Coal Mine Roof  
CSIRO  
Manoj Khanal  

**Value:** $279,989  
**Report Expected:** September 2023  
**Industry Monitor/s:** Brian Vorster, Dan Payne  
**ACARP Contact:** Patrick Tyrrell  

A major cause of roof instability in underground coal mines is the variable nature (for example, thickness, competence, discontinuities) of the coal mine roof that may be composed of different strata, including coal roof and uncertainty associated with the variation. Normally, the geotechnical and geological data gathered from exploration boreholes drilled at considerable distances from each other are used to characterise the thickness and competence of the coal mine roof. This limited data cannot capture local variability present in the coal mine roof. The objectives of this project are to investigate the applicability of the MWD concept to perform geotechnical characterisation of coal mine roofs and detect “signatures” of change in roof strata competence.

Two field experiments have been conducted. Drill data received from experiments at one of the open cut mines have been analysed and results are promising. The signals can be co-related with the geo-physical data.

Planned laboratory and field experiments have been completed. The seismic drilling data have been re-analysed with new methods and noted an encouraging correlation between the data and the strength of drilled medium.

A lot more experiments with the known geo-materials have to be performed to evaluate the validity of the correlation.

C33024  
Improved Model Upscaling of Overburden Hydraulic Conductivity for Input into Groundwater Models  
SCT Operations  
Yvette Heritage  

**Value:** $230,000  
**Report Expected:** November 2024  
**Industry Monitor/s:** Agi Burra, Bob Coutts, Gary Brassington, Peter Corbett, Peter Bergin  
**ACARP Contact:** Peter Bergin  

The key objective for the project is to determine an upscaling method that bridges the gap of geotechnical model fracture conductivity at longwall panel detail, to groundwater model bulk conductivity input requirements. It has so far been a challenge across the geotechnical and hydrological disciplines to upscale these detailed fracture flow conductivity results to the groundwater models, whilst resulting in flows that are consistent with experience.

Collaboration with groundwater modelling consultants has allowed understanding of groundwater model inputs and limitations. This project aims to understand the differences and limitations of the geotechnical and groundwater modelling to improve the disconnect between the approaches.

Initial investigations into upscaling methodologies has shown similar results between local and non-local upscaling techniques. Investigation into other potential causes of variation in overburden conductivity between geotechnical conductivity and groundwater balanced overburden conductivity are being investigated.

This project is on hold for six months.
C34012
User Friendly Computer Program for Modelling Fracture Induced Instabilities in Underground Mining Environments

University of Newcastle
Anna Giacomini

Value: $197,350
Report Expected: March 2024
Industry Monitor/s: John Grieves
Matt Tsang
Paul O'Grady
ACARP Contact: Peter Bergin

The project aim is to extend the core phase-field finite element code developed as part of project C29008 with algorithms that facilitate the robust modelling of fracture propagation through rock and to prepare a user-friendly program interface. These features will provide a more versatile analysis tool based on phase-field finite element technology which may be employed to assist in the design of roadway roof support systems under a range of site-specific conditions.

This quarter, work continued according to a revised project scope prepared in consultation with the Industry Monitors to ensure that the best possible outcomes are achieved for the coal mining industry. As part of the revised scope, a fast, robust, eigen-solver for computing principal strains and strain direction vectors has been successfully implemented and tested. The algorithm employed was selected to meet the specific project needs and allows for more complex brittle material models to be used in analyses. The research team also co-ordinated a series of meetings with mathematician colleagues to address several technical challenges encountered in the implementation of some important material model types.

In parallel with the work above, an executable prototype of the Graphical User Interface for the phase-field software has been produced through the research team’s collaboration with a specialist software engineer. The final report is now being prepared for publication.

C34018
Carbolt – Pre Commercial Fixed Length Carbolt Prototype

Mining3
David John

Value: $360,088
Report Expected: September 2024
Industry Monitor/s: Alex Wright
Bob Coutts
Peter Quinn
ACARP Contact: Patrick Tyrrell

The objectives of this project are:
- Develop a pre-commercial fixed-length carbon-fibre based roof bolt to provide tensile and shear strata support - the Fixed-Length Carbolt will be designed to be installed in a manner similar to a standard rebar rock bolts and provide a non-corroding alternative to existing rebar roof bolts, which includes the ability to be re-tensioned;
- Develop a locking mechanism that locks the carbon fibre braid without damaging them; and
- Characterise and statistically analyse the shear and tension load capacity of the Fixed Length Carbolt through a series of trials. Achieve comparable load performance to a steel rebar roof bolt.

Mining3 has partnered with University of Southern Queensland (UniSQ) to further the Carbolt technology through phase 2 of this project. UniSQ’s Centre for Future Materials is specialised in research and development in engineered fibre composites. To expedite the market introduction, researchers from the Centre for Future Materials at the UniSQ utilise their state-of-the-art industrial-scale robotic double-ring braiding machine, automating the manufacturing process. This plan includes integrating the braiding machine with an industrial pultrusion line to demonstrate a fully automated, cost-effective rockbolt manufacturing process.

The design and preliminary manufacturing stages to create a Fixed-Length Carbolt spanning approximately 2 metres is underway. A locking mechanism design that is suitable to terminate the carbon fibre is also being finalised; building upon the technology used in glass fibre rockbolts previously developed in UniSQ. Following the production of the sample Carbolts, there will be subsequent standardised testing carried out to ensure that they meet the mechanical properties expected of standard underground rockbolts.

Figure 2. Carbon fibre braiding using industrial-scale robotic double-ring braiding machine.
C34021
Roof Beam Support Assessment Tool

Resource Geotechnical
Terry Medhurst

Value: $150,000
Report Expected: September 2023
Industry Monitor/s: Brian Vorster, Roger Byrnes
ACARP Contact: Patrick Tyrrell

Previous CARP projects C22008 and C24015 funded the development of a roof support design approach that takes account of differing roof conditions, effect of support type and stiffness that can be used for mine design and in the strata management process. An analytical framework was developed for roadway development that provides a measure of both support load and roof convergence which can be matched and updated against roof monitoring data. It is based on beam-column principles and incorporates bending, immediate roof failure and shear. The model relies upon inputs from the Geophysical Strata Rating (GSR), roof bolt characteristics including pull-out stiffness/load, in-situ stress ratio and unconfined compressive strength (UCS). The current proposal is to now convert this method into a practical site-based software tool to accompany existing design methods. A windows based version has been developed that can be used to assess both development and longwall abutment loads. Testing and refinement has been finalised and user testing is intended over the coming months.

C34022
Risk Based Model for Forecasting Longwall Face Cavity Development

University of New South Wales
Chengguo Zhang
Ismet Canbulat

Value: $173,200
Report Expected: June 2024
Industry Monitor/s: Bob Coutts, Matt Martin
ACARP Contact: Peter Bergin

No report received.

C35008
Optimum Design of Pillars with Various Sizes and Shapes at Increasing Stress Environment

University of Queensland
Mehdi Serati
Paul Buddery

Value: $172,000
Report Expected: April 2025
Industry Monitor/s: Brian Vorster, John Grieves, Peter Corbett
ACARP Contact: Patrick Tyrrell

This project aims to establish a modified pillar load estimation methodology for the optimum design of pillars with various sizes and shapes at increasing stress environments to provide a more accurate pillar stability assessment. The project will verify the design of main pillars based on a load less than the tributary area load, which will potentially have considerable financial and operational benefits.

The project has conducted a literature review of pillar load determination within pillar design methodologies from coal mine industries throughout the world. Pillar stability databases in the USA South Africa and Australia have been acquired which will assist with evaluating the performance of pillar load determination methods. Different methods for pillar load estimation such as tributary area, pressure arch, beam spring, and abutment angle have been evaluated and compared. Initial numerical modelling has demonstrated the convergence of effective load on small coal pillars to tributary area load as the panel span increased, which also verified the value of the numerical tools for later research stages of the project.

The dimensional and factorial design of physical models (which will be carried out at future stages of the project) is in progress. Benchmark tests for the selection of load frame and monitoring apparatus have been confirmed. Geological, pillar design, and monitoring data will be further collected from supporting mines for the project to assist with the laboratory experiment design.
C35010
Causes for Swelling and/or Bearing Capacity Floor Failures in a Pillar System Under Varying Geological and Geotechnical Environments

University of New South Wales
Serkan Saydam

Value: $298,300
Report Expected: June 2025
Industry Monitor/s: Brian Vorster, Peter Corbett
ACARP Contact: Peter Bergin

This project aims to investigate the conditions to swelling and bearing capacity floor failures through an experimental program, in-situ monitoring program, and analytical and numerical approaches and determine timing of failure. Based on the learning from C26064 and C29041, an analytical model will be developed to evaluating the bearing capacity of soft floor strata in underground coal mines. The cutting-edge numerical modelling framework will be developed that will enable us to better understand the swelling failure mechanisms. The research team will develop a framework for assessment and prediction of floor heave. This approach will provide comprehensive guidelines to assess and predict floor heave failures.

The project work started with literature review of the floor heave mechanism. A PhD student has been recruited and started working on both literature review of floor heave failures associated with swelling and bearing capacity and numerical modelling studies. As a preliminary study, two-dimensional discontinuum based numerical modelling tool, UDEC-Itasca has been used for floor heave mechanism investigation (see Fig.1). The principal modes of shear failure in the field conditions have been modelled (Terzaghi’s theory). The outward rotation of the material under the pillar edge and material heaving in a roadway are shown in Fig. 1.

Fig. 1. Preliminary results of the bearing capacity simulations via UDEC

C35011
Revolutionising the In-Situ Stress Measurement Using a New Generation of Downhole Tools: DilaStress

University of New South Wales
Hamid Roshan, Ismet Canbulat

Value: $184,500
Report Expected: April 2025
Industry Monitor/s: Brian Vorster, Patrycja Sheffield
ACARP Contact: Peter Bergin

The knowledge of in-situ stress magnitude and orientation is important in subsurface engineering applications especially coal mining operations. Overcoring is undoubtedly one of the most used direct techniques of in-situ stress measurement in underground mining operations. However, limitations such as required time, operational difficulties, associated cost and technical challenges limit its extensive deployment in the field. Thus, new downhole tools for in-situ stress measurements having simple operational principle and accurate estimation are constantly sought. We seek to design the first prototype of the new generation of downhole tool (DilaStress) to improve the measurement procedures and overcomes current limitations. The tool works based on our newly proposed concept of borehole deformation principle.

In the quarter, we have finalised the design of the mechanical parts of the tool and started fabricating these mechanical components. The next step involves designing the sensors and electronics and design their integration with the mechanical components of the tool.

Ventilation, Gas Drainage and Monitoring

C25072
New Approaches to Mine Gas Analysis and Ratios

Simtars
Andre De Kock
Gareth Kennedy

Value: $416,192
Report Expected: December 2023
Industry Monitor/s: Bharath Belle, John Grieves
ACARP Contact: Peter Bergin

The project aim 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 C25072 project and ACARP Project C10015.

Expand the current “Fire Ladder” to include additional alkanes below the ethylene point which can be used to give earlier warning of a developing heating / spontaneous combustion and incorporated into TARPs.

The work status is as follows:

- The second coal sample was loaded into the 2m column on 27/2/2023. The 2m column control system was set to Mode 1, heating column to virgin temperature (40°C). On 21st of March 2023 the system was set to Mode 2 (adiabatic).
- The coal in Zones 3 and 4 (at the top) increased temperature rapidly, to reach 89.8°C. The other Zones followed suit, except Zones 9 and 10 (at the bottom) had a slower temperature rise rate and only at each 50°C. Zones 1 to 8 stabilised while Zones 9 and 10 continued to increase in temperature up to 160°C. At which point the 2m column automatically went into shutdown and inerted using nitrogen. The total time taken for the test run was 5.5 weeks.
- A total of 214 samples were taken during the test. This resulted in 14,499 analytical results.

<table>
<thead>
<tr>
<th>Table 1 Samples taken</th>
<th># Taken</th>
<th># of Components</th>
<th># Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Bags</td>
<td>204</td>
<td>47</td>
<td>9,588</td>
</tr>
<tr>
<td>VOC Tubes</td>
<td>162</td>
<td>13</td>
<td>2,106</td>
</tr>
<tr>
<td>Aldehyde Tubes</td>
<td>174</td>
<td>15</td>
<td>2,585</td>
</tr>
<tr>
<td>Water Samples</td>
<td>10</td>
<td>24</td>
<td>240</td>
</tr>
</tbody>
</table>

- The results are still being processed. VOCs by GC-MS and Aldehyde data has been finalised. Micro GC data is being reviewed. Preliminary component appearance tables have been generated to 80°C for all gas data.
- It was decided at the review meeting to use another Northern Bowen Basin Coal sample. This will then be used as a verification of the results from this 2nd coal sample.
- A PID controller to be installed to better control the flange temperatures.
- The Drager xPid needs to be configured and used during the next 2m column run.
- Next test run of the 2m column will commence during October 2023.

The objective of this project is to develop a fully automated prototype integrity testing system, based on information of the flow rates and pressures on tubes. This prototype will be able to be retrofitted to any tube bundle system, regardless of the supplier. The basis for the design of the automated system is Delta Automation’s manual integrity testing system. The project comprises three phases. The first phase is the accumulation and evaluation of presently available information relating to flow rates, designs and pressures in tube bundle systems used in underground coal mines. During the second phase the specifications for automatic system prototype will be developed. The final phase will be to test the prototype using the Simtars Mobile Gas Laboratory (MGL) and then retrofit the prototype to a tube bundle system for a trial at the mine site.

Simtars will conduct comprehensive testing using the Mobile Gas Laboratory (MGL), and adequate lengths of tube-bundle tubing to represent an actual scale of a mine site. This includes 2km of ½ inch tube, and 4km of ⅝ inch tube, which has been purchased and received at Simtars.

The aim of these tests are to evaluate the following:
- Effectiveness of the prototype to undertake leak testing according to AS 2290.3 2018.
- Ability and accuracy of the prototype to detect leaks and changes in tube integrity.

The development of the control system and data acquisition has been completed for the prototype. A detailed test plan has been developed with testing schedule to commence in August.
C28016
Ventsim Goaf Model Development - Stage 2: Goaf Flow – Ventilation Interactions

CSIRO
Martin Griffith
Qingdong Qu

Value: $319,465
Report Expected: August 2023
Industry Monitor/s: Bharath Belle, Paul Wild, Peter Baker

ACARP Contact: Patrick Tyrrell

The draft final report has been submitted to the Industry Monitors for review.

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

Ampcontrol
Gareth Kennedy
Ian Webster

Value: $90,000
Report Expected: September 2023
Industry Monitor/s: Bharath Belle, John Grieves, Ken Singer, Patrick Tyrrell

ACARP Contact: Peter Bergin

The overall objective of this project are 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.

During the quarter the following tasks were undertaken or completed.

Equipment modifications:
• Design and manufacture of brackets for glass tubes to measure dust suspension/concentration;
• Design and manufacture of test cups;
• Modification to gas supply system to include tests cups.

Dust measurement:
• Pre-tests to verify measurement method of dust concentration in suspension using glass tubes.

Schedule for the August - October period:
• Comparison tests between the OEM cal cups and test cups to verify response times;
• Occlusion simulation without dust to determine a baseline of expected performance;
• Source and fit the DustTrak II dust monitor; and
• Commence dust occlusion testing.

C29018
Evaluation of Explosion Resistant Ventilation Control Devices and Determining Explosion Risk Exclusion Zones

University of Wollongong
Alex Remennikov

Value: $562,560
Report Expected: June 2025

ACARP Contact: Peter Bergin

The throw of debris and fragments is one of the most dominant effects in underground coal mine explosion events and consequently the required safety distances and exclusion zones around mine entries should be determined. Greater knowledge of the explosion generation of debris inside and outside underground coal mines is required to develop scientifically validated exclusion zones for both blast overpressure and projectile hazards. This project will investigate the propagation of debris within drifts and shafts and outside mine openings and establish the relationship between the angle of incline of portals and projectile/debris risks to mine site infrastructure. Researchers will validate experimentally the existing procedures in DoD Explosives Safety Board and US Army documents for predicting debris velocities for coal mine explosion scenarios and define the appropriate exclusion zones for explosion risk for coal mine infrastructure.

C29036
Direct Measurements of Effective Diffusion Coefficient of Coal

University of New South Wales
Peyman Mostaghimi

Value: $175,000
Report Expected: August 2023
Industry Monitor/s: Bharath Belle, David Webb, Paul Wild, Russell Thomas

ACARP Contact: Peter Bergin

The draft final report has been submitted to the Industry Monitors for review.
C33018
Strata Gas Content using Geophysical Logs and Laboratory Measurements
University of New South Wales
Guangyao Si
Joung Oh
Peyman Mostaghimi

Value: $128,560
Report Expected: September 2023
Industry Monitor/s: Agi Burra
Mark Laycock
Russell Thomas
ACARP Contact: David Drakeley

The project objectives are to:
• Collect and examine geophysical logging data available at mine sites and select relevant data that can be used for gas content estimation.
• Develop correlation models for porosity, gas saturation, and gas sorption calculation of different coal measures based on routinely acquired geophysical logs.
• Conduct laboratory measurements of gas storage properties of key coal measures in Australian gassy mines and use the results for model training and validation.
• Establish gas content estimation models for various coal measures using multi-geophysical logs.

The draft final report has been submitted to the Industry Monitors for review.

C33029
Review Longwall Face Ventilation to Mitigate Goaf Gas Emissions onto Walkways and Tailgate End
University of Wollongong
Ting Ren

Value: $146,500
Report Expected: September 2023
Industry Monitor/s: Ventilation Task Group
ACARP Contact: Patrick Tyrrell

The draft final report has been submitted to the Industry Monitors for review and feedback received.

C34010
Time Lapse In-Seam Seismic and Resistivity Measurements as an Integrated Component of a Smart Coal Seam Gas Pre-Drainage Practice: Literature Review
University of New South Wales
Hamid Roshan

Value: $60,000
Report Expected: August 2023
Industry Monitor/s: Ventilation Task Group
ACARP Contact: Peter Bergin

The draft final report has been submitted to the Industry Monitors for review.

C34011
Appraisal of Gas Indicators from Goaf Drainage Holes for Spontaneous Combustion and Explosion Risk Management: Stage 2
University of New South Wales
Guangyao Si

Value: $223,254
Report Expected: June 2024
Industry Monitor/s: Bharath Belle
David Webb
John Grieves
Ken Singer
Paul Wild
ACARP Contact: Peter Bergin

The project objectives are to:
• Develop CFD models to simulate intensive goaf drainage impact and interaction with longwall ventilation airflow. This will be calibrated and validated by a large amount of goaf gas drainage data collected from the Stage 1 project.
• Understand the migration pathways of leaked air from the face to individual goaf holes.
• Evaluate the effect of goaf holes on pulling oxygen back and goaf fringe size, at various goaf drainage scenarios (completion depth, position, layout, suction pressure) and goaf natural characteristics.

In the quarter, we combined the 3D distribution of O₂ and CH₄ obtained through CFD modelling with the Coward triangle to determine the spatial distribution of gas explosion zones. Besides, we utilised FLUENT Volume Integration to calculate the volume of gas explosion zones within the goaf. We analysed the impact of different ventilation air flow rates on the gas atmosphere in the goaf. Figure 1 (a) and (b) display the O₂ and CH₄ in eight goaf wells under corresponding conditions. Furthermore, the impact of ventilation air flow rate on the risk of gas explosion was quantified by representing the percentage of the explosive gas zone (EGZ) in the goaf area, as depicted in Figure 1 (c). Further analysis was conducted on the effects of other natural characteristics.
such as goaf permeability and gas emission on the goaf atmosphere and its correlation with gas explosion risks.

Figure 1. (a) O2 distribution in drained boreholes, (b) CH4 distribution in drained boreholes, and (c) EGZ volume percentage (%) in goaf zone under different ventilation air flow rate (m$^3$/s).

C34014  
**Borehole Tools to Deal with Outbursting, Coal Bursting and Gas Drainage: Stages 1 and 2**

*Sigra*  
Ian Gray

| Value: | $1,678,320 |
| Report Expected: | April 2024 |
| Industry Monitor/s: | Ventilation Task Group  
Brad Lucke |
| ACARP Contact: | Patrick Tyrrell |

This project is to produce a survey system for drilling, including a rock recognition system and a packer system to enable coal seam permeability and pressures to be determined. The project is multi-faceted as it involves drilling hardware, sensing equipment, downhole and at the drill rigs sensing and electronics. This is in both IS and flameproof form and it also involves a lot of software development.

The project is progressing steadily towards an internal trial of the equipment at Sigra this year on Sigra’s drilling rig. In addition, discussions are being held with a drill rig manufacturer as to how to incorporate the design changes required to the rigs in use at that mine.

Improvements continue to be made to the survey system accuracy through improved calibration procedures and mathematics.

The design of the software is taking place. This is a complex task as it must take data from the drill rig, the sensors in the drilling head including the survey system and the torque and thrust probe or the packer system.

Progress continues to be made on firmware for each of the individual component systems.

C35012  
**Optimising Gas Management**

*CSIRO*  
Rao Balusu

| Value: | $100,000 |
| Report Expected: | March 2024 |
| Industry Monitor/s: | Ventilation Task Group |
| ACARP Contact: | Patrick Tyrrell |

The objective of this project is to determine research direction by undertaking workshops with the Ventilation Task Group to develop a set of research priorities in the areas of longwall goaf gas and spontaneous combustion management. It is also expected to develop scope of work for a significant project based on the discussions and recommendations of the Ventilation Task Group during the workshops. The main objective of the project is to develop optimum goaf management strategies to maximise goaf drainage, reduce oxygen ingress into the longwall goaf, and minimise fugitive emissions.

The first workshop has been conducted with Ventilation Task Group to discuss research requirements for longwall goaf gas and spontaneous combustion management.

C35015  
**Studies of Coal Toughness and Gas Sorption Dynamics for Outburst Risk Management**

*University of Wollongong*  
Ting Ren

| Value: | $275,000 |
| Report Expected: | June 2025 |
| Industry Monitor/s: | Ventilation Task Group |
| ACARP Contact: | Patrick Tyrrell |

The objective of this project is to improve industry knowledge and management of potential outburst risks by conducting systematic studies of coal toughness, geomechanical properties and gas sorption dynamics with different coals sourced from underground coal mines in New South Wales and Queensland.

The review of toughness index use and test apparatus including test procedures is being completed.

A new design of toughness test rig has completed and two new rigs machined and fabricated at UOW, and two more near completion after initial trials and slight improvement of the original design.

Meetings held with engineers from three mines participating in this project where agreed was reached on gas data sharing and sample sourcing from their current mining operations. Core and lump samples from different mine sites were collected and delivered to UOW gas lab for testing.
UOW provided two toughness test rigs and associated test procedures, and training demonstration to Gas Laboratory at Cordeaux Mine Site, GeoGAS Lab in Wollongong to conduct toughness tests on samples received from different mines. A similar working mechanism is to be established with CoalBed Lab at Narrabri of Whitehaven Coal.

The project team has started extensive lab test programs for coal toughness, coal fracture mechanics and mechanical properties, and gas sorption tests on both pulverised and intact coal samples, with some preliminary data (including data from Cordeaux and GeoGAS) showing consistency, sensisitity and correlations between gas parameters, and field observations when overlying toughness data with outburst sites/mine workings.

Some initial test results of coal toughness and gas sorption were presented to the Gas and Coal Outburst seminar.

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**Geology**

**C34016**

**Elements in Coal – A Start-to-End Analysis**

CSIRO

Jane Hodgkinson

Value: $119,035  
Report Expected: October 2023  
Industry Monitor/s: Raymond Howard  
ACARP Contact: Patrick Tyrrell

This project investigates the concentration/dilution of elemental content of Australian coal, providing strategic mapping to assist the opportunity for innovative exploration. The project objectives are to:

- Extend work on project C29030 on elemental content of Australian coals.
- Explore the journey and fate of elements in mined coal.
- Better understand where elemental value gets moved, concentrated or destroyed through current processes.
- Present recommendations on critical and valuable element concentration opportunities.

The motivation is to develop a better understanding of the way in which current processing may concentrate or reduce elemental content in coal through its full cycle at the mine. This will inform decision making for processing at some mines where concentrations may be improved sufficiently to provide a valuable by product from pre-mined material. The aim is to perform the process at three mines along their processing chain, to understand likely steps that may be beneficial or destructive to possible concentrations and clarify potential opportunities for improvement.

16 samples have been analysed and another 17 samples prepared from the second mine for the lab. Using additional methods including gamma-ray detection, XRD and LIBS, we have been analysing subsamples of the first batch for validation and comparison of methods and results. To date we have identified three potential locations in the coal measures where REEs are sufficiently higher than background levels to warrant further examination.

**C34020**

**Guideline for Standardising Structure Interpretation in ATV/OTV Logs**

University of Queensland

Mojtaba Rajabi

Value: $163,415  
Report Expected: May 2024  
Industry Monitor/s: Brian Vorster, Euan Macaulay, Matt Tsang  
ACARP Contact: Cam Davidson

This project aims to develop a guideline for processing, analysis, and interpretation of geological features in image logs. Such a guideline will significantly reduce the inconsistencies and misinterpretations through image log interpretations. To achieve this goal, we will combine a wide variety of data including core, ATV/OTV and company experts’ knowledge to develop a guideline for standardisation of image log interpretation and nomenclature.

During the last quarter, the team has analysed more ATV data from different mine sites. We are now in the final stage of ATV analysis. Until recently, over 900 image logs (ATV, OTV) have been analysed/reviewed.

The image log library, which illustrates different features in image logs, is almost completed and we are in the process of finalising if from the graphical point of view.

The classification scheme of features (i.e., dictionary of features) and flowchart have been updated a couple of times following the discussion with industry partners.

The completion of image log analysis will enable us to finalise the ‘image log library’ and classification scheme. Hence, the focus, in the last quarter, was on the image log analysis. We are hoping to finish all the available image logs in this quarter, and then complete the library by end of 2023.
C34029
Laser Induced Breakdown Spectroscopy (LIBS) as a Rapidly Deployable Field Technology to Estimate Coal Quality

CSIRO
Joe Perkins

Value: $135,510
Report Expected: September 2023
Industry Monitor/s: Mark Laycock
ACARP Contact: Patrick Tyrrell

The project aims to:
- Calibrate a rapidly deployable handheld LIBS device using mine site samples and established traditional testing with the aim of obtaining comparable analysis results for fixed carbon, moisture, volatiles, ash and sulphur.
- Develop experimental protocol to enable the rapid field assessment and estimation of coal quality to enable informed decisions regarding further laboratory testing and exploration strategies.
- Lay the foundation for future adaptation of this hardware that would enable LIBS to be utilised as a non-destructive method for assessing the numerous geophysical survey downholes, thereby greatly enhancing the characterisation of a targeted resource.

During this quarter, project researchers have finished data acquisition on the core samples and data analysis is in its final stages. As it stands the report will be delivered in September. CSIRO researchers met with Industry Monitors in August to present preliminary results and discuss a follow-up project.

C34033
Hyperspectral Analysis for Geotechnical Characterisation

University of Queensland
Joan Esterle
Karina Barbosa
Katerina Savinova
Nick Cook
Sandra Rodrigues

Value: $128,500
Report Expected: August 2023
Industry Monitor/s: Jafnie Muhsin
ACARP Contact: David Drakeley

The draft final report has been submitted to the Industry Monitors for review.

C34037
Statistical Analysis of Methods for selecting Lithology Boundaries from Density and Natural Gamma logs and assessing their ability to select Lithology Boundaries in Blast Holes

GeoCheck
Brett Larkin

Value: $76,000
Report Expected: March 2024
Industry Monitor/s: Mark Laycock
ACARP Contact: Patrick Tyrrell

This project has the following objectives:
- Compare the current methods for selecting the points on the downhole geophysical density and natural gamma curves that indicate lithology boundary depths.
- Assess statistically which method is the most accurate and whether this depends on the geological environment and/or make of the geophysical tool that collected the data.
- Most current methods make an additional adjustment on the selected boundary depths for thin coal bands and thin partings within coal seams. This is related to tool resolution. The study will compare these adjustments.
- Assess which adjustment method is the most accurate and determine if a better method can be developed. Again, the most suitable method may depend on the geological environments and/or make of the geophysical tool that collected the data.
- Assess if the lithology boundary methods can be applied to blast holes, primarily using density logs from the holes but also natural gamma and drilling penetration rates.

Current work has focused on the optimal degree of noise filtering of the natural gamma and density logs. Too little
filtering and geologically meaningful features are hidden in the noise and too much and they are lost. A method has been developed to determine automatically, the optimal filtering for each variable in each borehole.

The techniques for automatically selecting boundaries from density logs has been implemented on gamma logs. It has been found that the techniques have had to be altered slightly to be effective when applied to gamma logs.

C35023
Recovery of Critical Minerals from Coal and Coal Production Waste

CSIRO
Clint McNally
Jamie Hodgkinson
Nerrida Scott
Philip Ofori

Value: $154,000
Report Expected: April 2024
Industry Monitor/s: Andrew Lau
Caroline Lang
Shaun Booth
ACARP Contact: Patrick Tyrrell

The aim of the project is to assess the potential of coal, coal bearing strata, and production waste as an unconventional source of REEs and other critical minerals and to develop approaches to recover the REE in a sustainable manner.

The specific project objectives are to:
• Understand the mode of occurrence and the mineral associations of REE and use this knowledge to inform the development of innovative recovery technologies of these metals from coal-based resources; and to
• Investigate technologies and processes to recover and extract these high value products in an economic and sustainable manner.

The work program started with a literature review to understand the research work being done in other jurisdictions and how this study fits into the broader effort of developing technologies and processes for recovering critical minerals from coal and coal production waste. The literature review is in the final stages of completion.

In parallel with the literature review is the acquisition of coal, coal by-product and CHPP waste samples and their chemical analyses to identify suitable samples for this project. Several samples have been analysed that did not meet the requirements for use in this project. One of the supporting mine sites has conducted core samples acquisition campaign and analyses of the samples has identified core samples deemed suitable for use in this project. The exact locations of the samples are known. The site is in the process of getting bulk samples from these locations for further work on this project.

C35047
Real Time Prediction of Coal Top Through Guided Borehole Radar Wave Imaging for Open Cut Blast Hole Drilling Phase III

CSIRO
Binzhong Zhou
Matt van de Werken
Wayne Stasinowsky

Value: $396,792
Report Expected: April 2025
Industry Monitor/s: Jack Woollett
Troy O’Reilly
ACARP Contact: David Drakeley

The project objectives are to:
• Extend and mature the technology and engineering developed in Phase II.
• Develop a fully functional real-time coal top guidance system prototype suitable for field demonstration trials where it is fitted to a blast rig drilling production holes.
• Develop a prototype to the stage that the technology is ready to engage a commercial partner.

Progress for Phase III:
• Re-design of the bottom sub machining is completed. Machining of the bottom sub is necessary to fit the new electronics housing and radar antennas.
• The detail design for the new housing of the radar electronics, power supply and communications has also been completed ready for machining.
• Concept design for the top sub communications assembly has been completed.
• Electronics for the communications system has been redesigned and most critical electronic components have been purchased to mitigate the risk of supply chain issues.
• Initial discussions were conducted with a mine site to facilitate testing of a prototype. The mine site has supplied two bottom subs that will be used to fit the radar to their blast rig for the first test.

Drilling and Blasting

C27024
Evaluation of Production Trials of HP Explosives

Mining3
Andrew Kettle

Value: $477,920
Report Expected: September 2023
Industry Monitor/s: Andrew Lau
Brett Domrow
ACARP Contact: Cam Davidson

The objective of this project is to demonstrate the manufacture and delivery of Hydrogen peroxide (H2O2)/oil-based emulsion-style explosive using a
specialised Mobile Processing Unit (MPU) and evaluate blast performance in surface mine-site operations with increasing scales of production. This project progresses the research plan for H2O2-based explosives from confirmation of first viable formulations meeting sleep-time and detonation performance towards implementation and adoption by focussing on manufacture and delivery procedures to meet mine-site operational requirements with a central focus on safety.

Work undertaken during the quarter:
- Mining3 has acquired CSIRO research capability negating deployment complications which had delayed the project.
- Elquip has completed the duplication of the mixer unit tank (Figure 1.A.). The replication of the batch vortex mixer tank has doubled the capability of the machine and will enable serial manufacture of 250kg batches of the emulsion.

Definitions for safety in approaching alternative explosives has been forefront throughout the project. Where complications to the system have been encountered the preference has been for safety first, as seen in the full Hazchem suits used in trials (Figure 1.B.), and systemic simplicity. Another adjustment has been hole charging, this will be conducted with gravity feeding from IBCs (Figure 1.B.) to remove the need and additional risk of pumping the product for the initial trials.

Additional safety considerations have been implemented to limits the escalation of the increasing blast masses. This blast design consideration has alleviated budget constraints on the last large blast. With consideration of the last blast being attended by monitors, additional safety concerns have also been addressed for the demonstration by limiting the blast mass.

C33041
Production Trials in Two States of HP Explosives with Custom MMU

Mining3
Ewan Sellers

Value: $342,034
Report Expected: August 2024
Industry Monitor/s: Andrew Lau
ACARP Contact: Cam Davidson

The objective of this project is to utilise a prototype Mobile Production Unit (MPU), built within project C27024, to expand the blast demonstrations of Hydrogen peroxide (H2O2)-based explosives. Through executing these displays, across state jurisdictions, in varying mine-site locations, further technical confidence in the blasting agent will result. This new H2O2 technology has passed product stability testing in C27023, and authorisation testing in C27024.

In preparation for this project:
- See quarterly report for C27024 in this document for detail of MPU tank duplication.
- The ISO Tank to IBC Tank H2O2 transfer system (Figure 1.) has been completed and commissioned and is ready for field deployment. The system is composed of a compressor running a specialist diaphragm pump connected to passivated and compatible piping for high concentrations of H2O2 solution required for on-site manufacture of the emulsion.

Figure 4. Commissioning tests of the mobile shipping container-housed ISO tank to IBC tank H2O2 transfer system. The system is composed of a compressor running a specialist diaphragm pump connected to passivated and compatible piping for high concentrations of H2O2 solution required for on-site manufacture of the emulsion.
compatible piping for high concentrations of H2O2 solution required for on-site manufacture. Large volumes of oxidiser are required for this project, which can only be delivered in ISO tanks, so the focus on a safe, independently-operated and efficient system is required. This project component has been transferred from C27024.

- All but the bulk H2O2 ISO tanks remain to be secured. These components are required to be directly delivered to the mine-site, along with the custom transfer system.
- The blasting company collaborating with this project is likely to explore post-project activities as part our Mining3’s commercialisation roadmap.

This project requires the completion of blasting in the C27024 project, and is a run-on of the blasting capability demonstrations.

C34034
Advanced Blast Modelling and Geotechnical Analysis Tools

University of Queensland
Italo Onederra
Zhongwei Chen

Value: $157,825
Report Expected: August 2023
Industry Monitor/s: Adam Forgeron
Andrew Johnstone
Jafnie Muhsin

ACARP Contact: Cam Davidson

The draft final report has been submitted to the Industry Monitors for review.

C35018
Reactive Ground Testing

QMR Blasting Analysis
Gary Cavanough

Value: $250,000
Report Expected: January 2025
Industry Monitor/s: Andrew Micallef
Mark Laycock

ACARP Contact: David Drakeley

The objective of this project is to evaluate and introduce a new testing method for assessing reactive ground in coal mining.

Laboratory and field experiments have been conducted with the aim to understand the mechanism for spontaneous detonation. Experiments indicate that thermal properties are the key drivers of spontaneous detonation due to reactive ground. This highlights the risk of hot reactive ground and the increased risk of reactive ground conditions at the collar of blast holes. This work will be presented at the ISEE conference this November.

It has been identified that acidic conditions are required for reactions between sulphide and nitrates. Investigations continue to determine the “on ground” conditions that cause the acid production due to the weathering of sulphides.

Seventy samples have been received this month for parallel testing. Several of these samples contain high levels of reactive sulphide and coal which inhibits the ground reactivity. The reason for this will be investigated during the project.

C35028
Mining Explosive Sensitisation using Chemical Free Methods

Mining3
Andrew Kettle

Value: $297,256
Report Expected: March 2024
Industry Monitor/s: Andrew Lau
Brett Domrow

ACARP Contact: Cam Davidson

The objective of this project is to further enable and improve bulk hydrogen peroxide (H2O2)-based emulsion mixtures. This project investigates unique sensitisation methods of H2O2-based emulsion mixtures. Success of this project will lead to improved H2O2-based explosive performance, reduced material costs, and an in-line reactor for an on-bench emulsion manufacture process within a mobile production unit (MPU).

A unique feature of H2O2-based mixtures is the susceptibility of H2O2 to produce oxygen gas bubbles. This gas production can be exploited for sensitisation control of explosives to offer improvement and advantages to detonation performance, manufacture, and safety to blasting services and enhance H2O2-based emulsion appeal.

Figure 5. Preliminary laboratory bench-scale reactor tests have demonstrated the capability of the novel sensitisation method for oxygen gas bubble manufacture from the H2O2 solution.
We have successfully conducted preliminary trials of a laboratory bench-scale reactor (Figure 1). In these tests the novel sensitisation method produced oxygen gas bubbles. The initial tests created a bubble diameter capable of sensitisation application. Figure 1 displays the solution before and after the method with oxygen bubbles suspended in the reaction cell. We are progressing to a technical bulletin that will report the final calculations and system design to prototype the larger-scale reactor. A redacted component of this technical bulletin will be included in the final project report.

Environment

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

University of Queensland
Gordon Southam

Value: $226,450
Report Expected: September 2023
Industry Monitor/s: Stephen White
ACARP Contact: Patrick Tyrrell

The draft final report has been submitted to the Industry Monitors for review.

C29047
Reducing Uncertainty in Long Term Water Quality Predictions for Final Void Management

University of Queensland
Sue Vink

Value: $245,600
Report Expected: September 2023
Industry Monitor/s: Andrew Lau, Jason Fittler, Steve Downes
ACARP Contact: Patrick Tyrrell

The project aim is to generate information to assist management and closure of final voids as permanent water bodies, particularly with respect to improving water quality prediction. Fieldwork measuring vertical profiles of water quality parameters in two voids has been completed. Seasonal variations in water quality were consistent with expected water and heat balance in the pits, similar to natural lake dynamics.

A goldsim model has been developed to predict the temporal evolution of EC in the voids. Model inputs have incorporated the measured water quality results as well as the best available estimates of critical factors influencing pit water quality. This includes spoil properties/leaching and evaporation estimates, which sensitivity analysis showed were the most important factors controlling pit salinity over time.

C29049
Saline Pit Lakes as Aquatic Ecosystems: A Design Manual for Closure

Edith Cowan University
Mark Lund

Value: $108,9226
Report Expected: May 2024
Industry Monitor/s: Andrew Lau, John Watson, 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 the biophysical processes in unrehabilitated saline pit lakes and investigate options for enhancing ecosystem services in the Hunter Valley and Bowen Basin.

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 as aquatic ecosystems, recreational areas, and for aquaculture.

The overall project approach has two main components.

In situ component: Continuing the monitoring of four saline pit lakes (Hunter Valley and Bowen Basin) for a broad range of water chemistry, physical and biological parameters from C27043. We have added an additional four pit lakes in the Bowen Basin to the monitoring program in 2021. Based on findings from the C27043 monitoring program, we have introduced some refinements for 2021 that include improved replication of water quality data, and consistent numbers of macroinvertebrate and diatom samples between sites. We will sample each lake twice yearly. Using instrument chains, installed in all lakes we collect hourly data on stratification and salinity levels.

Experimental component to examine rehabilitation options: Carbon (in the form of terrestrial organic matter) determines the nature of the aquatic food web and creates important habitat. In C27043, using tank mesocosms (1000 L) on site, we tested the effects of
adding coarse, low-cost organic matter on lake water and sediments on biophysical and chemical endpoints (as measured in the lake). Based on the positive improvements recorded, in this project we will reset the mesocosms and test both organic matter phosphorus additions. Low phosphorus concentrations were recorded in all the pit lakes studies in C27043, and additions should stimulate primary production, creating more food for macroinvertebrates.

Littoral areas are well-established as the most important areas for biodiversity in lakes and yet also represent the most expensive component of pit lake rehabilitation (due to the earthmoving requirements to create these areas). We will conduct detailed sampling at a small rehabilitated saline pit lake to investigate the influence of water depth on biodiversity to determine the littoral area requirements of pit lakes for creating productive aquatic environments.

As shown in C27043, organic matter additions can enhance biodiversity in saline pit lakes. Experimentally we will move from mesocosms to a pit lake to test organic matter additions in situ.

Artificial floating islands of vegetation will be tested as a source of carbon and propagules that could assist in pit lake development during filling.

Quarter activities:

- Tank mesocosms were sampled in May 2022 and 2023, without having been reset as originally planned. After two years, they have responded differently to what was first seen and anticipated in C27043. It is planned to continue occasional monitoring of the mesocosms rather than to reset them to learn more about long term impacts of organic matter additions.

- Littoral areas are currently being assessed as a part of the experimental design for 2c. Further experimentation is being planned.

C33035
High Water Recovery, Low Cost Desalination using PV-Powered Membrane Capacitive Deionisation (mCDI)

University of New South Wales
Boyue Lian
Clare Bales
David Waite
John Fletcher
Yuan Wang

<table>
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<td>October 2023</td>
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<tr>
<td>Industry Monitor/s:</td>
<td>Kane Eskola, Nash Hancock, Nick Cook</td>
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<tr>
<td>ACARP Contact:</td>
<td>David Drakeley</td>
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The objectives of this project are to:

- Assess, through the implementation of a mine site pilot-scale trial, the viability of use of membrane capacitive deionisation (mCDI), in combination with appropriate pre-treatment processes, for the removal of salt and other contaminants from waters generated during coal mining operations.

- Provide advice on the designs of mCDI units considered appropriate for the treatment of particular process streams and/or wastewaters produced during coal mining operations with particular attention given to:
  o the volume throughput, salt removal capacity, water recovery and fouling propensity of particular designs;
  o the value and viability of different means of powering the mCDI unit (photovoltaics and/or mains power); and
  o the potential for use of VR/AR technology in remote monitoring and control of the mCDI desalination unit.

Progress during the quarter:

- Examination of process parameter impact on salt removal performance is ongoing with these studies critical to determining optimal strategy to produce water of a desired quality (i.e., remove more salt than needed then blend with untreated water, or operate to produce desired quality directly).

In the figure above, the process was varied to obtain best salt removal performance. Under this condition, the MCDI treatment plant was capable of producing water with a conductivity of 200 µS/cm (i.e., TDS ~ 100 mg/L) at a rate of 0.85 kL/module/day. This suggests that an eight electrode module plant could produce 6.8 kL/day of such water (if sufficient power available).

As it is desired to operate the plant completely using photovoltaic panels, the optimal operational strategy with regards to solar utilisation is also underway.
C33043

Best Practice Management and Performance Assessment of Biodiversity Offset Areas

Eco Logical Australia
Andrew Butler

Value: $335,540
Report Expected: September 2023
Industry Monitor/s: Jono Deacon, Mark Nolan, Michael Plain, Nigel Charnock
ACARP Contact: David Drakeley

The overall aim of the project is to produce industry toolkits (guides/frameworks supported by decision support tools) to help managers to:

- Select Biodiversity Offset Area (BOA) management measures that are evidence based, best suited to site circumstances and most likely to provide the best achievable biodiversity outcomes.
- Select monitoring and evaluation techniques that reliably measure the achievement of desired biodiversity outcomes and support adaptive management.
- Consider any emerging bushfire risks associated with BOA stewardship and identify options for management.

Draft reporting is in preparation and following discussion with the Industry Monitors, a progress meeting will be held on completion to discuss the main findings and outputs. This will be followed by a technical workshop, to be held in the Hunter Valley, with participating operations. The workshop will provide an opportunity for experienced industry practitioners to give feedback on the draft content of the technical guidance documents that are being prepared. This will improve the focus of these documents in areas where site environmental managers most need supporting information.

There have been delays in finalising the draft reporting and a project extension will be requested to allow for the completion of reporting and technology transfer.

C33046

Rationale for the use of Paired Continuous Real Time Noise Monitors to Reduce Uncertainty in the Quantification of Noise from Open Cut Coal Mines

Umwelt (Australia)
Steve Lyons
Tim Procter

Value: $125,000
Report Expected: September 2023
Industry Monitor/s: Ned Stephenson, Ngaire Baker
ACARP Contact: Patrick Tyrrell

The installation of continuous noise monitors either individually or as part of a continuous noise monitoring network has been a prescriptive requirement of the regulatory authorities since the mid-2000s. The systems are cumbersome and the data overwhelming. While the SMART phone application has improved information accessibility, quantitative source identification can still be difficult to achieve. This proposal aims to build on the previous work to develop a rationale for using the relationship between various data metrics collected by paired acoustic monitors to reduce uncertainty in the quantification of noise from open cut coal mines in complex acoustic environments. This rationale could then be used across the mining industry to provide more accurate noise source quantification.

During this period, further consolidation of the analysis of the noise and meteorological data incorporating additional clustering techniques was undertaken for the preparation of the report.

C33047

Best Method for Determining Atmospheric Stability for the Assessment of the Acoustic Environment in the NSW Coal Mining Industry

Umwelt (Australia)
Steve Lyons
Tim Procter

Value: $276,000
Report Expected: September 2023
Industry Monitor/s: Ned Stephenson, Ngaire Baker
ACARP Contact: Patrick Tyrrell

The prime objective of the project is to determine which method (Pasquill-Gifford sigma-theta method or temperature lapse rate method) is the most appropriate for the assessment of noise enhancing conditions, design of noise control strategies and the establishment of performance-based noise licence conditions within the NSW coal mining industry. This would include the identification of the most appropriate bin structure for the lapse rate analysis.

C33045

Extent, Spread and Risk of Pasture Dieback on Mine Site Rehabilitation using Remote Sensing

University of Queensland
Phil McKenna

Value: $291,990
Report Expected: August 2023
Industry Monitor/s: Andrew Lau, Nigel Charnock, Rod Norris
ACARP Contact: David Drakeley

The draft final report has been submitted to the Industry Monitors for review.
During this period, further consolidation of the analysis of the noise and meteorological data incorporating additional clustering techniques was undertaken for the preparation of the report.

C34025
New Landscape Evolution Model for Assessing Rehabilitation Designs

University of Newcastle
Greg Hancock

Value: $875,391
Report Expected: March 2025
Industry Monitor/s: Chris Quinn, Jason Fittler
ACARP Contact: Patrick Tyrrell

The objectives of the project are to:
- Test and develop the newly developed SSSPAM landscape evolution model (LEM) so that it can be used easily to evaluate both constructed and proposed post-mining landforms. The model will be tested and calibrated across a range of sites in Queensland and New South Wales.
- Develop a database of parameters that can be used by the industry across a range of sites, materials and climates.

A July site visit identified suitable areas for assessment and development of model parameters and model development. Field and GIS data needs have now been determined and GIS data requested for Queensland sites. The 2023 annual meeting was held in June with additional data needs discussed. These are now being pursued.

A laboratory weathering assessment of waste materials has developed material specific weathering parameters that can be used in the SSSPAM model to predict erosion reduction and pedogenesis. The model is currently being evaluated with a report now being prepared. This work demonstrates that for some sites weathering is rapid and is not a major influence on landscape evolution. It also confirms the robustness of the weathering model in SSSPAM. This work was presented at the Life of Mine Conference in Brisbane (August 2023).

A comparison of SSSPAM erosion and deposition rates and patterns with the CAESAR-Lisflood model has been completed with a report near complete.

One site has provided materials and landscape data for erosion assessment. Updated survey data has been requested. Former trial site data has also been supplied with additional data sourced from previous ACARP projects. The data is now being processed with needs for additional data being prepared for that site. A second site in an agricultural environment is now being also examined for both SSSPAM and SIBERIA.

C34027
Microalgae Cultivation as a Low Cost Method for Desalinating Void Water and Generator of Post Mining Bioeconomic Activity from Final Voids

University of Queensland
Ben Hankamer, Leigh Trevaskis

Value: $841,579
Report Expected: August 2023
Industry Monitor/s: Andrew Lau, Jason Fittler, John Watson, Trudy Mazucco
ACARP Contact: Patrick Tyrrell

The draft final report has been submitted to the Industry Monitors for review.

C34028
Guidelines for Assessment of Geotechnically Safe and Post Mining Landforms

Sherwood Geotechnical and Research Services
John Simmons

Value: $120,000
Report Expected: September 2023
Industry Monitor/s: Andrew Lau, Brian Vorster, Trudy Mazucco
ACARP Contact: Patrick Tyrrell

Landform safety and stability experience of industry professionals is being translated into good practice guidelines to provide a process that can be objectively followed and is therefore certifiable as required by industry and regulators.

Considerable progress was made over the period March – June 2023. A draft Guidelines document was submitted in early July for review by project monitors. At the project outset it was planned that a project report would be prepared, with the Guidelines document appended. In accordance with standard-writing good practice and the requirement for more detailed explanation of many issues, the Guidelines is now intended to be a stand-alone document. In due course this will be accompanied by a Guidelines Commentary document that will also provide the function of a project report. The Guidelines Commentary is in preparation with an expected delivery to project monitors in mid-August 2023.

Other mining industry sectors are also preparing guidelines for geotechnical assessment of mine closure. The Guidelines prepared within this project are likely to require updating from time to time as knowledge and experience with mine closure issues evolves.
This project has the primary objective of optimising plant survival on tailings dams by assessing pre-conditioning to flooding, growth medium mixes and pot size. It also aims to expand the number of primary species appropriate for coalfields in New South Wales and Queensland.

A nursery is maintaining plants over winter from past experiments, so they are ready for inclusion in tailings dams in spring. Plants for the final preconditioning experiments of this grant are being grown in readiness for flooding in October when they are large enough.

Within the Eucalyptus tereticornis plants being grown, two Queensland seed batches have been used, one from plants growing on sandy soil and one on clayey soil. Those from plants growing on sandy soil emerged much more quickly than those from clayey soil, and, by 15 days from seeding, more than double the number of seedlings had emerged. Currently, plants growing under semi-controlled conditions (warmer than outside) from the sandy soil are taller, suggesting growth conditions of the parents may have provided an advantage because of speed of emergence. This demonstrates yet again that seed provenance must be evaluated when assessing outcomes.

Following familiarisation, we are beginning to use the LI600 Porometer/Fluorometer (C35048 grant) on experimental plants linked to the upcoming preconditioning experiment, and to develop survey techniques suitable for plants growing in the field on tailings dams.

A primary focus of recent months has also been to progress the writing of the final report due in November.

Objectives of the project are to:

- Develop closure beneficial land use opportunity with hardy local high interest native species;
- Document benefits of reference population including 'local knowledge' and prior scientific research;
- Develop Geodatabase of CQ phenotypic populations relevant to mine operators to facilitate;
- Utilisation of the species distribution best suited for site implementation;
- Genomic characterisation by Australian Genome Research Facility (AGRF) to facilitate sub-species utilisation. Contribute to national knowledge of Australian native plant genomic mapping;
- Tailored phytochemical extraction methodology developed by University of Newcastle specialists;
- Assay anti-cancer properties of phytochemical active ingredients by Bill Walsh Centre Kolling Institute;
- Develop robust practical methodology for successful vegetative propagation not previously achieved;
- Deliver P.angustifolium tubestock suitable for field implementation by interested operators; and to deliver workshop to engage with operators and facilitate tech transfer.

Project progress:

- Good progress being made with the Prostate Cancer Cell Line testing;
- Plant populations plant material sampling programmed again for November with a focus on key project Genomics investigations and fresh material for Tissue Culture Program.

Tissue Culture Australia (TCA):

- Ongoing vegetative propagation attempts underway at TCA at this juncture not showing great success with typical of these hardy Native Plant Species as well as significant plant pathogen issues;
- Future sampling will endeavour to utilise a plant material anti-pathogen pre-treatment regime (previously not recommended by TCA due to potential plant material viability impacts); and
- Plant material collection November and potential for hand delivery required by RNA Team to Victoria.
AGRF Genomics:
- AGRF have completed DNA extractions on all available plant material collected, now in stable storage;
- Collection of further Pittosporum populations’ representative plant material to be completed in November as per project commitments;
- To facilitate safe stable shipping, a local provider for freeze drying samples will be investigated to facilitate process sampling immediately post-collection.

University of Newcastle (UoN) / Bill Walsh Centre Kolling Institute (BWC):
- Phytochemical extraction methodology program developed by UoN has now been implemented with a range of freeze-dried extracts provided to the BWC Laboratory for the human prostate cancer cell line testing in vitro;
- Preliminary Testing (early results) by the BWC indicate that extracted phytochemicals utilising organic solvent extraction methodologies have some cytotoxic efficacy while aqueous extracts do not appear to have an impact on prostate cancer cell survival;
- Some challenges encountered with bringing Freeze Dried Extracts into solution in DMSO, to be resolved through collaboration between UN and BWC UoS Lab Team;
- The main program of Laboratory Testing is now underway at BWC to determine the effect of the extracts on cell cycle and apoptosis using Muse Cell Health Assays;
- The ability of extracts to inhibit prostate cancer cell migration using scratch wound assays will follow;
- Project delay due to key personnel Maternity Leave and laboratory media supply issues.

C35006
Literature Review: Creating Viable and Productive Grazing as a Beneficial Final Land Use Through Targeted Design and Land Management

Mumbulla Environmental
Leigh Trevaskis

Value: $100,000
Report Expected: August 2023
Industry Monitor/s: Andrew Lau, Morné van Zyl
ACARP Contact: Patrick Tyrrell

The draft final report has been submitted to the Industry Monitors for review.

C35021
Delineating Water Tables and Flow Pathways Inside Spoil Piles to Support Water Quality Predictions

University of Queensland
Mansour Edraki
Neil McIntyre
Thierry Bore

Value: $297,420
Report Expected: August 2025
Industry Monitor/s: Andrew Lau, Steve Downes

ACARP Contact: David Drakeley

The aim of the project is to detect the spatial and temporal distribution of major flow pathways and water table(s) inside spoil piles with the level of confidence required for the progressive rehabilitation of spoil piles and prediction of water balance and water quality of final voids, in particular predictions of spoil seepage quality.

Work during the quarter has focused on review of potential sites for case study.

C35026
Management Strategies for Invasive Leucaena on Coal Mine Sites

University of Queensland
Shane Campbell

Value: $531,528
Report Expected: January 2027
Industry Monitor/s: Andrew Lau, Cian Morgan, Dominique Taylor, Morné van Zyl, Stephen White

ACARP Contact: Patrick Tyrrell

The primary objective is to develop strategies to effectively manage the invasive species leucaena (Leucaena leucocephala) in rehabilitation on coal mine sites. Leucaena is a leguminous tree introduced to Australia for use as a forage for livestock production, but it has also become an environmental weed in subtropical and tropical regions, including on several coal mine sites in central Queensland. This project aims to identify improved herbicide options, explore the impacts of fires, improve the resilience of rehabilitated land intended for grazing purposes through competitive pasture species and soil amelioration (e.g. fertilisation and soil additives), and test a fumigant for potential control of small but high priority infestations. Several demonstration sites based on best bet options will also be established to test strategies to not only deal with initial infestations but also subsequent regrowth.

Seed collections for various trials have been undertaken and establishment of the fumigant trial is underway.
Several project staff visited Mine 1 in Central Queensland in July 2023 to commence planning of research trials and associated logistics with a full scope of works currently under development. Discussions are also underway for Mine 1 to transport mine soil to the University of Queensland to commence residual herbicide and competition trials.

C35029
Renewable Energy as Post Mining Land Use

University of Queensland
Claire Cote
Shona Stevens

Value: $186,628
Report Expected: July 2024
Industry Monitor/s: Jason Fittler
Ned Stephenson
Raymond Howard
ACARP Contact: Patrick Tyrrell

Renewable energy produced by solar and wind has vast potential in the Bowen and Surat basins. However, the pathway to implementation is not clear. High level guidance is available but it is difficult to translate the recommendations into actions on the ground as regulatory barriers and planning constraints are not fully understood. This project will undertake two case studies to examine how renewable energy projects can be established on a mining lease and gain acceptance from regulators and stakeholders. Recommendations will be made on how to update the regulatory and planning frameworks to encourage and accommodate renewable energy as a post-mining land use.

C35030
Erosion and Sediment Control Framework for Queensland Mines – Calibration and Validation

University of Queensland
Robynne Chrystal

Value: $347,196
Report Expected: April 2026
Industry Monitor/s: Andrew Lau
Jason Fittler
Steve Downes
Tim Kendrick
ACARP Contact: Patrick Tyrrell

A framework for Erosion and Sediment Control Plans (ESCP) for Queensland coal mine sites was developed during project C29046. The ESCP Framework uses a GIS-based RUSLE tool that was developed to quantify soil loss on site, assist with identifying erosion risks and with selecting, designing, and implementing controls on site. This work also provided guidance on the key steps for sediment basin design. This new project aims to verify that the soil loss rates calculated using the GIS-based RUSLE tool accurately represent site conditions at different spatial scales and that the guidance provided in project C29046 is applicable and reflects approaches that ensure compliance.

In the previous quarter, various aspects of project administration and initiation have been underway. Training and medical assessments have been completed by personnel who will be carrying out experiments on site, information and data have been requested.

In the following quarter, site inductions and site familiarisation will be completed. The two remaining study sites will be finalised, and preliminary GIS-based RUSLE models will be developed for these sites. Site visits to the study mine sites will be carried out to observe the current condition and management of sediment basins. These findings will be recorded. Available results from previous erosion studies will be assessed to determine the key gaps in our understanding of soil erodibility on Queensland mine sites.

Geotech

C29005
System for Rock Fall Analysis Field Trial

CSIRO
Marc Elmouttie
Peter Dean

Value: $321,268
Report Expected: October 2023
Industry Monitor/s: Matt Tsang
ACARP Contact: Cam Davidson

Systems to detect, monitor and analyse rock falls in open cut 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. This project will field trial a prototype system which will consist of software and computing hardware to integrate data from radar, vision and microseismic monitoring systems.

In response to recommendations regarding site-support constraints (in particular, difficulty in securing infrastructure on-site for housing the monitoring equipment), the project work plan was modified to support development of a trailer-based solution. The team successfully sought internal funding to design and commission the construction of a trailer to house, power
and cool the geophone and interrogator systems needed for the seismic monitoring system.

Since the last update, the contractor engaged to fabricate this trailer has completed works and the trailer was delivered to CSIRO in July 2023. As shown below, the trailer consists of extendable solar panels, power hardware and an air-conditioner.

This trailer-based solution has also been discussed with a potential site supporter for the field trials.

In the next quarter, the trailer will be fitted with the monitoring equipment and CSIRO-based testing will be undertaken. It is hoped that the site support can be secured and field trial details will be finalised.

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### C29048
**Image Based Automated Characterisation of Waste Materials**

**University of New South Wales**

Klaus Thoeni  
Simit Raval

**Value:** $279,540  
**Report Expected:** January 2024  
**Industry Monitor/s:** Adrienna Robotham  
Leonie Bradfield  
Ned Stephenson  
**ACARP Contact:** Patrick Tyrrell

This project aims to utilise image processing techniques to facilitate the automated characterisation of spoil in dumpsites. The project involves collection of a large number of drone images from multiple dumpsites, both in New South Wales and Queensland. A parallel project, C29044, is conducted to provide ground validation for the image-based characterisation approaches.

In the past quarter, a progress is made to improve the workflow of the automated characterisation of UAV images achieving over 90% overall accuracy in coal spoil categorisation. Deep leaning algorithms were also trained to classify closed-range spoil pile images captured from iPhone and iPad achieving 95% accuracy in the characterisation. Additionally, a time series data comprising of truck dumping locations, loads and spoil material types together with a series of UAV images were collected to capture dump progress as it builds. A 3D dump profile has been built based on these data. Final report will be prepared for submission in January.

### C29050
**Low Cost Terrestrial Stereo-Pair Photogrammetric Monitoring System for Highly Hazardous Areas**

**University of Newcastle**

Anna Giacomini  
Klaus Thoeni

**Value:** $210,720  
**Report Expected:** August 2023  
**Industry Monitor/s:** Dan Stolberg  
Gareth Johnson  
John Latilla  
**ACARP Contact:** Patrick Tyrrell

The draft final report has been submitted to the Industry Monitors for review.

### C29052
**Autonomous Water Pressure Sensors for Spoil Dumps and Dams**

**Mining3**

Byron Wicks

**Value:** $458,040  
**Report Expected:** August 2023  
**Industry Monitor/s:** Craig Hagan  
Dan Payne  
**ACARP Contact:** Cam Davidson

The draft final report has been submitted to the Industry Monitors for review.

### C33040
**Machine Learning for Rockfall Analysis: Feasibility Study**

**University of Newcastle**

Anna Giacomini  
Klaus Thoeni  
Marc Elmouttie

**Value:** $92,580  
**Report Expected:** July 2023  
**Industry Monitor/s:** Dan Stolberg  
Matt Tsang  
**ACARP Contact:** Cam Davidson

The draft final report has been submitted to the Industry Monitors for review.
C35022
Quantifying Hoek-Brown Disturbance Factor (D) for Coal Measures Through an Integrated Laboratory and Numerical Modelling Approach

University of Queensland
Italo Onederra
Zhongwei Chen

Value: $355,776
Report Expected: May 2025
Industry Monitor/s: Adrienna Robotham, Matt Tsang, Peter Chern
ACARP Contact: Patrick Tyrrell

The main objective of the project is to construct a comprehensive and generalised estimation method for the Disturbance factor (D) in coal measure strata. This mainly includes the quantification of the variation of D in response to blast-induced damage and scale effects, establish an effective guide for the definition of D in surface coal mining slope stability analysis.

The technical work has started with a production scale highwall cast blast model configured in the Hybrid Stress Blasting Model (HSBM) platform. This initial stage focuses on evaluating and testing HSBM capabilities to generate blast damage envelopes involving both single and multiple hole blasting scenarios. The configurations incorporate history points to better quantify particle velocity, displacement and fracturing in specific locations and facilitate the calibration process. Results to date have shown that it is possible to study and quantify the extent of stress induced damage in cast blasting conditions. To supplement this work, an applicable and improved peak particle velocity (PPV) model developed in MATLAB is being converted to Python for easier use. One of the gaps in blast damage modelling is the ability to quantify the impact of gas loading (propagation/penetration) in coal measure strata, to this end a review of analytical and empirical gas propagation models that could be applied to the problem is underway. It is envisaged that a combined modelling approach will provide a more realistic damage envelope at the scales of interest.

Maintenance and Equipment

C26020
Preventing Fatigue Cracking Via Proactive Surface Dressing

Bureau Veritas AIRS
Simon Krismer

Value: $126,940
Report Expected: October 2023
Industry Monitor/s: Shane Saunders
ACARP Contact: Patrick Tyrrell

Condition monitoring mining equipment and structures for fatigue cracking is costly. Proactively dressing surfaces susceptible to fatigue cracking could be significantly cheaper than condition monitoring in terms of labour costs and downtime. This project will assess the effectiveness of using surface finishing to remove accumulated fatigue damage. Surface finishing is a cheap, readily accessible technique that requires no special tooling.

Very little progress has been made with the testing program since the last update.

The current stage of the project work is to establish the base-line testing parameters for the sample testing. This is quite labour intensive, involving checking the samples every half hour over the duration of the testing (up to 8 hours) to check for the development of cracking. The goal is to consistently achieve fatigue crack development on a statistically significant basis before moving to the next phase of the testing and intervening before crack formation to attempt to remove the accumulated fatigue damage and then continue testing to see if the fatigue life is extended. This is quite a complex process to both find the right parameters (rpm and sample deflection), while also being able to sufficiently control the randomising effects of surface roughness, sample runout, and inherent equipment variability in the lathe set-up. Seven samples have been run so far, but it is not yet clear how many more will be required to achieve the required baseline data. Possibly up to 20 more samples may be required for baseline data, with a further 20 for the experimental work.
C33033
Vibration Energy Harvesting for Self Powered Sensors at Mine Sites

University of New South Wales
Binghao Li

Value: $145,860
Report Expected: October 2023
Industry Monitor/s: Brendan Wilkins, Peter Walsh, Tim Gray
ACARP Contact: Patrick Tyrrell

The objectives of this project are to:
• Identify the potential vibration sources at mine sites,
• to evaluate the vibration energy capacity available to harvest from the vibration sources at mine sites;
• Review and test the existing vibration energy harvesting (VEH) devices in the market;
• Design and develop new VEH devices for mining applications; and to
• Test the new VEH device.

In this quarter, the following tasks have been carried out:
• A VEH device combining the auxetic structure and a sliding proof mass has been designed for efficient broadband vibration energy harvesting at low dominant frequencies. When the energy harvester subject to an excitation acceleration of 0.3 g, the maximum root mean square (RMS) output power of the developed energy harvester reaches 18.78 μW. Besides, the sliding proof mass widens the working bandwidth of the energy harvester by 9 Hz (from 21 Hz to 30 Hz).
• The developed piezoelectric energy harvester can successfully power a humidity and temperature sensor node with Bluetooth Low Energy (BLE) connectivity based on the vibration produced by the centrifuges (characterised by an RMS acceleration of 0.346 g and a dominant frequency of 25 Hz) in the coal handling and preparation plant (CHPP).
• Have drafted the final report and a journal paper manuscript.

Following activities are planned for the coming months:
• Report our findings on vibration energy harvesting at the mine site to our project monitors;
• Submit the report for peer review and revise the final report based on their comments.

C33034
Dozer Suspension Seat to Reduce Body Vibration

University of Queensland
Danellie Lynas

Value: $83,107
Report Expected: November 2023
Industry Monitor/s: Shane Apps, Tim Gray, Troy O’Reilly
ACARP Contact: Cam Davidson

The project objective is to evaluate the effectiveness of an innovative passive vibration and movement cancelling seat prototype in reducing dozer operator exposures to excessive whole-body vibration during normal operation at surface coal mines.

This project extends projects C23022 and C26026 through an evaluation of a potential engineering control. Previous ACARP project data indicates dozers are associated with whole-body vibration levels that frequently exceed the upper limit of the Health Guidance Caution Zone defined by ISO2631.1. Project C26026 provided the technology to allow continuous remote monitoring of floor and seat accelerations, as well as simultaneous GPS data.

An innovative passive suspension system has been patented and successfully tested in lab-based experiments recreating vertical vibration exposures from several different types of commercial vehicles and in a field-based experiment evaluating an on-road truck application. The design was found to reduce whole-body vibration exposures by 50% compared to conventional, commercially available mechanical and air-suspension seats. Based on these preliminary results, the seat suspension design appears to have the potential to substantially reduce operator exposure to whole-body vibration.

This technology along with data collected in previous projects, will be utilised to develop a prototype seat tuned to the specific vibration attenuation requirements of dozers. Independent evaluation of the performance of the seat will be undertaken in real mine operation utilising the technology developed in project C26026.

Progress to date:
• Analysis software is in place and two dozers have been instrumented with floor and seat sensors - data is being received;
• A prototype seat base tuned to the specific vibration attenuation requirements of the dozer has been laboratory tested in the US and fabrication to replicate the site dozer seats has been undertaken;
• Seat installation scheduled for mid-October. Pre and post installation gold standard measurements will be taken.
C33036
Radar Tyre Monitor System

CSIRO
Luke Powell
Pat Humphries

Value: $132,382
Report Expected: November 2023
Industry Monitor/s: Brendan Wilkins
Rob Fraser
Tim Gray
ACARP Contact: Cam Davidson

Underinflation and/or overloading of mine truck tyres causes undue cyclic stress to the internal steel cords, causing them to fatigue. “Zipper” failures can occur when such damaged tyres are reinflated, potentially causing serious injury or fatality. This project is undertaking the development and trialling of a monitoring system for haul truck tyres to identify tyre fatigue. The proposed system would consist of a continuous monitoring sensor combined with software analytics that will seek to identify and characterise significant changes in the tyre structure that correlate with incipient failure modes.

During the past quarter, further in-house depth-penetration testing and data processing has been conducted. Adjustments to mounting hardware and additional hardware mounting brackets have been made to facilitate on-vehicle stationary and in-motion data collection. An investigatory visit has been made to test vehicle mounting systems and data collection steps in preparation for the upcoming collection visits. The inspection highlighted changes that are required to be made to improve the data collection process to be actioned prior to follow-up visits in order to scan stationary and in-motion tyres with the clustered ultrawide-band sensors.

C33044
Design and Evaluation of a Passive Structural Fatigue Gauge

EngAnalysis
Charl Pieterse
Ian Stevenson
John Vazey

Value: $169,055
Report Expected: August 2023
Industry Monitor/s: Brendan Wilkins
Peter Walsh
Tim Gray
Weylon Malek
ACARP Contact: David Drakeley

The draft final report has been submitted to the Industry Monitors for review.

C34026
Human Aspects of Automation and New Technology in Mining: Integrating People and Technology Through Human Centred Design

University of Queensland
Robin Burgess-Limerick

Value: $375,573
Report Expected: April 2024
Industry Monitor/s: Belinda Martin
Brad Lucke
David Martin
Leveson Sutton
Tony Egan
ACARP Contact: Patrick Tyrrell

This project focuses on how automated subsystems and other new technologies being introduced to coal mines can fully accommodate human abilities and limitations and be fully integrated into overall operational work systems.

During the quarter a site visit for an underground longwall case study was undertaken and information for a dozer automation case study was obtained.

C34031
Reducing Noise Emitted by Heavy Vehicles in Open Cut Coal Mines

University of Technology Sydney
Mahmoud Karimi

Value: $231,645
Report Expected: April 2024
Industry Monitor/s: Brendan Wilkins
Tim Gray
ACARP Contact: David Drakeley

The aim of this project is to develop bespoke computational software that will be used to develop and optimise the design of splitter silencers used to attenuate noise on the intake and exhaust openings of cooling systems incorporated on turbomachinery in the mining industry.

The objectives of the project are to:

- Develop a theoretical model for the prediction of sound attenuation by splitter and louvre silencers used in turbomachinery intake and exhaust openings of cooling systems.
- Validate the new model by predicting the performance of existing designs and compare against experimental measurements provided by Hushpak.
- Use the validated model to optimise silencer design, which is likely to be through the optimisation of material parameters and the number and geometry of the baffles.
- Design and test a new silencer for Hushpak, who will build, install and test the new silencer on a real commercial application.
During the quarter, work has been performed on the generation of a series of design curves for louvre performance. Initial predictions have been completed for three general louvre geometries. The parameters considered in this parametric study are the louvre length, angle, material properties, baffle thickness, perforation ratio and open area ratio. These curves allow for an acoustic engineer to assess the effect of altering individual parameters and to optimise the design accordingly. The analysis will be compiled into a report for circulation. The aim is to provide a tool that may inform acoustic louvre development and design on future equipment.

In the coming quarter the analysis will be continued to cover less common geometries. The findings will also be applied to investigate existing solutions for equipment used on mining sites, such as the Caterpillar 789D truck and MD6250 rotary drill.

C34036
Tyre Handler Testing Rig Stage 2

University of Queensland
Michael Heitzmann
Peter Knights

Value: $97,292
Report Expected: August 2023
Industry Monitor/s: Brendan Wilkins
Rob Fraser
Tim Gray

ACARP Contact: Cam Davidson

The draft final report has been submitted to the Industry Monitors for review.

C34038
Development of Innovative Lock Ring Free OTR Wheel

University of Queensland
Lenny McInnes

Value: $60,000
Report Expected: August 2023
Industry Monitor/s: Brendan Wilkins
Rob Fraser
Tim Gray

ACARP Contact: Patrick Tyrrell

The draft final report has been submitted to the Industry Monitors for review.

Mining and the Community

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

Myuma
Michael Limerick

Value: $199,472
Report Expected: September 2023
Industry Monitor/s: Anthony Galante
Hayden Leary
Weylon Malek

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 research findings were presented at a Queensland Resources Council forum in June, attended by more than 70 resources industry personnel. This was followed by a workshop session, where participants discussed the implications for industry practice and provided feedback on the draft results. The feedback and suggestions are being incorporated in the report. The report will be peer reviewed by a relevant university expert before being finalised for publication and distribution.

Health and Safety

C33008
Relevance and Applicability of Inhalable Dust and Current Issues with AS3640

University of Queensland
Guldidar Kizil
Hsin Wei Wu
Mehmet Kizil

Value: $244,833
Report Expected: September 2023
Industry Monitor/s: Andrew Lau
Bharath Belle
Brad Lucke
Kevin Rowe
Sharif Burra
Tony Egan

ACARP Contact: Patrick Tyrrell

The aim of this project is to investigate the relevance and applicability of inhalable dust monitoring program implemented by Australian coal mining industry at the present, identify any issues with AS3640 - Workplace...
atmospheres - method for sampling and gravimetric determination of inhalable dust, and examine the reason behind the suspension of inhalable dust person exposure limits in the US.

The project will focus on:

• Investigating the relevance of inhalable dust particulates and its adverse health effects associated with exposure of these particulates to CMW.
• Validating the applicability of the inhalable dust monitoring program currently implemented by Australian coal mining industry.
• Identifying any issues with AS3640 (Workplace atmospheres - method for sampling and gravimetric determination of inhalable dust).
• Examining the suspension of inhalable dust person exposure limits in the US.

During the next quarter:

• Prepare two paper submissions for the Mine Ventilation conference as part of technology transfer and sharing with the industry the project outcomes.
• Finalise the draft report for submission.

C35020
Human Centred Interactive Training Experiences in OTR Tyre Handling
ViVA! Health at Work
Sara Pazell

Value: $236,776
Report Expected: September 2023
Industry Monitor/s: Brendan Wilkins, Rob Fraser, Tim Gray, Tony Egan

ACARP Contact: Patrick Tyrrell

The aim of this project is to contribute to resilient tyre maintenance work systems in the global mining community through a human factors analysis of accessible and effective training and learning experiences that depict safety-critical tyre handling equipment operations.

The project objectives are to:

• Gain rich insight into the critical learning requirements (e.g., what does someone need to know and do) to manage safe and productive tyre handling operations, with a focus on mitigating the credible fatal consequences.
• Use human factors findings to inform the instructional design and development of high-fidelity educational content with 15 – 20 learning experiences about safety-critical tyre maintenance activities per an Interactive Product Viewer.
• Determine the utility and impact of interactive training material about tyre handling equipment use and its Required Operating States, Credible Failure Modes, and Business Inputs within a Control Framework (i.e., To examine whether the learning experiences are accessible, comprehensible, meaningful, and manageable).

Activities during the quarter:
The 18 video-based animations (17 plus one compilation video) were finalised, and the collateral was submitted to ACARP. It will be available online to industry through EMERST Tyres and Rims Technical Working Group website hub.

Four more facilitated small-group workshops were held with the subject matter experts, the human factors principal investigator, and the project’s instructional designer. These workshops were held to develop scripts for formative learning elements in the interactive product viewer. We are near completion of this process before the next validation step to review with subject matter experts. The formative learning includes two multiple-choice questions and a true and false question for most scenarios. These features help fulfil the gap in existing educational material.

It was determined that three points of view were needed per camera angles for each scenario to provide a balanced systems perspective: the operator, the tyre technician (spotter), and the birds-eye view to aid the perspective of another system actor, such as an equipment or facilities designer, or a maintenance supervisor. A detailed design guide was developed and submitted for review by the Industry Monitors.

Determinations were made about the methods to evaluate the effect of these educational modules once tested with technicians. These included: a) telemetry (measurements of formative learning results) built into the software functions of the IPV, b) semi-structured interviews to consider the utility of the scenarios and learning experiences, and c) concept mapping with thematic analysis to test the way that users (tyre technicians) organise the work factors (like known fatality hazards and Credible Failure Modes) and their relationships compared with how they were intended to be understood (per the EMESRT Control Framework).

Overburden Removal

C27063
SATS Automated Mission Planning
University of Queensland
Peter Beasley
Ross McAree

Value: $346,046
Report Expected: August 2023
Industry Monitor/s: Brian Neilsen, Shaun Booth

ACARP Contact: Cam Davidson

The draft final report has been submitted to the Industry Monitors for review.
**COAL PREPARATION**

**Maintenance and Equipment**

**C35036**  
*Autonomous Stockpile Dozing: Quantifying Viability*  
University of Queensland  
Ross McAree  

| Value: | $352,797 |  
| Report Expected: | April 2024 |  
| Industry Monitor/s: | Chris Huth, Chris Jackson, Frank Mercuri, Jimmy Pollack, Peter Shumack |  
| ACARP Contact: | Patrick Tyrrell |  

This project looks into the feasibility of using automated bulldozers for coal stockpile operations. Bulldozers are crucial equipment for managing the construction and reclamation of stockpiles. They push material outward from piles created by stackers and later retrieve this material by pushing it back to the reclaim valves. During this work, the bulldozer and its human operator face the risk of being engulfed if it falls into the ratholes formed around reclaim valves.

The vision behind this project is that unmanned semi-autonomous machines would be responsible for planning and executing the material pushing tasks from the piles to the reclaim valves, all while considering supply and demand requirements. In this vision, decisions on when and how the dozers should act would be made autonomously.

The case for this potential semi-autonomous technology rests on two factors:
- the technical feasibility of achieving efficient, effective, and safe operations.
- the business drivers that balance the cost of owning and operating the technology against the potential performance benefits available with automation.

Work completed so far on the project includes the development of a sensor pack and preparations for a field trial to assess the current performance of a bulldozer handling stockpile management. The trial site has been visited twice, and the next step is to complete a lidar survey of dozer that will be used in the trial. Data collection is expected to take place during the current quarter.

**Dewatering**

**C27016**  
*Eriez HydroFloat in Plant Evaluation*  
Eriez Magnetics  
Darren Mathewson, Liam Davis  

| Value: | $155,600 |  
| Report Expected: | September 2023 |  
| Industry Monitor/s: | Han Hooi |  
| ACARP Contact: | Ben Gill |  

The Eriez HydroFloat is a small footprint, high capacity, coarse particle flotation technology capable of recovering coal from a fine (e.g. -2.0 +0.25 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 flotation.

The yields from 19 tests on the TBS feed stream at the first site were very high at an average of 97.1% (ad) at low average product ashes of 8.8% (ad). The tailings ashes were high at an average of 75.4% (ad) and the combustibles recoveries were extremely high at an average of 99.2% (ad). As expected, the greatest variation in yield 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. The Organic Efficiency for the -2.0+0.25 mm fraction was up to 99.7%.

The Whiten equation was curve fitted and showed cutpoints between 1.80 and 2.20 RD with -2.0+0.5 mm Eps of between 0.087 and 0.166 for the four best tests. 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 very first Australian HydroFloat trial, it was also expected that some results would be sub-optimal.

Testing at a second site was delayed and an alternate site is being sought.
Surface Alloying of Centrifuge Baskets and Sieve Bends Screen Surfaces to Increase the Service Lifetime

CSIRO
Andrew Taylor
Mike O’Brien
Teresa Kittel

Value: $131,644
Report Expected: October 2023
Industry Monitor/s: Caitlin Campbell
ACARP Contact: Patrick Tyrrell

The objective of this project is to investigate thin alloyed coatings to stainless steel wedge wire substrates to improve the wear resistance of centrifuge baskets during standard operation. Earlier reports have discussed material selection, optimisation of coating conditions and results from dry sand rubber wheel wear testing.

The final stage of testing that occurred during this recent quarter involved accelerated wet slurry erosion testing. Treated, alloyed stainless steel wedge wire surfaces were produced as coupons and basket sections. These coatings were tested alongside untreated stainless steel wedge wire for comparison. The wet slurry erosion testing was selected in place of in-service testing.

Experimental work has been completed and the final report is being drafted.

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

University of Queensland
Liguang Wang

Value: $157,400
Report Expected: August 2023
Industry Monitor/s: Jason Schumacher, Josh Kowalczuk
ACARP Contact: Ben Gill

The draft final report has been submitted to the Industry Monitors for review.

Tailings Management - Dewatering Flume Site Trials

University of Newcastle
Craig Wheeler

Value: $242,500
Report Expected: September 2023
Industry Monitor/s: Kevin Rowe, Peter Shumack
ACARP Contact: Patrick Tyrrell

The objective of this project is to further refine and conduct site trails of a dewatering flume developed in C27067. The aim of the flume is to increase the solids content of the tailings entering the tailings dam and recover water before it is deposited in the tailings dam. The recovered water would be recycled back to the CHPP as process water, thus limiting the volume of water stored in the tailings dam and reducing, or eliminating, the use of secondary flocculant in the tailings dam.

Onsite testing is complete, and the final report is currently being prepared.

Process for Separating and Dewatering Fine Particles

University of Queensland
Liguang Wang

Value: $177,400
Report Expected: September 2023
Industry Monitor/s: Michael Carnell
ACARP Contact: Ben Gill

The draft final report has been submitted to the Industry Monitors for review.

Efficient Reagents for Disposal of Coal Tailings – Phase 2: Pilot Scale Studies

University of Queensland
Anh Nguyen

Value: $180,000
Report Expected: August 2023
Industry Monitor/s: Brodie Chapman, Tom Wilson
ACARP Contact: Patrick Tyrrell

The objective of this project is to deliver further progress and developments of projects C27065 and C28054. In phase I, we developed a new technique to screen suitable chemicals for disposal by measuring the sample yield stress, strength via the peak force, and stickiness via the tack energy. In phase II, we will focus on extending pilot-scale testing to a belt press filter - BPF (and continuing the work with solid bowl centrifugation - SBC)
and collaborating with chemical suppliers on designing, testing, and screening new, efficient reagents for disposal of coal tailings. They will help to achieve efficient handleability and disposal stability. The knowledge gained from this project will help develop simple on-site tools to assess the consistency of tailings that are suitable for stable disposal and to support decision-making on the allocation of the current tailing stream.

The draft final report has been submitted to the Industry Monitors for review.

C33048

University of Newcastle
Jubert Pineda

| Value: | $232,600 |
| Report Expected: | October 2023 |
| Industry Monitor/s: | Jianping Li, Kevin Rowe, Leonie Bradfield |
| ACARP Contact: | Ben Gill |

This project focuses on commissioning laboratory testing equipment to generate high-quality data, from which a new state-of-the-art model for the mechanical characterisation of CHPP wastes can be developed. The laboratory equipment includes stress-path triaxial cells equipped with advanced systems for controlling/measuring soil suction whose results may be used to formulate a Critical State Soil Mechanics (CSSM) model able to predict the behaviour of fine wastes under saturated but also unsaturated conditions.

Over the past quarter we have continued with the suction-controlled tests on Dewatered Tailings (DT) but also we have commenced the unsaturated triaxial tests on MPR samples. Eight suction-controlled tests and 3 fully saturated tests on compacted DT samples have been completed using the 2 GDS® triaxial devices recommissioned for this project. Test results on DT samples are summarised in Figure 1. All specimens were compacted to the same initial density and water content (i.e. suction). Then, loading and suction (drying) paths were applied prior to shearing as indicated in Figure 1(a).

The variation of the volumetric strain during the loading and suction paths is shown in Figure 1(b). Specimens were sheared under constant water content conditions. As reported before, the stress-strain curves shown in Figure 1(c) demonstrate the increase in soil’s shear strength with suction. For a given mean net stress, the higher the initial suction before shearing, the greater the peak deviatoric stress. Figure 1(d) presents the variation in volumetric strain during shearing for the 8 suction-controlled tests completed on DT samples. Volumetric compression is observed in almost all tests performed under suction controlled conditions, with only one test showing significant dilation. The evolution of soil suction during shearing is shown in Figure 1(e), in which suction clearly reduces upon ‘undrained’ shearing, to the point where initially unsaturated specimens may reach very high degrees of saturation. Figure 1(f) reports the stress path in the q – p’ plane. Results from 3 fully saturated tests are included.

We have also started the testing on MPR specimens. Results for 3 suction-controlled tests and 1 fully saturated test on MPR samples are summarised in Figure 2. The same experimental protocol described for DT samples was followed on MPR specimens. Figure 2(a) shows the suction and loading paths applied. Axial and volumetric strain measured during suction and loading paths are shown in Figure 2(b). The stress-strain curves obtained during shearing are presented in Figure 2(c). As observed on DT specimens, the stress-strain curves are strongly affected by the initial suction and confining stress. The volumetric response measured during shearing (Figure 2(d)) shows that, for a given suction, soil compression takes place at high confining stresses whereas dilation seems to occur at low stresses. Suction reduces upon shearing but, for the conditions tested, suction remains greater than zero when peak conditions are achieved. Figure 2(f) reports the stress paths in the q – p’ plane which show good consistency.

Unsaturated triaxial tests results obtained on DT and MPR samples show a remarkable consistency and confirm the good performance of the unsaturated triaxial devices recommissioned for this project.

The completion date for this project is 25th September 2023. In the next 7 weeks we will complete the remaining suction-controlled tests on MPR samples and prepare the final report. No delays in the submission of the final report are expected.

Figure 1. Results of triaxial test performed on compacted dewatered tailings (DT) from ‘mine site 1’
C33049
Emerging Pulsed Power Technology for Dewatering Mineral Tailings
University of Queensland
Mansour Edraki

Value: $277,630
Report Expected: May 2024
Industry Monitor/s: Dan Delahunty
Jack Lauder
ACARP Contact: Ben Gill

The aim of this project is to use pulsed electric fields to liberate water bound within, or to, the mineral and organic components of coal tailings. In the process, electrical energy stored in a system over a long time, is released within a fraction of a second, and a massive amount of peak power, a powerful pulse with a short pulse width, is delivered to tailings.

New coal tailings samples were received and dewatering tests on new samples is underway.

C33050
Dewatering Efficiency of Fine Flotation Concentrates by De-Aerating Froth Products - Plant Demonstration
University of Queensland
Yongjun Peng

Value: $627,923
Report Expected: January 2024
Industry Monitor/s: Frank Mercuri
Naresh Racha
Shivank Vijayakumar
ACARP Contact: Ben Gill

The objectives of this project are to:
- Develop large demonstration-scale mechanical and vacuum deaerators which are fully automated and can run continuously in plants.
- Identify optimum operating conditions and control strategies through continuous plant trials.
- Evaluate and optimise equipment stability, wear, maintenance requirement and operational costs.
- Identify equipment size and key parameters for future full-scale operation in plants.

The vacuum deaerator has arrived in Australia and the electrical and mechanical tests based on national requirements have been completed. Upon obtaining the approval from the mine site, the vacuum deaerator will be delivered to the site. The mechanical deaerator has also arrived in Australia and the electrical and mechanical tests on the deaerator have been organised.

In addition, the experiment work for the plant trials to achieve the project objectives has been planned.

C33051
Hybrid Microwave Technology for Dry Stacked Tailings Applications
University of Queensland
Christian Antonio

Value: $121,335
Report Expected: January 2024
Industry Monitor/s: Frank Mercuri
Kevin Rowe
Naresh Racha
ACARP Contact: Ben Gill

One of the most pressing challenges facing the mining industry today is the increasing frequency of catastrophic tailings dam collapses. Such events are known to cause significant environmental damage as well as loss of life. There is a strong industry push to move away from wet tailings dams to drier and safer options. A viable alternative to tailings storage in dams is Dry Stack Tailings (DTS) technology.

This project proposes a new approach that could reduce tailings moisture contents to levels required for dry stacking – the use of Hybrid Microwave Technology. This approach combines microwave treatment with conventional dewatering techniques. This method could bridge the moisture content gap between conventionally dewatered material and Dry Stack Tailing requirements.

The project aims to evaluate the feasibility of a continuous process and measure the energy requirements to achieve different product moisture content. Finally, it will provide a concept for a microwave-assisted dewatering process for future research studies.

Progress during this quarter include:
- To confirm the results of the splitting undertaken in the last reporting period, another trial on the 250mm Semi-Inverted hydrocyclone (SIV) was done. The results indicated the best condition tested that maximised separation of the fine material was achieved at 100kPa with an 80mm spigot. The samples produced (feed, overflow and underflow) from this test will be used for subsequent drying trials.
• Microwave drying of the as-received Solid Bowl centrifuge cake and decanted SIV samples (feed, overflow and underflow) material was undertaken at different microwave powers (0.5-2.0kW) and time. An example of a drying curve vs. time for different MW power is shown in Figure 1.

• Microwave coupling efficiency was found to decreases as the sample’s moisture content reduced. An Autotuner was implemented during microwave processing to ensure good microwave coupling with the sample as drying proceeds. The incident, absorbed and reflected power data were collected to obtain the coupling efficiency. An example of the autotuner output is shown in Figure 2.

• The SIV samples are currently undergoing different water removal techniques (pressure filtration, centrifuge) prior to microwave drying trials in batch and continuous modes.

Figure 1: An example of a drying graph for the as-received SB Cake at different MW powers

Figure 2: Incident, Absorbed and Reflected power measured during microwave drying

C33053
Improving Centrifugal Dewatering via Modelling and Analysis

University of Queensland
Liguang Wang

Value: $149,400
Report Expected: September 2023
Industry Monitor/s: Clinton Vanderkruk
Colin Surawski
Josh Kowalczuk

ACARP Contact: Patrick Tyrrell

The objectives of this project are to:
• Develop a capability for modelling and simulating dewatering and size classification of full-scale screen bowl centrifuge.
• Validate the model through pilot-scale trials, followed by full-scale trials if feasible.
• Provide a guide to flowsheet design and industrial operation of centrifugal dewatering.

In the quarter, the team further refined the centrifuge model for predicting product moisture and solids loss in the effluent stream of both the solid bowl centrifuge and screen bowl centrifuge. Using the refined model, the team was focused on developing a guide for centrifugal dewatering. More specifically, an in-depth analysis was undertaken to assess the influence of various operational parameters towards the dewatering performance. The parameters evaluated include feed particle size distribution, feed flow rate, feed solids content, differential speed, and pool depth.

At a given feed throughput, the simulation results suggested that variation in feed volumetric flow rate and feed solids content had minor effects on the dewatering performance (i.e., solids loss of the effluent stream and product moisture). They also suggested an optimum feed flowrate and an optimum differential speed, and there were differences in response of the screen bowl centrifuge and solid bowl centrifuge to an increase in the throughput.

The final report is expected to be submitted in the next quarter.
The application of coagulation, flocculation, and mechanical dewatering units such as belt press filters (BPF), centrifuges, and horizontal belt filters (HBF) is currently used by industry as a practical approach for dewatering coal tailings. However, there are still challenges that limit dewatering of coal tailings which affects the performance of these dewatering processes. These include the presence of clay materials, elevated fines and ineffective coagulation and flocculation methods, amongst others.

This project aims to develop a technologically and economically viable approach to reduce moisture content and capture fine clay particles in tailings to improve tailings dewatering outcomes, by using Semi-Inverted (SIV) Hydrocyclone Technology, followed by coagulation, and flocculation. The study aims to use the SIV to split a tailings sample into a coarse stream (underflow product), with reduced moisture content, and a clay-rich fines stream (overflow product). This will enable targeted processing of the two streams that could consequently improve the efficiency of downstream dewatering units. A potential tailings sample has been received for evaluation for use in this project.

Progress during this quarter include:
- Additional coal tailings sample was provided by the sponsor for the testing (16 x 200lt drums). The solids content of the new material is approximately ~36%. A sample has been sent for analysis to determine clay content.
- For consistency, the previous test on a 250mm Semi-Inverted hydrocyclone (SIV) was repeated using the new sample. The testing parameters tested were SIV inclination (40°, 85°, 130°), Pressure (60-100kPa) and a spigot size of 70mm. The flowrates obtained during the test varied between 55-72 m³/h. Figure 1 shows some images during the tests.
- The feed, overflow (OF) and underflow (UF) products from each test were taken and currently being prepared for moisture and solids content, particle sizing and downstream coagulation/flocculation tests.
- Partition curves will be generated using JKSimMet to assess the water splits and efficiency of the cyclone with respect to the different operating conditions.

- A testing apparatus to perform coagulation and flocculation of the samples has been sourced. The test will be undertaken using coagulant/flocculant chemicals provided by the mine site. Turbidity measurements of the supernatant will also be undertaken.

Figure 1: Coal slurry in mixing tank (left), SIV at an angle of 85° (right)

C35032
Improving the Dewatering of Fine Coal Tailings by Minimising Micro-Nano Bubbles

University of Queensland
Yongjun Peng

Value: $238,470
Report Expected: January 2025
Industry Monitor/s: Han Hooi, Naresh Racha, Tom Henshaw
ACARP Contact: Ben Gill

The project aims to improve the dewatering efficiency of fine coal tailings by minimising micro-nano Bubbles. In this quarter, a start-up meeting was conducted with the project monitors to plan the project. The project monitors recommended three mine sites equipped with different dewatering systems for case studies in this project.

Researchers have visited one of the three mine sites, gathered information about the dewatering issues, operational and tailing systems, and also collected samples for lab tests. We have also started to set up lab facilities for test work.
Environmental Improvement

C29042
Tailings to Topsoil

University of Newcastle
Ken Williams

Value: $350,000
Report Expected: August 2023
Industry Monitor/s: Bill Baxter
Paul O’Loughlin
Phillip Enderby

ACARP Contact: Patrick Tyrrell

The draft final report has been submitted to the Industry Monitors for review.

C35019
Utilisation of Coal Mining Tailings in Australian Cement Production

Central Queensland University
Hassan Baji

Value: $277,017
Report Expected: October 2024
Industry Monitor/s: Kevin Rowe
Luke Dimech
Shaun Booth

ACARP Contact: Patrick Tyrrell

This project proposes a new framework of the circular economy and sustainable development by incorporating coal mine tailings as an alternative raw material in cement and concrete production instead of being a source of risk in polluting the environment. The solution proposed in this project will lead to the conservation of finite natural resources extensively used in the construction industry and to reduce the environmental impacts related to mining wastes. The project, in partnership with Holcim Australia and Cement Australia, has two major parts. In the first part, the use of coal tailings (treated and untreated) as a supplementary cementitious material (SCM) will be investigated, while in the second part the feasibility of utilisation of the coal tailings as a raw material in production of Portland cement will be explored.

During the quarter, coal tailings from four different sites were delivered to CQU. Other raw materials, e.g., silica fume, limestone, and sand, were provided by Cement Australia and Holcim Australia. Suitable treatment (drying, milling and calcination) has been conducted on coal tailings for a wide range of temperatures and grinding times. After the treatment, proper mixes for pozzolanic reactivity tests were prepared and tested to obtain the optimum treatment method. The reactivity testing is undergoing with most of reactivity tests have already been completed. The results are being analysed for summarising the reactivity tests. Raw and treated samples are under investigation for determining particle size distribution at CQU laboratory. Further samples are being processed at WSU to determine the chemical and mineralogical compositions of raw and treated samples using XRF and XRD techniques. Preparation of mortar samples to determine the Strength Activity Index (SAI) using raw and treated coal tailings is undergoing at CQU and Charles Strut University. Finally, literature review on the utilisation of coal tailings as a raw material in cement manufacturing is ongoing.

C35033
Non-invasive and Real Time Monitoring of Slurry Tailings Density and Velocity in the Transmission Pipeline using Electrical Resistance Tomography Method

University of Queensland
David Williams

Value: $259,000
Report Expected: March 2025
Industry Monitor/s: Angus Morrison
Naresh Racha
Peter Shumack

ACARP Contact: Patrick Tyrrell

The objective of the project are to:
- Develop a resistivity inverse model that converts the longitudinal and cross-sectional resistivity tomography of coal slurry to its density and velocity, accounting for the effects of temperature, EC, air content and coal tailings mineralogy.
- Test the system at a coal transmission pipeline for in situ and real-time monitoring of the slurry transport conditions.
- Verify the monitored results with those obtained using concurrent technologies.

Work during the quarter:
- The coal tailings from Stanwell were delivered to the UQ geomechanics laboratory. The pH and electrical conductivity of the coal tailings sample were tested. This dataset forms the basis for the selection of an electrical resistivity tomography system.
- A purpose-made settling column with 1.5m in height and 0.2 in diameter is under construction. This large column will be used to carry out settling tests of coal slurries, where tailings density increases as it settles from slurry form to solids form. The electrode ring will be installed as a section of the column to measure the changes in the electrical resistivity of the settling sample over time.
- UQ team has started the advertisement to engage RHD students working on this project.
- The team have contacted a few suppliers for identifying the best set of electrical resistivity tomography device that can effectively measure resistivity from the pipeline with flowing slurries.
Cost Effective Rehabilitation of Tailings Dams

CSER Research
Carmen Castor
Mike Cole

Value: $973,580
Report Expected: March 2027
Industry Monitor/s: Andrew Lau
Shaun Booth
Trent Cini

ACARP Contact: Patrick Tyrrell

This project develops the research undertaken in C27009, C29041 and C34030 towards a possible conclusion allowing cost-effective closure of tailings dams. It will aim to assist in developing a final land use plan with each mine and further test tailings amelioration techniques to maximise success for the native vegetation used. In addition, we will work to maximise plant and soil biodiversity of the dams and their surrounds.

In the last three months we have been developing baseline and research timelines for the Bowen Basin and Hunter Valley dams. These are yet to be finalised with the mines and Monitors. This will contribute to landscape planning with the mines and planting plans which we seek to commence this year with those plants available. This will be further developed as the project continues.

An aim of this work is to develop, not only diversification of the dams and their surrounds, but a successional zonation plan to allow ‘more natural’ community development. Literature studies and plans for laboratory investigations together with collection of root associations are being developed to include the use of microbes involved in sustainable nutrient acquisition and cycling to support vegetation of tailings dams. In addition, we are exploring the possible use of dams for the two extreme outcomes of ‘drying the dams to death’ to speed up conventional capping or ‘development of an ecological community’ for its environmental value and expected cost reduction for closure.

Full Scale Trial of the Reflux Flotation Cell

University of Newcastle
Kevin Galvin

Value: $294,820
Report Expected: August 2023
Industry Monitor/s: Clinton Vanderkruk
Kevin Rowe
Luke Dimech
Penny Walker

ACARP Contact: Patrick Tyrrell

The draft final report has been submitted to the Industry Monitors for review.


University of New South Wales
Seher Ata

Value: $295,750
Report Expected: August 2023
Industry Monitor/s: Jenny Park
Peter Shumack

ACARP Contact: Patrick Tyrrell

The draft final report has been submitted to the Industry Monitors for review.

Measuring and Correlating CGA Data at Particle Topsize

Basacon Services
Bruce Atkinson

Value: $55,444
Report Expected: August 2023
Industry Monitor/s: none
ACARP Contact: Patrick Tyrrell

The draft final report has been submitted to the Industry Monitors for review.
C29055  
Froth Flotation of 4mm Feed Coal Particles  
University of Newcastle  
Graeme Jameson  
Value: $198,000  
Report Expected: August 2023  
Industry Monitor/s: Frank Mercuri, Jason Schumacher  
ACARP Contact: Patrick Tyrrell  
The draft final report has been submitted to the Industry Monitors for review.

C29061  
Improving Flotation Recovery and Throughput with a Combined Method  
University of Queensland  
Liguang Wang  
Value: $199,000  
Report Expected: October 2023  
Industry Monitor/s: Clinton Vanderkruk, Doug Field-Akred, Kevin Rowe  
ACARP Contact: Patrick Tyrrell  
The objectives of this project are to:  
• Develop and assess a method combining the use of oscillatory air supply and vibrators for further improving the flotation recovery and throughput.  
• Prove the new method on an industrial scale.

Approval from a site to do the in-plant trials in continuous mode is pending. An interim report has been submitted for Industry Monitors for feedback.

C29065  
Wash Plant Fines Testing Methods Enhancement  
McMahon Coal Quality Resources  
Chris McMahon  
Value: $197,330  
Report Expected: October 2023  
Industry Monitor/s: Frank Mercuri, Jason Schumacher  
ACARP Contact: Patrick Tyrrell  
This project seeks to better determine predictive size distribution on small samples by testing multiple enhanced attrition apparatus and methods.

Originally a new “attrition” apparatus was to be designed, manufactured and trialled on “unbroken” coal (from strip samples and / or borecores supplied) and compared against plant feed / in-plant samples and standard laboratory drum tumbling test outcomes. CHPP operations data and operator expertise in relation to predictive/actual size distributions will also will be sought, documented and used in the planning and evaluation stages.

On further consultation with industry and examination of potential for building such an attrition apparatus, the process has evolved to test existing laboratory attrition processes in elevated time allotments, and the gauging of increased attrition effects compared with CHPP outcomes.

The attrition apparatus now being evaluated include additional drop shatter, dry and wet tumbling, sieving and use of a coke testing “Micum” tumbling drum. Individual and compounding effects (fines generation increase) will be examined.

Two potential coal sources have been confirmed. Source I has had sample retrieved, dispatched to the laboratory, methods confirmed and issued, and testing of all Stages (1, 2 and 3) now completed. Source II has had sample retrieved, dispatched to the laboratory, methods confirmed and issued, and testing of Stage 1 and Stage II completed, and Stage III to be completed during August.

Lab processing of samples (final Stage IV to come after confirmation of Stage III results) is expected to be completed by November 2023, with draft reporting due late March 2024.

The outcomes of this project will be testing of each attrition apparatus with attained bore core / in-pit site samples, and comparison of outcomes with both current methods of processing and CHPP actual outcomes (pre-plant / estimated in-plant). Methods for use of such will be produced for application to routine unbroken coal predictive samples (borecores and strip samples).

C33055  
Optical Profiling of Coal and Mineral Particles in the Ultrafine Circuit for Online Analysis  
University of Newcastle  
Rohan Stanger  
Value: $157,387  
Report Expected: October 2023  
Industry Monitor/s: Clinton Vanderkruk, Jason Schumacher, Michael Carnell  
ACARP Contact: Patrick Tyrrell  
This project aimed to extend our Particle Profiling system to the ultrafine particle region with hardware upgrades and software additions. Conceptually, the intention was to introduce a number of characterising features to enable particle component differentiation on shape and colour/greyscale. The goal was to enable both coal and mineral detection.

This project has been extended following a recent meeting with monitors. The intention is to test the
systems capabilities on industrial samples supplied by the monitors.

All industrial ultra-fine circuit samples (flotation, thickener feed) have been received and Particle Profiling analysis has begun.

**C33058**

**Full Scale Studies of Diesel Emulsification by Ultrasonication for Fine Coal Flotation**

**University of Queensland**
Anh Nguyen

| Value: | $180,000 |
| Report Expected: | September 2023 |
| ACARP Contact: | Patrick Tyrrell |

The objectives of this project are to:
- Examine the adaptability and feasibility of incorporating a full-scale ultrasonic unit into the flotation process of an Australian coal preparation plant. Prove the superiority of ultrasonic emulsification to other mechanical methods.
- Scan effective surface-active agents for diesel dispersion using the ultrasonicator. Examine the compatibility of the utilised reagents with frothers and saline process water.
- Optimise the fraction of diesel, surfactants, and water to produce stable oil-in-water emulsions, which improve the flotation of low-rank fine coal.
- Optimise the operational parameters of the ultrasonic device including the ultrasound amplitude, reaction time, and the addition point.

Additional full-scale tests for diesel emulsification and flotation in a coal flotation circuit at a coal processing and handling plant in Queensland were completed in July. These additional tests were delayed due to the unavailable access to the platform where the emulsifier was located at the plant. The team is now working on the final report and will submit it for review by mid-August.

**C34002**

**Full Scale Beneficiation of Coal Fines by Novel Agglomeration**

**University of Newcastle**
Kevin Galvin

| Value: | $3,283,000 |
| Report Expected: | February 2024 |
| ACARP Contact: | Patrick Tyrrell |

The objective of this project is to investigate the scale-up of a novel fine coal agglomeration technology through a study at full-scale. The project involves the design, commissioning and operation of the novel agglomeration technology. The feed source is expected to be a fine coal tailings stream suitable for the thermal market. The study will quantify the scale-up at 500 m³/h in terms of yield, ash, moisture and economic benefits.

The novel agglomeration technology offers the prospects of a low capital investment for processing the fine coal tailings stream normally sent to the thickener. The agglomeration can be achieved by pumping the slurry and novel binder through an orifice plate in a pipe. Oil consumption is an order of magnitude below conventional requirements, while the final product moisture is lower than the usual level.

The initial program of work will consist of the design phase and equipment selection. The second phase of the project involves the tender process, followed by the construction and commissioning of the plant. The final stage involves the project phase.

Concerns regarding a potential cost increase for the MCC were evoked by aligning the research facility and site requirements, allowing for cheaper components. However, the project incurred a notable delay associated with the preparations for the site works, specifically the core sampling required for the design of the concrete pad. Design work proceeded ahead of the analysis to recover some of the lost time. Nevertheless, the sequence of events that followed led to an estimated project delay of 6-8 weeks. Several of the major equipment items have been fabricated in preparation for installation in the new year. Other items have incurred a delay, and cost increases have been identified, and are under review.

Civil construction work has been completed, and major equipment items delivered to site and installed including the emulsification column, pumps, trough, tanks, and MCC. The feed Y-piece connection has been completed. Mechanical completion of the facility was achieved following the arrival of hire items such as the RO facility, and generator. The electrical work has been completed.
following mechanical completion. Dry and wet process commissioning have been completed. Safety systems to address the delivery, storage, management and handing of RO chemicals are being finalised. Full commissioning is likely to occur within the next two weeks. The research program will then follow.

C34040
Optimising the Diesel Droplet Size in Coal Preparation Plants

University of Queensland
Yongjun Peng

Value: $231,157
Report Expected: December 2023
Industry Monitor/s: Albert Blom, Han Hooi, Jason Schumacher

ACARP Contact: Ben Gill

The objectives of this project are to:
• Develop full-scale emulsification systems incorporating the online droplet size measurement;
• Determine the optimal diesel droplet sizes in representative coal preparation plants varying with coal type, water salinity and diesel dosing through statistically designed ON/OFF trials;
• Identify the most efficient and economic diesel dispersion system to achieve each optimal droplet size;
• Develop the most suitable diesel dispersion strategy for each representative plant through an assessment of flotation improvement, reduction of diesel consumption, hurdles to implementation (e.g. safety, ease of installation and conversion, ease of operation) and capital and operating costs.

The mechanical and electrical certifications for the emulsification device have been obtained. The device arrived at a coal preparation plant on 1st August, and the installation and testing processes for the device are currently in progress.

UQ researchers have developed a plan for the plant trial, aiming to achieve the second to fourth objectives of this project. This plan was reviewed by Industry Monitors on 11th July. The plant trial is expected in the middle of August.

C34041
Coal Spiral for the 2020s

Mineral Technologies
Ian Mangelsingdorff
Wendy Nutt

Value: $199,646
Report Expected: April 2024
Industry Monitor/s: Dan Delahunty, Naresh Racha, Phillip Enderby

ACARP Contact: Ben Gill

The objective of the project is to develop an enhanced coal processing spiral incorporating learnings from recent improvements in spiral design used in other mineral processing operations.

After an extended delay due to personnel resourcing (covid, maternity leave and other long term illnesses) and equipment resourcing (coal spirals can only be tested in a particular rig due to their large diameter) and an extended Christmas shutdown period (imposed company wide), the timeline has been updated with resourcing levels and anticipated future shutdowns factored in.

Coal characterisation and baseline testing of coal samples on Mineral Technologies’ current suite of coal spirals and the CT1 spiral model has been completed.

Points to note:
• Coking coal feed;
  o LC3 4 turn out performed LD7 4 turn at similar feed rates;
  o LC3 8 turn out performed the LD7 RC at higher feed rates;
  o CT1 was able to handle a wide range of feedrates (up to 5tph) of material and achieved some separation between product and reject material;
• Thermal coal feed;
  o LC3 4 turn out performed LD7 4 turn at similar feed rates;
  o LC3 8 turn performed similar to the LD7 RC but at higher feed rates;
  o CT1 was able to handle a wide range of feedrates (up to 5.6tph) of material achieved some separation between product and reject material;
• Other coal feeds have been requested:
  o Unfortunately, one sample took the most scenic route possible via Perth! We are 3 weeks behind on where we were hoping to be due to this delay.
  o A Qld site sample has now been received and base model CT1 testwork has been completed, ash samples have been dispatched for analysis.

Due to the nature of the CT1 spiral injection moulded segments, modifying the base design at this early stage is not a likely benefit until we have established the boundaries of performance. The additional benefit is that we can create many spiral configurations with the
current set up before we embark on a new injection mould design. We are 3D printing new internal parts to test in the current configuration to assist with establishing the boundaries of what a new design would require, which will keep the project moving forward on the current timeline.

A new spiral configuration will be constructed based on the results achieved to date and the test work repeated in the next quarter with our existing Queensland site sample and the New South Wales site sample when it arrives.

C34043
In Plant Demonstration of the Next Generation Flotation System
University of Queensland
Liguang Wang

Value: $258,347
Report Expected: July 2024
Industry Monitor/s: Kevin Rowe
Nic Roberts
ACARP Contact: Ben Gill

The objectives of this project are to:
• Build a prototype of the next-generation flotation system with low energy and maintenance requirements for coal preparation; and to
• Demonstrate the prototype in a coal preparation plant.

The construction of the apparatus for characterising the size of bubbles generated using a novel sparging system is about to begin at the UQ mechanical workshop. It is expected that the completion of the construction will be done and some gas dispersion results obtained in the following quarter.

The design of the pilot scale flotation system is still awaiting engineering feedback and approval from a participating site.

C34045
Real Time Automatic Measurement of Frother Distribution in a Coal Preparation Plant
University of Queensland
Liguang Wang

Value: $124,560
Report Expected: September 2023
Industry Monitor/s: Chris Denyer
Peter Shumack
ACARP Contact: Ben Gill

The objectives of this project are to:
• Build a prototype for real-time automatic measurement of frother concentration; and to
• Evaluate and demonstrate the prototype at a participating site to maximise coal recovery and prevent the overfrothing (‘froth out’) problem.

In the quarter, the team made an initial site visit to examine the adequacy of the existing formulation for frother concentration measurement. During the visit, the team collected multiple slurry samples across the CHPP. Immediately after that sample collection, the team removed particles larger than 0.45 μm from the sample slurry using disposable filters. The efficacy of various types of disposable filters (i.e., with various pore sizes, membrane materials and filter areas) was evaluated.

The filtered process water samples were brought back to The University of Queensland for frother concentration measurement. The measured frother concentrations of the samples collected from the return water dam, tailing thickener overflow (i.e., clarified water), and flotation feed before MIBC addition were communicated with the site personnel. The results confirmed the adequacy of the existing formulation for the MIBC concentration measurement for process water samples from the site.

The team also consulted the electrical and process engineers from the site to improve the design of the prototype unit of the automatic MIBC measurement device.

In the following quarter, the team will finalise the design of the prototype and start its construction.

C35031
Demonstrating Better Classifying Cyclones
Elsa Consulting Group
Andrew Swanson
Andrew Vince

Value: $377,475
Report Expected: April 2026
Industry Monitor/s: Clinton Vanderkruk
Jack Lauder
Jenny Park
Jimmy Pollack
ACARP Contact: Ben Gill

The overall objective of this project is to leverage off the significant past ACARP expenditure on better classifying cyclones, to build and demonstrate the industrial benefits of the new Rong Classifying Cyclone Concept (RCCC) at an appropriate scale, namely 380 mm diameter cyclone. Specifically, coal-independent performance efficiencies will be determined using: 1. Size separation partition curves and related characteristic parameters α, d50 and Rf 2. Size-by-size Tromp curves and related characteristic parameters d50 and Ep. These will then be used as benchmarks to compare against such curves generated by existing technologies.
The first stage of the project is to determine small-detail RCCC design adjustments impact on capacity/pressure/metallurgical performance characteristics prior to unit construction and testing. To do this, Western Sydney University (Centre for Infrastructure Engineering, School of Engineering) have been engaged to develop a discrete element model (DEM). Early results suggest that, conceptually, the RCCC design leads to more efficient metallurgical separations when compared to existing concept classifying cyclones. This confirms what was expected, and further work, following the original project plan, is underway to specify detailed 380mm diameter RCCC dimensions for construction of a 380mm test cyclone.

Parallel work has also commenced on designing the ALS pilot plant reconfiguration required to facilitate the testing when the 380mm test unit is constructed.

C35034
Working Effectively with Swelling Clays in Fine Coal Flotation to Improve Product Quality and Recovery

University of Queensland
Anh Nguyen

Value: $200,304
Report Expected: September 2024
ACARP Contact: Ben Gill

The objectives of this project are to:

- Characterise clay types and compositions, clay-coal liberation, and surface properties of three clay-rich fine coal samples from three mines. Rerinding and recharacterisation will be performed as required to achieve reasonable liberation for efficient flotation separation.
- Screen/design and test specific (natural and synthetic) chemicals to remove slime coatings of clay minerals from coal particles to facilitate clay-coal separation by flotation. Small-scale experiments on clay-coal-bubble attachments will be conducted to quickly establish the efficiency of the chemicals in conjunction with pilot-scale flotation experiments (below).
- Design matrices of pilot-scale test works and conduct the experiments using three major flotation devices, namely, a mechanical cell, a Microcel, and a Jameson cell for evaluating and benchmarking the flotation technologies, the chemicals, the clay types, and liberation degrees in terms of ash contents and combustible recovery vs. size.
- Design, conduct, and evaluate hydrodynamics of washwater and its performances vs. washwater bias and residence time (froth depth and circulation) for washing off swelling clay particles that mechanically entrained into the froth phase.

The project activities have been focussed on the first objective: collecting coal samples from coal mines and characterising them. At a meeting held in June, it was discussed that it would be critical to look at the clays present in the samples and how much, and to check if oxidised coal was not present. That would help inform which samples would be best to move forward with the extensive trails and will aid in the range of suppressants selected. In place of three samples proposed, nine samples would be collected and delivered to the team. They will cover a full range of coal types in this first pass: Hard Cooking Coals, PCI/Mid Cooking Coals and Thermal Coal. These coal samples together with process water samples have been being collected by the mine site staff and delivered to UQ.

C35035
3D Particle Surface Composition Analysis for Flotation Using Micro CT

University of Newcastle
Rohan Stanger

Value: $81,730
Report Expected: June 2024
Industry Monitor/s: Araz Ejtemaeei
ACARP Contact: Ben Gill

This project aims to characterise a suite of plant flotation samples using microCT surface analysis. The technique involves determining the composition (vitrinite, inertinite, mineral content) at each particles surface interface. The project will focus on +38um material for this technique development to suit this microCT instrument resolution.

The project has performed an initial trial characterisation of feed/product/reject material from an industrial flotation circuit. It was found that the instrument settings used for fine circuit spiral samples are not suitable for ultrafine particles. This means that further maceral calibration is needed under these new test conditions. A new form of sample preparation was found to be needed to present particles so close to the x-ray source. Otherwise, the current samples appeared to be well resolved and capable of determining surface composition (see Figure 1). The next body of work will calibrate with known maceral concentrates and evaluate different size ranges for remove agglomeration during drying. Figure 2 shows a preliminary surface analysis of the feed sample.
Figure 1. Industrial flotation sample suite (+38um) scanned with microCT. The product sample appears to have a number of agglomerated particles (likely from drying process). As a point of reference, each sample is wrapped in several layers of sticky tape.

Figure 2. Surface and volumetric particle analysis using micro-CT; shown for flotation feed sample. This indicates that the surface of particles may contain less high grade coal relative to their volume.

Gravity Separation

C33054
Measurement of DMC Wear Using 3D Laser Technology

CSIRO
Andrew Taylor

Value: $173,022
Report Expected: September 2023
Industry Monitor/s: Luke Winkelman, Peter Shumack, Phillip Enderby

ACARP Contact: Patrick Tyrrell

The objective of this project is to identify and adapt current commercial 3D laser technology to produce a device/instrument configuration capable of mapping the internal dimensions of a Dense Medium Cyclone (DMC) to an accuracy better than 1mm without the need personnel to enter the enclosed space of the DMC. An adjustable telescopic scanner mounting system has been built and taken to a CHPP allowing the commercially available scanning unit to be deployed inside the refurbished DMC in situ in a plant environment, during a normal shutdown shift, after almost three months of operation. The resulting scans have been compared to the original scans of the ‘as new’ DMC prior to going into operation. Wear patterns can be observed when the data is analysed. And Proof of concept has been achieved. The final report has been written and will be submitted shortly.

Figure 1. Modelled wear patterns in a DMC scanned using laser scanning. Increased wear is noted around the spigot area which is to be expected.

Figure 2. Adjustable telescopic mounting system for DMC Scanning mounted inside the shroud.

C33056
Modelling and Control of Classifying Cyclones

Ausenco Services
Andrew Swanson

Value: $227,080
Report Expected: January 2024
Industry Monitor/s: Colin Surawski, Michael Carnell, Naresh Racha

ACARP Contact: Patrick Tyrrell

The objectives of the project are:
• Interpretation and evaluation of CGA data will allow the modelling of cyclone performance to be further developed to better understand behaviours of finer particles both in terms of size and density;
• New data from small diameter cyclones will allow the utilisation of these cyclones in fine coal treatment to be better appraised;
• The use of CGA as a technology to investigate cyclone performance and operation will be assessed;
• By examining cyclone performance, along with a review of on-line measurement techniques and a range of sample testing methodologies, it is hoped
that improved approaches to managing cyclone operational efficiencies will be identified;
• If justified, the scope for a detailed large-scale evaluation will be developed.

The project is currently experiencing delays resulting from an issue accounting for all the -5 micron material in the CGA samples. A mathematical correction has been used to complete the preliminary analysis on one sample to complete a paper of the International Coal Preparation Conference.

The preliminary results show that denser particles have a smaller cut-point and the cut-point increases as particle density decreases. However, these results suggest that the magnitude of the shift is considerably smaller than expected.

Following discussions with project monitors, the CSIRO is performing further CGA + scanning electron microscope analysis to improve analysis of the ultrafine high density particles. This will allow for the mathematical adjustment to be reviewed and partition curves reassessed.

**C34046**
**Clay Type Effect on Magnetite Medium Properties in Dense Medium Cyclones**

CSIRO
Clint McNally

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<td>Chris Denyer, Frank Mercuri</td>
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<tr>
<td>ACARP Contact:</td>
<td>Ben Gill</td>
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The project objective is to review the effect the clay component of dense medium has on the performance and operation of dense medium cyclones. It is understood that different clay types when mixed into slurries of the same % solids, the viscosities can vary significantly depending on the clay type used. This difference can impact dense medium cyclone operation.

A literature review to catalogue the clays present in Australian coal seams is continuing. In addition, samples of dense medium from various mine continue to arrive and be analysed for Magnetite content, clay content and type. Mine samples that have arrived have been processed and sent for XRD analysis. Mine samples have be tested for settling rate and viscosity at RTP. Constituent parts of dense medium (clay types and magnetite size grades) are next to be tested in preparation so different combination mediums can be created for performance testing in the small dense medium circuit at QCAT.

**C34048**
**Using Clay Stabilised Medium for the Separation of Small Coal in a Dense Medium Cyclone**

CSIRO
Andrew Taylor

| Value:               | $204,432 |
| Report Expected:    | April 2024 |
| Industry Monitor/s: | Chris Denyer, Frank Mercuri |
| ACARP Contact:      | Ben Gill |

No report received.

**Process Control**

**C33057**
**Foreign Contaminants Detection on Conveyor Belts Using Digital Imaging Processing Techniques and Coal Penetrating Sensors**

Mincka Engineering
Fidel Gonzalez

| Value:               | $365,000 |
| Report Expected:    | September 2023 |
| Industry Monitor/s: | Dan Delahunty, Dave Young, Kevin Rowe, Phillip Enderby |
| ACARP Contact:      | Patrick Tyrrell |

This project seeks to evaluate the feasibility of a host of different sensor technologies for the identification of different material types (ferrous, non-ferrous, polymeric and ceramic among others) as they pass through the conveyor belt in real-time. The project will create a foreign objects detection algorithm using artificial intelligence and machine learning image processing techniques, capable of scanning through and over the coal conveyance.

The draft final report has been submitted to the Industry Monitors for review.
C34039
Soft Sensor for Predicting Dense Medium Cyclones Performance

University of Queensland
Gordon Forbes

Value: $189,300
Report Expected: March 2024
Industry Monitor/s: Araz Ejtemaei, Peter Shumack, Rick Jeuken, Sam Rynne
ACARP Contact: Ben Gill

This project aims to develop a soft sensor for predicting dense medium cyclone performance. The soft sensor will build on current state of the art DMC models, with the aim of including a wear model, as well as data driven machine learning models to better characterise the feed and pump operating regime.

Over the last quarter of the project the work has focussed on utilising equipment and historian process data for the DMC circuit. DMC maintenance logs are being used to develop wear models for the DMC cone and spigot. A pump model is being developed which will also include wear information once this information is made available.

Initial data analytics has commenced to better understand the variation of the feed to the DMC as coal type changes. This will be linked to the coal washability to and used as an input to the DMC model to allow it to better account for changes in feed.

Discussions with sponsors and site contacts are ongoing to obtain access to further data and undertake a site visit in the near future.

C34044
Real Time Monitoring and Control of Froth Flotation

University of Queensland
Liguang Wang

Value: $106,667
Report Expected: November 2023
Industry Monitor/s: Albert Blom, Angus Morrison, Chris Denyer, Chris Huth, Josh Kowalczuk, Rick Jeuken
ACARP Contact: Ben Gill

The objectives of this project are to:
- Develop remote control strategies corresponding to the sub-optimal operation identified by the sensor.

In the quarter, the team constructed two drag sensors of different design and evaluated their diagnostic performances for a single flotation cell in a coal flotation plant in Central Queensland. During the onsite testing, the team adjusted the aeration rate of a flotation cell to vary flotation performance so as to assess the suitability of the sensor design for accurately diagnosing the flotation yield (or mass pull). We also identified drag sensor installation points across the flotation plant for the next field testing (i.e., one per flotation column for all flotation cells in the circuit). However, the variation of the flotation yield was rather small (i.e., 64 – 74%); consequently, the outcomes from the site visit were insufficient to draw a solid conclusion as to whether the provisional design of the drag sensor would be suitable for forthcoming long-term field testing. The team will obtain a more comprehensive dataset to fine-tune the sensor and prepare for the long-term field testing.

C34047
Using EIS Technology to Measure the Amount of Magnetite in Dilute Magnetite Streams

CSIRO
Clint McNally

Value: $224,220
Report Expected: September 2023
Industry Monitor/s: Chris Denyer, Frank Mercuri
ACARP Contact: Ben Gill

The project will test the functionality of modifying the CSIRO impedance spectrometer (EIS) to measure sub 1g/L to 5g/L concentrations of magnetite at magnetic separator overflows.

Currently the method used to assess the quantity of magnetite overflowing the magnetic separator is to collect a 1L sample and submerge a magnetic wand into the sample for a fixed time, then visually compare the wand to pictures of known concentrations of magnetite attracted onto the wand and record the result. This method is qualitative and requires good lighting and experienced operators to achieve consistent results.

The ability to measure quantitatively in real-time the amount of magnetite overflowing magnetic separators would provide the ability to intervene if magnetite levels exiting the magnetic separator increase too high.

The design and fabrication of two new electrode types is complete and new software configuration variables for the impedance spectrometer have been reprogrammed and tested for suitability. Experiments in lab conditions are completed and are being processed waiting for analysis.
Field deployment to a mine site has been completed successfully. Multiple locations have been tested with varying degrees of performance related to sensor design and amount of flow present.

Final report is written and undergoing internal peer review.

C34050
Hand Held Sensor for Real Time Measurement of Fluorine Mineral Contamination in Coal

University of Adelaide
Nigel Spooner

| Value: | $261,215 |
| Report Expected: | July 2024 |
| Industry Monitor/s: | Jack Lauder, Jenny Park, Mel Robbins, Rick Jeuken |

ACARP Contact: Ben Gill

The project objectives is to create a new type of hand-held sensor for real time measurement of fluorine (mineral) contamination in coal. The minerals targeted are the two dominant non-clay fluorine minerals, fluorite and fluorapatite.

Electronics manufacturing is complete: LED ring (24 high-power LEDs) is connected to a driver board; onboard potentiometer controls and limits the LED current, allowing optimal stimulation of fluorescence.

The board has four programmable buttons. Functions will be assigned according to the process requirements. Currently, one active button that turns on the LEDs for ten seconds. The LEDs and the board are powered by a battery, custom-made for this project.

The sensor body includes an IR-transmitting lens, tube and IR camera. The prototype optical setup has been optimised and comprises optical tubes of various diameters, allowing focusing on the object plane. The hood tube was designed to touch the focal surface, to set the distance to the object and remove coarse focusing needs which change the field-of-view (FOV). FOV smaller than allowed by statistics calculations is not achievable. Error! Reference source not found. shows the prototype handheld sensor ready to commence lab trials on real-world samples.

Figure 6 Prototype Handheld Sensor

Next steps for the project are as follows.

Technical: cases for electronics and battery, enabling easy, safe use in the field. A larger battery will be manufactured to allow longer use and voltage stability, powering camera, LEDs and electronics.

Software: GUI design to control image acquisition and electronics, and associated image processing algorithms.

Data collection started with the prototype (see Figure 7). A collection of minerals available in PELL will be used, as well as the coal core provided by UQ. Further test samples will be acquired from our project industry partners.

Figure 7 Fluorine-bearing minerals under LED excitation. Bottom-right image shows the scale of the grains on bottom-left.
C34052
Simulation Enabled Digital Twin for the Control, Design and Optimisation of a Teeter Bed Separator

University of Queensland
Kym Runge

Value: $232,531
Report Expected: January 2025
Industry Monitor/s: Albert Blom, Chris Denyer, Chris Jackson
ACARP Contact: Ben Gill

Up to a fifth of in-plant material in Queensland metallurgical coal preparation plants is too fine to be efficiently upgraded using a dense medium cyclone and too coarse to be separated using froth flotation. This middling fraction (typically >2+0.35mm) is processed using hydraulic classifiers, such as teeter bed separators. In this project, researchers will use a combined experimental and simulation-based approach to develop a computational model that can be used as the basis of a performance-maximising advanced control strategy for the teeter bed separator (TBS).

The work to be performed will involve site surveys of full-scale TBS units, laboratory fluidisation test work, regression modelling of site survey data and development and validation of a CFD model.

Since commencement of the project in January 2023, an approach to model the TBS has been established. Using this approach, a water-only simulation of single-phase flow in a TBS of 3 meter diameter and 2.52 meter height has been developed and has recently been extended to predict two phase (solid and liquid) flow incorporating multi-size and multi-density particles. Validation of the simulation methodology using data sourced from the TBS Handbook and other published literature is underway. The geometry of the TBS in this initial work matches the worked example in Section 4.6 of the TBS Handbook (Drummond, 2006).

This work is in preparedness for calibration and validation of a CFD representation of the industrial TBS units which will be surveyed in test work planned towards the end of 2023 and early 2024. Samples of the feed during these surveys will also be collected and characterised in the laboratory to establish fluidisation properties. Planning is underway for this site work, including the organisation of a preliminary visit to review sampling options and laboratory facilities. Required inductions are also being arranged.

C26011
CSIRO Instruments at Multiple Plants

CSIRO
Mike O’Brien, Teresa Kittel

Value: $427,798
Report Expected: August 2023
ACARP Contact: Patrick Tyrrell

The draft final report has been submitted to the Industry Monitors for review.

C26016
Benefits of Online Thickener Underflow Rheology Measurements

Clean Process Technologies
Alexander Everitt, Noel Lambert

Value: $251,000
Report Expected: November 2023
Industry Monitor/s: Michael Carnell
ACARP Contact: Patrick Tyrrell

Although the thickener underflow monitor is able to generate information about the rheology of coal thickener underflow, plant operators are not using this data. This project will determine 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. There are no existing online rheology measurements of thickener underflow and it may be possible with online measurement to reduce flocculant dose rates, particularly where flocculant is dosed after the thickener. All is going well and the completion should be achieved in October.

C28061
Quantitative Based Structural Integrity Evaluations Using Modal Parameters Estimation

Mincka Engineering
Fidel Gonzalez

Value: $363,651
Report Expected: November 2023
Industry Monitor/s: Chris Jackson, Kevin Rowe, Peter Shumack, Phillip Enderby
ACARP Contact: Patrick Tyrrell

The objectives of the project are to:
- Develop a technique for reliable, cost effective and objective structural condition assessments of mining infrastructure used in coal mining;
• Eliminate the subjectivity and conservative structural condition assessments; and to
• Enable data driven decision making and increased the reliability of structural condition assessments.

This project is waiting for field installation to complete the measurement campaign.

C33042
Coal Quality Borecore Methods Amalgamation Guide

McMahon Coal Quality Resources
Chris McMahon

Value: $42,180
Report Expected: January 2024
Industry Monitor/s: Clinton Vanderkruk
Jason Schumacher
John Kelly

ACARP Contact: Ben Gill

This project seeks to produce a guide that will amalgamate the various Australian and ISO Standards for borecore sampling and testing (preparation and measurement) so that definition of resources and reserves can be planned more effectively and efficiently.

The outcomes of this project will be a guide that can be applied to multiple coal quality testing scenarios for borecores. Different method options for raw coal mines, mines with wash plants and for coking and thermal coal will be made. Definitions of ply, raw, wash and product stages will be made in reference to Standards requirements and links between the relevant Standards where overlapping information is required.

This will benefit the industry by providing practitioners with a concise, referenced method for determining methods of sampling and testing, resulting in reduced time spent in planning, increased accuracy in planning, better definition of resource and reserve potential, and minimised financial risk. A further significant aim is to document comparison of ISO versus AS Standards equivalence/if they are comparable and differences along with rationale for decisions made.

Standards required have been identified and attained and collation review of overall targets is set.

A table of contents has been issued, commencement of reporting, and a stage review meeting is scheduled for September.

C34042
CPP Water Chemistry Impacts on Corrosion Rates for a Range of Materials

Basacon Services
Bruce Atkinson

Value: $78,080
Report Expected: September 2023
Industry Monitor/s: Michael Carnell
Nic Roberts

ACARP Contact: Ben Gill

Project C28059 was completed in January 2021, and its outcomes demonstrated specific correlations between water quality parameters and each of:
• Mild steel corrosion rate;
• CPP Tailings flocculant consumption.

Due to the success of C28059, this project is being undertaken to evaluate water chemistry impacts on the corrosion rates of other common construction and fabrication materials including galvanised steel, aluminium, and stainless steel grades 304 and 316 and 3CR12.

This project involved laboratory-based Linear Polarisation Resistance (LPR), and Electrochemical Impedance Spectroscopy testing (EIS) to measure corrosion rates for each of six different materials and eight different CPP clarified water samples. Microscopic and SEM observation was also included to examine the material surfaces following testing.

Samples of mild steel, galvanised steel and aluminium each registered differential corrosion rates in the different waters, and correlations for corrosion rate have been generated based upon water quality. None of the stainless steel samples (304, 316, 3CR12) exhibited sufficient corrosion to facilitate a water quality correlation.

The project report is expected to be submitted during August.
**TECHNICAL MARKET SUPPORT**

### Metallurgical Coal

**C29071**

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

**CSIRO**

Lauren Williamson

- **Value:** $144,760
- **Report Expected:** August 2023
- **Industry Monitor/s:** Jeremy Byrnes, Nick Andriopoulos
- **ACARP Contact:** Ashley Conroy

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

The draft final report has been submitted to the Industry Monitors for review.

**C29074**

*High Temperature Tribological Testing of Coke Coupled with 3D Visualisation to Enhance Understanding of Coke Breakage and Link to Parent Coals*

**University of Newcastle**

Hannah Lomas

- **Value:** $161,029
- **Report Expected:** August 2023
- **Industry Monitor/s:** Kim Hockings, Morgan Blake, Stephen Brant
- **ACARP Contact:** Ashley Conroy

The draft final report has been submitted to the Industry Monitors for review.

**C33063**

*Micro-CT Based Characterisation of the IMDC-RMDC Interfacial Interaction in Blends of Australian and International Coals*

**University of Newcastle**

David Jenkins

- **Value:** $175,000
- **Report Expected:** July 2023
- **Industry Monitor/s:** Graeme Harris, Kim Hockings
- **ACARP Contact:** Ashley Conroy

The draft final report has been submitted to the Industry Monitors for review.

**C33066**

*Washability and Distribution of Sulphur and Trace Elements for Different Sizes and Densities of Product Coals*

**University of Newcastle**

Rohan Stanger

- **Value:** $128,550
- **Report Expected:** August 2023
- **Industry Monitor/s:** Caroline Lang, Jane Lawson, Shaun Booth
- **ACARP Contact:** Ashley Conroy

The draft final report has been submitted to the Industry Monitors for review.

**C34054**

*Design of Cokes from Biomass Coal Blends for Sustainable Blast Furnace Ironmaking: Scoping Study*

**University of New South Wales**

Pramod Koshy

- **Value:** $181,700
- **Report Expected:** March 2024
- **Industry Monitor/s:** Shaun Booth, Stephen Brant
- **ACARP Contact:** Ashley Conroy

This project is focussed on understanding the impact of biochar addition and coal type on determining the quality of cokes for ironmaking. The aims of the present work are:

- Understand the impact of biomass addition (up to 10 wt%) and base coal properties on the macrostructural and microstructural characteristics and room-temperature and high-temperature (1100°-1400°C) strengths after gasification of the resultant cokes;
- Correlate the mineralogical, microstructural, microtextural, bonding and fracture characteristics of...
these cokes with strength measurements at room and high-temperature; and
• Compare the properties using standard coke quality indicators such as CSR / CRI to determine optimal addition levels.

New samples of coke with biochar additions at lower particle sizes were fabricated and then subjected to different tests to assess industrial scale performance. This was done at CSIRO to obtain more finer and uniform particle sizes (<0.5 mm). Performance test summaries below show along with performance data that shows better integration and superior properties of the biochar when utilising the smaller size fraction which is a promising result.

<table>
<thead>
<tr>
<th>Charge Identifier</th>
<th>Blend information</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR0588-C1</td>
<td>97.5% 0.1C-0.09 &amp; 2.5% 152-B-001 Biomass crushed to -0.5mm</td>
</tr>
<tr>
<td>SR0588-C2</td>
<td>95% 0.1C-0.09 &amp; 5% 152-B-001 Biomass crushed to -0.5mm</td>
</tr>
<tr>
<td>SR0588-C3</td>
<td>90% 0.1C-0.09 &amp; 10% 152-B-001 Biomass crushed to -0.5mm</td>
</tr>
<tr>
<td>SR0588-C4</td>
<td>93% 0.1C-0.09 &amp; 5% 152-B-001 Biomass crushed to -0.5mm</td>
</tr>
</tbody>
</table>

Three single coals have been selected for this project. One pair of coals are differentiated only by rank (mean maximum vitrinite reflectance values of ~0.9 and ~1.15) and one pair of coals are differentiated only by parent coal measure (Moranbah vs Rangal).

Separation of the macerals from all three coals using a hand-picking technique in an inert atmosphere has been completed with a high maceral purity obtained. Small-scale coking experiments have been carried out to generate the RMDC and IMDC components. Thermogravimetric analysis (TGA) to examine the lump vs intrinsic reactivity of the individual RMDC and IMDC components is underway. In the next quarter, analysis of the TGA results will be completed and the most influential factors for coke reactivity to CO₂ will be identified.

**C34056**

Real Time Three Dimensional In-Situ Imaging of Structural Evolution of Coal During Coke Making Process Using Adaptive Electrical Capacitance Volumetric Tomography

University of Newcastle
Behdad Moghtaderi

Value: $128,755
Report Expected: October 2023
Industry Monitor/s: Graeme Harris, Kim Hockings
ACARP Contact: Ashley Conroy

The principal vision of this project is to advance our collective understanding of the coking behaviour of Australian coal during coal-to-coke conversion and in doing so facilitate/promote Australian coal experts. To fulfil this vision, we will examine representative coal samples at various stages of softening, semi-coke, and coke annealing to gain a more fundamental insight into the temporal and spatial evolution of their respective plastic layer. We will utilise the unique capabilities of the Adaptive Electrical Capacitance Volumetric Tomography (AECVT) technique (i.e., real-time non-intrusive and non-optical imaging) to achieve this goal. Concerning the project structure plan, several essential key tasks of phase one have been achieved in the third quarter of the project:

• The capability of the AECVT sensors in detecting coal and coke particles were assessed to distinguish coal from coke knowing the dielectric constant of coal increases when it is converted to coke. In this approach, at the static state, half of the vertical bed was filled with coke while the remaining half was filled with coal, aiming to assess the sensors capability in distinguishing between coal and coke (Figure 1-A).

• Another approach was also introduced to determine the minimum detectable air bubble flow rate to find the sensors’ sensitivity and accuracy by injecting air into the middle of the bed.
• At air bubble flow rate of less than 0.1 L/min (during 10 sec), the size and flow rate of the bubbles that pass through the bed are not large enough to be detected by sensor (Figure 1-B).
• The results also indicate that the bed volume fraction is the only detectable parameter by the sensors. Other parameters such as extremely small movements (like bubbles), particle sizes, and pore structure might fall beyond the scope of detection for the sensor (Figure 1 - C).

Figure 1: A) 2D - X axis (Static), B) 3D view – Air injection (air flow < 0.1 L/min), C) Coke – bed volume fraction.

C34057
Impact of Co-Injecting Hydrogen and Australian PCI Coals on Overall Blast Furnace Performance Using a Heat and Mass Balance Model

University of New South Wales
Yansong Shen

Value: $166,200
Report Expected: September 2023
Industry Monitor/s: Cameron Tasker, Geoff O’Meley
ACARP Contact: Ashley Conroy

The project aims to evaluate the impact of the co-injection of Australian PCI coals and hydrogen on overall blast furnace performance using an HMB model. In an HMB model, the different zones are connected by mass and heat exchange and specific metallurgical considerations govern each zone, for example, the reactions of hot metal, slag, iron ore pellets, coke, injectants and additives. Of particular interests are to assess the RAFT, TGT, fuel rate, productivity of Australian PCI coals and hydrogen, respectively, when the Australian PCI coals and hydrogen are co-injected into tuyeres, and to identify the requirements on potential (future) Australian PCI coal products with respect to overall BF performance when different co-injection scenarios are employed.

During the quarter:
• Results analysis: The refined heat and mass balance (HMB) model was applied to the whole range of ACARP PCI coals under 4 scenarios, in other words, constraint sets, to generate the result of key BF performance indexes, including raceway adiabatic flame temperature (RAFT), top gas temperature (TGT), coke rate (CR), pulverised coal rate (PCR), fuel rate, production rate, CO2 emission, utilisation rate of CO (ηCO) and H2 (ηH2), slag rate, composition of hot metal and molten slag, etc. Particularly, the operating windows have been generated for different PCI coals and different scenarios.
• Final presentation: The model and results analysis have been delivered in terms of the final presentation on 21 June 2023. There are four scenarios reported for the co-injection of three PCI coals with H2, both the effect on the key BF performance indexes (e.g. Figure 1) and the operating windows (e.g. Figure 2).
• Report writing: The project is >95% done, and the team is polishing the full report. The monitors’ comments received from the final presentation have been applied in the modification of the report. Different from the previous years, the body of this report will be concise and technical details will be provided in Appendix, as suggested by the Industry Monitors.

Figure 1 Injection rate of injectants through tuyere and the corresponding RAFT and TGT.

Figure 2 Operating windows for co-injection of low-VM coal and H2 with coal rate fixed or H2 rate fixed.

C34059
Coke Reactivity with CO2 and H2O and Impacts on Coke Microstructure and Gas Diffusion

University of Newcastle
Arash Tahmasebi

Value: $170,700
Report Expected: October 2023
Industry Monitor/s: Shaun Booth, Stephen Brant
ACARP Contact: Ashley Conroy

The project will investigate the differences in coke reactivity, and microstructure and microtexture
evolution during gasification reactions relevant to the conventional and hydrogen rich blast furnace conditions. Specific objectives are to:

- Evaluate the impact of CO2 and H2O gasification reactions on the physical structure of cokes made from Australian coking coals using micro-CT analysis.
- Investigate the mechanism of coke gasification under CO2 and H2O, i.e., reaction at the coke surface vs. reaction throughout the coke volume.
- Gain a deeper understanding of how coke quality indices relate to its degradation mechanism by studying three cokes with varying CSR/CRI.
- Evaluate the susceptibility of IMDC/RMDC and associated microtextures to reactivity with CO2 and H2O by exploring changes with the progression of coke gasification.
- Develop a reaction-diffusion model for comparing CO2 and H2O gas diffusion in coke microstructure with the progression of gasification.

Progress during this quarter:

- Coke cylinders before and after gasification reactivity to 20% were imaged at the ANU’s CT lab and image reconstruction has been completed.
- Image registration to identify the reaction regions and grayscale quantification is currently underway at ANU.
- An algorithm was developed to quantify the CT grayscale and mass loss changes along the radius of coke cylinders. The method is being used to evaluate the gasification mechanism of the reacted coke samples.
- Partial gasification of coke cylinders to 40% conversion was completed this quarter with the last step of CT imaging currently underway at ANU.
- A preliminary reaction-diffusion model was developed this quarter to fit the TGA gasification and radial grey-scale data. Model validation using experimental measurements is currently underway.
- Polished samples of the unreacted and partially gasified cokes for Pearson microtexture analysis were prepared and analysis is planned for next quarter.
- Registration of CT images for unreacted and gasified images has taken longer time than expected, primarily due to the complexity of the coke microstructure which has made the work challenging. This has delayed the post-registration image analysis work.

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**C34060**

**In-situ Investigation of Coke Structure Formation Under Stamp Charged Coking Conditions**

**University of Newcastle**

Arash Tahmasebi

**Value:** $158,900  
**Report Expected:** October 2023  
**Industry Monitor/s:** Graeme Harris  
Stephen Brant  

**ACARP Contact:** Ashley Conroy

This project aims to gain insights into the coke formation mechanism under stamp charge coking conditions and understand how higher caking densities affect coke structure. Specific objectives are to:

- Evaluate the impact of charge density on in-situ coking behaviour to identify key drivers of coke strength under stamp charged conditions.
- Differentiate the impacts and benefits of stamping on coke strength across semi-soft to premium Australian coking coals.
- Demonstrate the fundamental process by which stamping improves coke quality by analysing impacts on microstructure and microtexture.
- Explore potential correlations between blend composition and coke quality under stamp charged conditions.
- Identify coal properties that have the greatest potential of benefiting from stamp charged cokemaking.

Progress during this quarter:

- A new technique was developed to assess the impact of stamping on the microstructure transformation of coke and bonding at the IMDC-RMDC interface utilising the plastic layer and coke CT images. Analysis of the coke CT images is currently underway.
- The remaining 9 top-charged and stamped cokes were prepared in the 8kg coke oven for CSR/CRI testing. Stamping was found to be more effective on coals producing weaker coke. Relative changes in CRI were less than in CSR.
- Pearson microtexture analysis of the polished top-charged and stamped coke samples is currently underway with the analysis of 12 samples already completed. Stamping was found to improve the anisotropy of coke microtextures.
- The project is on track for completion in September 2023.
C34061
Gasification Kinetics of Coke Lumps Under Simulated Conventional and Hydrogen Rich Blast Furnace Processes

University of Newcastle
Arash Tahmasebi

Value: $69,600
Report Expected: August 2023
Industry Monitor/s: Kim Hockings, Nick Andriopoulos
ACARP Contact: Ashley Conroy

The overall objective of this project is to gain fundamental insight into the rate and mechanism of coke gasification under the simulated hydrogen-enriched BF environment, benchmarked against conventional BF operations. Specific objectives are to:

- Compare and evaluate the impact of reaction conditions in conventional and hydrogen-rich BF on coke gasification reactivity.
- Investigate how elevated H2/H2O concentrations affect the mechanism of coke gasification in BF, i.e., diffusion-controlled vs chemically controlled.
- Develop correlations between coke quality indices and gasification rate as an indicator of coke degradation.
- Develop gasification kinetic models for cokes made from Australian coals under simulated conventional and hydrogen reduction BF conditions.
- Link parent coal properties with coke reactivity under the two reaction scenarios.

During the quarter, the following activities have been completed:

- All experimental and modelling work was concluded.
- The draft final report was sent to the project monitors in June and following Industry Monitor feedback, a revised report was submitted in July.

C34062
Improving the Classification of Microstructure Distribution in Coke CT Images using Deep Learning and Lineal Path Calculations

University of Newcastle
Bishnu Lamichhane

Value: $111,020
Report Expected: March 2024
Industry Monitor/s: Kim Hockings, Nick Andriopoulos
ACARP Contact: Ashley Conroy

This project aims to extend the research of two previous projects (C27036 and C29073) that examined the link between 3D coke microstructure and coke strength. These projects were partly successful, and the review identified two areas to improve – increase the number of samples studied and make the classification of microstructural features more automatic with improved classification. This project aims at extending the approach to 90 samples from 9 different cokes (c.f. 37 samples from 9 cokes previously) and applying the convolutional Autoencoder (CAE) to provide an alternative microstructure classification. The project further aims to refine 3D statistical characterisation approaches for classifying coke strength based on the distribution of microstructural features.

Specific objectives of the project are to:

- Enhance and further evaluate an automated characterisation process that uses the distribution of microstructural features in 3D to characterise coke. Two complementary techniques will be used – Landmark Multidimensional Scaling (LMDS) with K means clustering and Autoencoding deep learning techniques.
- Further develop the 3D statistical characterisation to better quantify the linear distribution of classes of structural features.
- Apply and evaluate the techniques’ ability to “explain” coke strength using the same broad range of cokes characterised in C29073, but to check statistical validity by including 10 samples from each coke in the analysis.

Overall project progress is hampered by computer issues. However, we have completed the following items:

- The LMDS and convolutional Autoencoder (CAE) classification results are now completed.
- The chord length distributions are computed, and these results are also visualised in pictures.
- The next step is to complete the 3D statistical characterisations, interpret all these results and write the report.

Below is the classification results for nine coke types using CAE.
C34063
International Round Robin for Coke Reactivity Index, Coke Strength after Reaction and I600

CSIRO
Lauren Williamson

Value: $77,800
Report Expected: November 2023
Industry Monitor/s: Caroline Lang, Graeme Harris, Kim Hockings

ACARP Contact: Ashley Conroy

The main objectives of this project are to:
• Update the understanding of the consistency of practice with regards to CSR and CRI across a group of international laboratories by conducting a round robin using two cokes produced in a pilot scale coke oven; and
• Investigate the extent of use of I600 in coke testing laboratories and determine its potential as a standard test.

This quarter, the following activities were completed:
• Two coal blends have been coked in the moveable wall oven at CSIRO-QCAT;
• Coke samples have been crushed and subsampled for despatch;
• Samples have been sent to 15 participants from six countries, freight delays were experienced;
• Results have been received from 12 participants; and
• Preparation of the project report is underway.

C34064
Effect of Coal Quality on Carbon Products Produced with Alternative Thermal Processing – Extrusion and Direct Casting Technologies

University of Newcastle
Rohan Stanger

Value: $159,425
Report Expected: August 2023
Industry Monitor/s: Caroline Lang, Oliver Scholes, Peter Austin, Shaun Booth

ACARP Contact: Ashley Conroy

This project aims to investigate alternative heating systems that might produce different carbon material properties. Both extrusion and direct casting methods have large scale industrial processes based around them in other industries and this project is considered as an important first stage in using coal for different purposes. For extrusion, the study will aim to produce a lower emission coke with a biochar blend additive; whilst non-extrudable coals will be considered for directly cast carbon tiles (a precursor to construction and energy storage materials).

The draft final report has been submitted to the Industry Monitors for review.

C34065
Impacts of Plastic Layer Permeability and Internal Gas Pressure on the Formation of Coke Microstructure and Coke Quality

University of Newcastle
Soonho Lee

Value: $158,900
Report Expected: November 2023
Industry Monitor/s: Cameron Tasker, Morgan Blake, Nick Andriopoulos

ACARP Contact: Ashley Conroy

The objective of this project is to examine the relationship between coal properties and the permeability of the plastic layer, intermediate gas production (IGP), and the resulting microstructural changes in coke. To achieve this, we collected coal samples with varying properties such as rank (0.90-1.53MMVR), fluidity, and maceral compositions (50-70% inertinite) but similar ash chemistry. These samples were used for plastic layer sampling, in-situ IGP and permeability measurements, using the 4kg coke oven facility.

In this quarter, we analysed 3D microstructure results to find key parameters linked to IGP and impermeability. These parameters include porosity, pore/pore wall throat size distribution, and pore/pore wall chord length distribution. We compared parameter changes from the plastic layer to coke/semi-coke, aligning them with cross-section micro-CT images.

Also, we extracted coke pieces from the in-situ measurement test samples. One coke piece, representative of the microstructure, was taken from 100mm away from the heating wall. We analysed the same parameters from the 3D images of these samples. We then correlated these parameters and trends with in-situ measurement outcomes, such as maximum IGP and impermeability, measured at different locations. This helped us understand the effects of IGP and plastic layer permeability on coke microstructure formation. We also related these key parameters to coke strength indices (M40 and I600).

Results revealed that higher-ranked coals and those with higher vitrinite content displayed higher IGP and lower plastic layer permeability. These differences influenced pore structure during plastic layer formation, impacting final coke microstructure and strength. Before submitting the final report, we’ll conduct further analysis and correlation studies in consultation with Industry Monitors.
C35037  
**Examination of Contraction Pre and Post Resolidification using a High Temperature Dilatation Rig**  
University of Newcastle  
David Jenkins  

Value: $99,250  
Report Expected: May 2024  
Industry Monitor/s: Cameron Tasker, Graeme Harris  
ACARP Contact: Ashley Conroy

The project objectives are to:
- Measure the dilatation and contraction behaviour of a range of coals, both pre- and post-resolidification, using the UoN dilatation/contraction test rig.  
- Develop a mathematical model of the configuration used in the dilatation/contraction test rig and calibrate with experimental results.  
- Utilise the combined results from experiment and modelling to understand the key processes of dilatation and contraction of coal particles at coke oven feed size, particularly in the region around resolidification.

Progress so far includes:
- Test coals chosen, and most coals sourced from the coal bank.  
- Modifications to the high temperature dilatation rig have been made, in order to improve the quality of contraction measurement. This involves replacing the steel tube containing the sample with a graphite tube, which has the advantage of minimising measurement error due to tube expansion during heating, as well as significantly reducing sample sticking to tube walls during contraction phase. Final modifications to allow three samples to be tested simultaneously are underway.  
- Work has commenced on a model of dilatation and contraction of samples, appropriate for the particle size used in the rig. The first stage is to model the swelling of particles during the plastic phase, due to volatile evolution, gas transport through the plastic melt and bubble growth in the particles.

C35038  
**Microalgae Blending for Low Carbon Metallurgical Coke Production**  
University of Newcastle  
Arash Tahmasebi  

Value: $172,000  
Report Expected: November 2024  
Industry Monitor/s: Nick Andriopoulos, Stephen Brant  
ACARP Contact: Ashley Conroy

This project aims to evaluate the impact of microalgae blending on the coking behaviour, coke properties, and coke gasification performance of selected Australian coals to determine the tolerable microalgae addition level and carrying capacity of Australian coals. Specific objectives are to:
- Analyse the influence of microalgae on the thermoplastic and thermal decomposition behaviour of Australian coals.  
- Evaluate the coking behaviour and pressure generation of coal/microalgae blends at different addition levels.  
- Determine the optimal microalgae addition rate and study the carrying capacity of Australian coals in blend with microalgae from coke property analysis.  
- Evaluate the impact of microalgae on coke microstructure and microtexture and coke quality indices.  
- Explore the fate of alkali species during the coking process.  
- Evaluate high-temperature reactivity of bio-cokes under simulated blast furnace conditions.

Progress during the quarter:
- Four coal samples varying in rank and fluidity from the Moranbah and Illawarra measures were received in July.  
- 24 blends incorporating up to 20 wt.% microalgae have been prepared.  
- Blend samples are being analysed to understand the impact of microalgae addition on the volatile matter, ash content and chemistry, and standard fluidity measures of blends.  
- Our merit time application to access IMBL at the Australian Synchrotron has been successful. The plastic layer samples for the blends are being prepared for imaging in September 2023.

Next quarter:
- Involves rheological testing of coal-microalgae blends at UQ.  
- Preparation of coke samples at the 8kg coke oven at NIER for CSR/CRI testing.

C35039  
**Impact of Coal Grain Composition and Macerals Association on Fluidity Development in the Plastic Layer of Australian Coals**  
University of Newcastle  
Arash Tahmasebi  

Value: $141,600  
Report Expected: May 2024  
Industry Monitor/s: Graeme Harris, Stephen Brant  
ACARP Contact: Ashley Conroy

The project aims to understand the impact of grain composition and maceral associations on the thermoplasticity of Australian coals from different coal measures. The project utilises the coal grain analysis (CGA) capability at CSIRO, rheometry and micro-CT expertise at UQ, and in-situ coking, plastic layer main components.
characterisation, and micro-CT analysis expertise at UON. Specific objectives are to:

- Improve the mechanistic understanding of the thermoplastic behaviour of Australian coals.
- Explore the differences in vitrinite and inertinite size distribution and the degree of association between reactive and non-reactive macerals in coals sourced from different measures.
- Analyse thermoplastic behaviour of selected coals using the permeability/dilatation and the 4kg coke oven test facilities at UON and the rheological testing at UQ using the coke oven feed size.
- Develop correlations between coal grain composition and fluidity development in the plastic layer.
- Analyse micro-CT images of quenched plastic layer samples to determine the difference between the “real” plastic range of coals and those measured by standard tests.

Progress during the quarter:

- Seven (out of eight) coal samples varying in rank and fluidity from the Moranbah, Rangal, Hunter Valley, and Illawarra measures were received in July.
- The plastic layer samples for five coals were prepared and imaged during IMBL merit time in July. Reconstruction and analysis of these images in GeoDict are underway. CT imaging of the remaining samples is scheduled for September.

Next Quarter:

- Involves rheological testing of coal samples at UQ, as well as coal grain analysis (CGA) at QCAT.
- In-situ coking of the coal samples in the 4kg coke oven for IGP measurements is also planned.

C35040
Changes in Combustibility of Coal when Co-Combusted with Hydrogen Rich Fuels in PCI

University of Newcastle
Liza Elliott

Value: $218,367
Report Expected: June 2025
Industry Monitor/s: Cameron Tasker, Caroline Lang, Oliver Scholes
ACARP Contact: Ashley Conroy

With the steel industry under pressure to reduce CO2 emissions, there are several possible changes to the steelmaking process that could be adopted. The first and easiest step in improving sustainability is the introduction of a material with high hydrogen content via tuyere injection. This injectant could be coke oven gas, waste plastics, biomass materials or hydrogen and hydrogen containing gases. However, as most of these materials have lower coke replacement ratios, most steelmakers will be looking to introduce these fuels along with coal. It is unclear, however, what the impact of co-combustion has on the possible injection rate.

This project aims to determine the impact on coal reactivity of co-combustion of hydrogen rich fuels: biomass, plastics, coke ovens gas, ammonia, and hydrogen. Two techniques will be used: the combustibility of solid fuels will be assessed using the Drop Tube Furnace technique developed in project C19049, that compares the combustion behaviour of coals in a set standard condition. Then a TGA (Thermo-Gravimetric Analyser) will be used to measure the reactivity of these materials individually and when co-combusted with coal. This will show changes in behaviour expected due to reduction of oxygen concentrations caused by the consumption of the hydrogen rich fuel.

Coal and plastic samples have been obtained and biomass samples hopefully to arrive soon. Essential maintenance to the drop tube furnace has been completed and experimentation is about to begin.

Unfortunately, the TGA to be used in this study has been found to allow feed gas to fill the electronics chamber and it was therefore decided that ammonia combustion was unsuitable for this machine, and an alternate TGA is being sought for tests utilising ammonia, with further safety reviews required for the alternate TGA.

C35041
Effect from the Co-Combustion of Coal and Biomass on Production of Fine Particles (<PM10)

University of Newcastle
Liza Elliott

Value: $228,531
Report Expected: August 2025
Industry Monitor/s: Cameron Tasker, Caroline Lang, Oliver Scholes
ACARP Contact: Ashley Conroy

Many power stations are looking to reduce their CO2 emissions with the addition of biomass to the feed coal for combustion. Biomass is an overarching term to describe organic material derived from plants and is considered CO2 neutral as the CO2 emitted during combustion is equivalent to the CO2 absorbed during the plant’s growth. However, biomass generally has much higher contents of Na and K than coal, and these elements are associated with the organic structure of the plant. In bituminous coals these elements are generally associated with minerals that may be liberated during milling. The proximity of the alkalis to carbon increases the chance of vaporisation during combustion.

Project C29075 has shown that the proportion of PM10 particles produced during combustion of relatively refractory ashes is much higher than expected. When co-combusted with biomass, the PM10 produced would be expected to increase dramatically as the alkalis associated with the biomass would be expected to report predominantly to the fine particle fraction of the particle
size distribution, though a high ash load associated with the coal ash may limit this. It is unresolved where other species within the biomass would report. The source of PM10 from co-combustion materials must be understood if the value of coal is not to be undermined.

This project aims to assess the scope of fine particle emissions produced during combustion of biomass and the interactions expected between biomass and coal when these fine particles are forming during co-combustion.

Preliminary experimental set-up and procurement of samples underway.

C35042
Physical and Chemical Interactions Between Charcoal and Coal During Coking

University of Queensland
Karen Steel

Value: $135,694
Report Expected: December 2024
Industry Monitor/s: Graeme Harris, Morgan Blake
ACARP Contact: Ashley Conroy

This project examines the interactions between charcoal and high fluidity coals. Given that biomass adversely affects the fluidity of coal, the hypothesis put forward in this work is that high fluidity coals could be used in a blend to deliberately interact with the biomass and preserve the fluidity of prime coking coals in the blend. The project therefore also examines interactions occurring between charcoal, high fluidity coals, and prime coking coals with the view to identify blends that allow a high carrying capacity for biomass without adversely affecting coke strength indices.

During this first quarter we selected all samples needed for the project, acquired the first samples, and started preparing the charcoals (Task 1). Activities over the next research quarter will involve small coking studies with prepared charcoals and high fluidity coals (Task 2).

C35043
Abrasion Resistance of Coke Under Hydrogen Reduction Blast Furnace Conditions

University of Newcastle
Hannah Lomas

Value: $159,416
Report Expected: December 2024
Industry Monitor/s: Nick Andriopoulos, Oliver Scholes, Stephen Brant
ACARP Contact: Ashley Conroy

The hydrogen enriched blast furnace is emerging as a viable alternate technology to reduce the carbon footprint of blast furnace ironmaking, during which injected hydrogen reduces the ferrous burden, generating water vapour as a by-product. To develop the practical applicability of the hydrogen reduction blast furnace, it is important to understand how the degradation of coke under such conditions differs in comparison with the conventional ironmaking blast furnace, and thereby identify the impact of a hydrogen reduction blast furnace on coke quality requirements.

This project will specifically focus on the impact on coke abrasion resistance. The project objectives include:

- Evaluate the impact of reaction conditions that simulate both the conventional and the hydrogen reduction blast furnace on coke abrasion resistance.
- Develop correlations between conventional coke quality indices and abrasion resistance measured using tribological testing at 950°C in an atmosphere comprising steam or CO2.
- Relate results to the microtextural components, including the degree of anisotropy of those components, and the rank and maceral composition of the parent coal.

Five pilot-scale cokes have been selected for this project; each of these has been produced in the 400 kg recovery coke oven at QCAT. Three of the five cokes have varying CSR values (from ~ 43 to 68) but have similar MBI values, to avoid ash chemistry influencing the results. The other two cokes are generated from parent coals from the Moranbah measures which have similar maceral composition but different rank, to examine the rank effect on both coke reactivity and coke resistance to abrasion.

In the next quarter, preparation of samples for tribological testing will commence. We will also in collaboration with the University of Wollongong identify the most appropriate method for introducing an atmosphere comprising water vapour to the tribometer.

C35044
What We Now Know about Coking Coals and Coke

CSIRO
Lauren Williamson

Value: $96,284
Report Expected: June 2024
Industry Monitor/s: Kim Hockings, Morgan Blake
ACARP Contact: Ashley Conroy

The main objectives of this project are to:

- Integrate the findings from ACARP projects completed since 2014, with other, primarily Australian, research into an overall picture of what makes a coke “good” and what is a good coke.
- List new findings that research has established that are useful to industry.
• Review the effects of adding biomass and hydrogen into the iron making process.

Researchers have commenced reviewing the 56 ACARP reports completed in this area.

C35045
Impacts of Chemical Structure Transformation in the Plastic Layer on the Microtexture Development during Coking

University of Newcastle
Soonho Lee

Value: $158,900
Report Expected: November 2024
Industry Monitor/s: Morgan Blake, Nick Andriopoulos
ACARP Contact: Ashley Conroy

The objective of this project is to investigate underlying mechanisms of the formation and development of microtextures during coking through Pearson Petrography Analysis and micro-FTIR chemical mapping techniques and thus advance the understanding of coke microtexture formation. To achieve this, we collected coal samples with varying properties such as rank (0.90-1.53MMVR), fluidity, and maceral compositions (50-70% inertinite) but similar ash chemistry.

During this quarter, we utilised these samples in plastic layer sampling via the 4kg coke oven. Each sample comprises distinct layered structures: loose coal, plastic layer, and coke/semi-coke. To analyse microtexture and IR characteristics, plastic samples underwent resinification and polishing to achieve cross-sectional views. Some samples underwent Petrography for anisotropy quotient color-coded reflectance mapping. Quantitative reflectance across the coke/semi-coke region was gauged using a CCD camera and a polarizer, determining bireflectance as the disparity between maximum and minimum reflectance. Bireflectance versus maximum reflectance plots unveil various carbon forms, such as isotropic/fused inert and incipient/fused vitrinite. Microtexture components' transition from loose coal to coke/semi-coke is showcased through a colour map, influenced by coal rank, macerals, and fluidity.

In the upcoming quarter, we'll finalise the analysis of the remaining samples and send them back to UON. These samples will undergo Synchrotron IR microspectroscopy to pinpoint areas of interest and perform micro-/macro-IR mapping spanning the plastic layer to semi-coke. The proposal to utilise the IRM facility at the Synchrotron has been approved and is scheduled for December 2023. The IRM mapping data will be correlated with microtexture findings to delve into the underlying mechanisms steering the formation and evolution of microtextures during coking.

C35046
Gasification Reactivity and Degradation of Coke Lumps Under Simulated Conventional and Oxygen Rich Blast Furnace Processes

University of Newcastle
Apsara Jayasekara

Value: $98,500
Report Expected: June 2024
Industry Monitor/s: Kim Hockings, Nick Andriopoulos
ACARP Contact: Ashley Conroy

The project aims to explore the differences in coke reactivity, microstructure and microtexture evolution, and coke degradation during gasification reactions relevant to simulated conventional and oxygen-enriched blast furnace conditions. The project objectives are to:

• Assess the gasification reactivity of different coke samples under simulated conventional and oxygen blast furnace conditions.
• Investigate the influence of varying oxygen enrichment levels (ranging from 21% to 100% O2) in the input gas on the evolution of coke microstructure and microtexture, and coke degradation.
• Compare the post-gasification strength of coke samples at both room and high temperatures under conventional and oxygen blast furnace conditions.
• Establish correlations between oxygen content and coke degradation.
• Establish connections between coke qualities and coke reactivity under oxygen-enriched scenarios.

Progress for this quarter includes the following:

• Three out of four selected coke samples (high, mid, and low CSR) were cored at UON, producing coke cylinders weighing 0.5 g each. Preparation of the remaining coke sample is currently underway.
• A total of 36 coke cylinders (12 per coke sample) were prepared for testing under four oxygen levels (21% - conventional, 35%, 50%, and 100%).
• Micro-CT imaging of the coke cylinders before gasification was successfully completed at the Australian synchrotron.
• Calculation of the gas compositions (CO/CO2/H2/H2O and N2) for different oxygen enrichment levels is in progress.

Next Quarter:
• Gasification experiments of coke samples under both conventional and oxygen-enriched gas conditions.
• Processing of Micro-CT image of unreacted samples using GeoDict is scheduled.
**Thermal Coal**

**C33061**  
Optimisation of Co-Firing Selected Australian Thermal Coals with Biomass and International Coals  

CSIRO  
Joe Perkins

| Value: | $122,660 |
| Report Expected: | August 2023 |
| Industry Monitor/s: | Graeme Harris, Greg Wickman |
| ACARP Contact: | Ashley Conroy |

The draft final report has been submitted to the Industry Monitors for review.

**C34058**  
Strength Development in Fouling Deposits  

University of Newcastle  
Liza Elliott

| Value: | $213,600 |
| Report Expected: | July 2024 |
| Industry Monitor/s: | Caroline Lang, Oliver Scholes |
| ACARP Contact: | Ashley Conroy |

Deposition within the convective pass of boilers can significantly affect gas and heat flows and alter boiler performance. Regular cleaning is required to ensure optimal boiler efficiency and ease of ash removal. Timeframes required for cleaning depend on the time it takes for strength to develop in the ash deposits, which build-up in temperature regions well below the ash melting temperature. At present, to assess a coal ash’s behaviour, a boiler operator will compare the ash fusion temperature (AFT) to those of coals with known performance in their boiler. But AFT has no correlation with strength development at sintering temperatures below the melting temperature and, instead is related to the surface tension of liquid phases above the melting temperature.

This project aims to produce a model for the development of strength in ash compacts to be able to predict the optimum time required for cleaning boiler walls. To do this the project will:
- Determine a correlation for the sintering temperature of Australian thermal coal ash.
- Gain an understanding of strength development in these coal ashes by assessing the impact of particle size and ash chemistry.

Fourteen fly ash samples have been collected and analysed for chemistry and particle size. The sintering temperature of each fly ash has been measured, along with the sintering temperature of blends of the selected fly ash samples. Additional tests to determine the impact of particle size have shown that the sintering temperature is not impacted by the size of the particles and is solely a function of chemistry. Modelling of the sintering temperature based on the ash chemistry using a neural network is complete. Early attempts to model the sintering temperature using a least squares fit was abandoned when each model produced could not accurately predict the validation set. Figure 1 shows the model predictions compared to the measured values.

![Figure 1: Model predictions of sintering temperature compared to measured values.](image)

Sintered compacts have been produced. These will be used to link the changes in open porosity with compact shear strength. Trials of the CT scanner to determine open and closed porosity were disappointing, with the pixel size appearing to be too large for accurate analysis. The Kozeny-Carmen-Rose equation, which was hoped to be used for porosity analysis based on pressure drop of gas flow through the compacts has been found to be inaccurate with these fly ash samples. Endo’s equation is being assessed for suitability, but it includes an experimentally determined variable that reflects the character of the sample that requires the determination of a minimum of least squares, and several minimums have been observed.

To measure the strength of these compacts, the TUNRA Jenke shear strength testers were found to have an upper strength limit that was too low. Alterations to the testers were considered before an alternate tester was found. Mounting the sample to ensure accurate testing is required and a technique has been determined and strength testing of the samples should be able to start soon.
C35005
Feasibility Study, Upgrade and Commissioning of
ALS-ACIRL Pilot Scale Combustion Test Facility

ALS Coal
ACIRL
James Bottle

Value: $591,250
Report Expected: March 2025
Industry Monitor/s: Caroline Lang
Greg Wickman
Jane Lawson
Oliver Scholes

ACARP Contact: Ashley Conroy

The overall objective of this project is to upgrade ALS-ACIRL’s existing pilot scale coal combustion test facility so that it can more accurately simulate current and emerging coal fired combustion technology.

The project has been separated into three stages, each with their own specific objectives:
1. Feasibility study to assess the implementation and cost of key technical requirements of the upgraded facility including:
   • Co-firing with 5 – 15% biomass;
   • Increased heat transfer metal temperatures for the assessment of ash deposition behaviour;
   • Capture of fine particulates (<10 μm).
2. Present findings and if viable proceed with upgrade of ALS-ACIRL Combustion facility.
3. Upon completion of the upgrade, undertake a commissioning project that:
   • Determines combustion performance of two coals and compare their performance against results prior to the upgrade.
   • Co-fire with 5% and 10% biomass for each coal and investigate impacts on combustion performance.

Progress made in the first quarter of the feasibility study:
• Trialed air-cooling the slagging panels and fouling probes to achieve high metal surface temperatures. The trial was successful for the fouling probes with temperatures maintained at 650°C but unsuccessful for the slagging panels due to too high surface temperatures (>650°C).
• Reverted to water-cooling the slagging panels and fabricated a new design that removed a greater proportion of the metal surface, thereby reducing the heat transfer from the face plate. Initial trials suggest higher face temperatures (550 - 600°C) can be achieved.
• Designed and trialed separate biomass feed system to allow co-firing into Boiler Simulation Furnace.
• Investigating cascade impactors for capture and analysis of ultra-fine particles (<10 μm) that may not be collected by electrostatic precipitators.

C25053
Coal Sample Bank

CSIRO
Lauren Williamson

Value: $451,801
Report Expected: November 2024
Industry Monitor/s: Technical Market Support Committee

ACARP Contact: Ashley Conroy

The objective of this project is to make coal and coke samples available to researchers and to enhance the systematic provision of the samples for ACARP projects.

To date, 86 coal samples have been delivered, stored at -18°C and their details recorded in a database, there are also 35 cokes, 1 biomass and 1 fly ash stored. Of the coal samples stored coal quality data has been provided by coal producers for 77 of the samples.

In the most recent quarter the coal bank has taken delivery of several coal samples for use in new projects, the majority of these have been distributed. Samples have been provided to the following projects: C35037, C35038, C35039, C35040, C35042 and for continuing project C34054. Cokes required for projects C35043 and C35046 are being sourced.

C26003
Management of SA and ISO Coal Technical Committees Work Programs

Carbon Connections Consulting
Barry Isherwood

Value: $391,150
Report Expected: July 2024
Industry Monitor/s: Graeme Harris
Kevin Rowe
Kim Hockings

ACARP Contact: Anne Mabardi

The ISO Technical Committee TC27 Solid Mineral Fuels convened its 28h meeting in Delft, the Netherlands from May 14-19, 2023. The Committee is responsible for approximately 110 Standards or projects in the areas of Coal and Coke Sampling, Preparation and Analysis.

Active participation in the ISO TC27 Committee work program is still an ongoing issue, noting that TC27 has 22 Participating (P) member countries as well as 17 Observer (O) member countries.

ISO has specific rules concerning the obligations of a P member country, including attendance at meetings, balloting, and technical input. There are a number of countries which do not fulfil these requirements and
their status will be questioned with them. It was pleasing that there were 52 delegates registered from 13 countries, a record on both accounts, including Kazakhstan, Turkiye, Spain and Tanzania for the first time.

The WG 13 Convenors’ Manual, developed under SC5, to ensure consistency and robustness of Standards, containing valuable information on language, Interlaboratory Studies (ILS) preparation and reporting, has been re-titled as the TC27 Quality Manual and will be transferred to TC27 for implementation across all work done in the SC’s.

The scope of ISO TC27 and each of its SC’s (Subcommittee) were reviewed for consistency and formally adopted noting that at least 2 SC’s did not have an actual defined scope.

In the Coal Preparation Subcommittee SC1, it was agreed to revise the ISO Standard for On-Line Analysers and to convert it into a more descriptive Guide, rather than a prescriptive Standard. Minor Revisions will be carried out on 6 published Standards, based mainly on editorial comments from Australia, submitted at the time of recent SR’s (Systematic Review).

In the Coke Subcommittee SC3, Canada, has appointed a new Chair. Following a negative vote from Australia, but initially ignored, the Standard on Coke Relative Density, Apparent Relative Density and Porosity will now be revised and the Standard split into 3 separate parts.

In the Sampling Subcommittee SC4, all 8 parts of the Mechanical Sampling Standards require Minor Revisions as well as the Guide to Sampling of Coal Seams.

In the Analysis Subcommittee SC5, there are 36 active projects, and all were discussed, following many SR’s over the 4-year period since the last meeting. Many will require Minor Revisions based on the SR comments submitted. There were 8 presentations on potential NWI proposals including 2 from Kazakhstan - one on Self Ignition of coal, and the other on Determination of Coal Oxidation.

There was also a presentation, based on work carried out in Canada on a “Relative Precision Model” (RPM) which reviewed the relationship between Repeatability (r) and Reproducibility (R), demonstrating that there appears to be a robust relationship. Thus, it may be possible to derive an R value, for a specific test, from r values routinely encountered in laboratories every day. This may solve the logistical issues and expenses of conducting ILS programs, including where an ILS is not possible because of sample stability issues. Further work and comparisons are required.

It was noted that succession planning is becoming a critical issue with the Chair terms for Barry Isherwood (TC27), John Kelly (SC5) and Dave Osborne (SC1) all terminating end 2024 or 2025 and no further extensions allowed under ISO rules.

The next meeting will be held in New Delhi, India in Sept 2025, with a number of countries all vying for the following meeting in 2027, including China, Kazakhstan and USA, which is encouraging.

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

Standards Australia
Jon Meunier

| Value: | $390,370 |
| Report Expected: | February 2024 |
| Industry Monitor/s: | Graeme Harris, Kevin Rowe, Kim Hockings |

ACARP Contact: Anne Mabardi

SA support for Australian Mirror Committee—Schedule of meetings:

- MN-001 (Coal and Coke)—Mirror Committee for ISO/TC27
  - Chairman: Barry Isherwood
  - Last meeting: 20 July 2023 (Zoom meeting)
  - Next meeting: (TBA).

- MN-001-01 (Coal analysis) —Mirror Committee for ISO/TC27/SC3 and SC5
  - Chairman: Barry Isherwood
  - Last meeting: 20 July 2023 (Zoom meeting)
  - Next meeting: 16 November 2023 (Newcastle with Zoom Option—Hybrid)
  - Meeting objective: Review ISO/TC27/SC5 and SC3 documents including systematic reviews and finalise Australian mirror Committee position on ISO ballot (and comments).

- MN-001-02 (Coal Preparation) —Mirror Committee for ISO/TC27/SC1 and SC4
  - Chairman: Dave Osborne
  - Last meeting: 22 June 2023 (UNSW, Sydney)
  - Next meeting: 24 August 2023 (Zoom based)
  - Meeting objective: Review of ISO/TC27/SC1 and SC4 documents including systematic reviews and finalise Australian mirror Committee position on ISO ballot (and comments). Review update on national Standards and projects.

- MN-001-05 (Coal Mining and Geology)
  - Chairman: No chair
  - 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.
**C27001**  
**Maritime Regulation Project**

**Goodwin Port Solutions**  
Ash Goodwin

- **Value:** $4,169,012
- **Report Expected:** June 2024
- **Industry Monitor/s:** Maritime Regulation Task Group
- **ACARP Contact:** Anne Mabardi

The project includes research to investigate issues relating to the accuracy, repeatability and reliability when testing coal cargoes for self-heating potential. Experimental work investigating the test methods was finalised in May 2022, with the outcomes presented to the Australian Maritime Safety Authority (AMSA) in June 2022.

In September 2022, AMSA provided the project report and recommended regulatory responses to the International Maritime Organisation’s Sub-Committee on Carriage of Cargoes and Containers (CCC) for consideration. Work continues to progress amendments to the International Maritime Solid Bulk Cargoes (IMSBC) Code, with subsequent submissions to the IMO planned in September 2023.

As an interim measure, AMSA has issued Certificate of Approval No. 8024, allowing coals meeting specified criteria to be classified and shipped as materials hazardous only in bulk (MHB). This approval is available on the AMSA website and remains valid until 31 December 2026.

**C33065**  
**Digital Petrographic Atlas of Australian Coals - Maintaining the Knowledge**

**University of Queensland**  
Joan Esterle

- **Value:** $197,537
- **Report Expected:** April 2024
- **Industry Monitor/s:** Graeme Harris, Jay Zheng, Sean Flanagan
- **ACARP Contact:** Ashley Conroy

This project will create a Digital Petrographic Atlas of Australian coals, their maceral and mineral composition at different ranks, linked into our current understanding of basin scale variation in rank, type and grade, highlighting case studies that assist with conceptual mine scale models for understanding and predicting coal quality variation. In addition to the atlas, a library of scanned petrographic images of product coals from different basins and formations, illustrating the variation in rank, grade and type will be developed. This can be used for reference, training and round robins.

A public presentation was made to the GSA Coal Geology Specialists Group about the project. To date, some 70 samples from the Geological Survey of Queensland collection, and the UQ teaching collection have been cut and polished for retrieval and analysis using the Fossil ViewerTM software. The majority of the samples are from exploration drilling through the late Permian coal measures, and illustrate the story of changing rank across the basin as well as maceral composition. Analyses are being conducted to ISO-ICCP standards. The team has put together a master table that highlights variations that would occur between different standards (ICCP, ASTM, SA). At the recent monitors meeting it was suggested to limit the digital database to the Queensland and UQ collection, with provision for addressing the other samples in future projects. The volume of the task to capture all Permian basins was underestimated. The project has been extended to March 2024, and the remaining tasks are involved with completing analyses on the current sample data and reporting.

**C33070**  
**Update of Coal Dustiness and Dust Extinction Moisture Standard AS4156.6**

**University of Newcastle**  
Dusan Ilic

- **Value:** $150,000
- **Report Expected:** August 2023
- **Industry Monitor/s:** Anthony Edwards, Graeme Harris, Jane Lawson, Kevin Rowe
- **ACARP Contact:** Ashley Conroy

The draft final report has been submitted to the Industry Monitors for review.
Increasing pressure to reduce anthropogenic greenhouse gas emissions has driven the development of mitigation technologies, identified as necessary for maintaining financial feasibility. This requires a system which exhibits high levels of activity and stability, promotes safe operational regimes and needs minimal energy input. Initial experiments in a laboratory environment have demonstrated that this can be achieved through catalytic oxidation. The developed catalyst has demonstrated high activity and stability, with hydrophobic supports exhibiting resistance to deactivation caused by water vapor in the VAM stream while requiring temperatures below the autoignition temperature of methane. These experiments utilised a packed catalyst bed, which are not a suitable configuration for continued scaled reactors due to the development of a significant pressure drop and the tendency for the formation of channels through the bed which reduces methane interactions with the active species. Catalysts deposited on structured supports have shown that high levels of activity can be maintained without the development of any significant pressure drop.

Experiments have successfully shown that the developed catalyst on a monolith support converts methane in VAM (>90%) at elevated flowrates several orders of magnitude larger than lab scale without the development of any significant pressure drop across the reactor. However, a priority for the implementation of mitigation technology requires operation which maintains high levels of safety. To identify the inherent safety of Catalytic Oxidation of Methane with Multidimensional Structured Supports (COMMSS), a dedicated reactor has been constructed with safety mechanisms to allow for the operation under elevated methane concentrations. The system is currently being operated both under elevated methane to determine the effect on system parameters and catalyst, together with operational temperatures in the flammable region to highlight the inherent safety of the system for VAM mitigation, particularly under abnormal reaction conditions.

The principal vision in this project is to advance the development of a Rapid Action Inflating Nitrogen Bag Obstruction Explosion Suppression (RAINBOES) concept as an effective and ultra-fast suppression system for gas explosions. To fulfil this vision, the project aims at proving the concept through a combined theoretical and experimental approach. Theoretical studies will involve both analytical assessments and CFD modelling aimed at gaining a deeper understanding of the fundamental science that governs the operation of RAINBOES and its key components. The experimental studies include prototype development followed by small-scale assessment and concept validation.

With reference to the project structure plan, several essential and key tasks of phase II have been achieved in the second quarter of the project duration as follows:

- A comprehensive computer simulation was conducted to determine the viability and application of multiple airbags to obstruct ducts with larger diameters in under 1 second. The simulation results indicated ducts with diameters up to 8.5m can be successfully blocked in under 1 second using 4 airbags (see Figure below).
- Ducts with larger diameters (>8.5m) can be blocked with multiple airbags (>4).
- The required total air volume to inflate a single airbag to block a duct with a 4.16m diameter was calculated at about 122 m$^3$. This volume of air can be easily supplied using a 12-pack of nitrogen cylinders available in the market. To fully inflate four airbags to block a duct with 8.5m in diameter and under 1 second, approximately 160m$^3$ nitrogen is required. This volume can be supplied using multiple packs of nitrogen cylinders.
We have now completed our first of two field campaigns to both quantify methane emissions/fluxes from open cut coal mines and to ground-truth observations from satellites. Our revised research path (Stage 2) is to be completed in two phases:

Stage 2, Phase 1 (report completion August 2023)
- Monitoring campaign at the chosen mine to quantify methane fluxes from different surfaces across the site – complete.
- Use this to inform a conventional atmospheric dispersion model to predict methane ‘heat maps’ across the mine site – in progress.
- This will allow us to optimise the location of medium / long duration monitoring equipment to be deployed in Phase 2.

Stage 2, Phase 2 (completion September 2024):
- Deploy Picarro instruments in a (predominantly) upwind-downwind configuration.
- Deploy additional research-grade instrumentation to characterise methane emissions / flux:
  - an open-path Fourier Transform Infra-Red (FTIR) instrument; and an EM27/Sun instrument.

Fugitive methane emissions from mine shaft ventilation (VAM) is one of the major greenhouse emissions associated with the sector. It has been identified that a technology to significantly reduce this is critical for the ongoing financial viability of a mine site. Previous studies have shown catalytic reactors exhibit high levels of activity and stability, offering a potential mitigation solution which is able to address many of the issues associated with currently implemented thermal abatement systems. In addition to requiring a significantly smaller physical footprint to achieve the same levels of methane conversion as a thermal system, the proposed Catalytic Oxidation of Methane with Multidimensional Structured Supports (COMMSS) solution is designed to be self-sustaining, requiring much lower energy input. Catalytic systems also offer enhanced safety, not only exhibiting high levels of activity below the auto ignition temperature of methane, but also offering an intrinsically safe system via surface oxidation reactions as opposed to a cascade of radicals, which characterise typical combustion reactions. The current project investigates the performance of a...
COMMSS unit under abnormal conditions to validate safe operation.

Experiments were conducted examining operation under elevated methane concentrations and at temperatures above the auto ignition temperature. While the increased methane concentration produced a concomitant increase in the bed temperature due to the resultant reaction exotherm, this increase was observed to be relatively slow, without a loss of activity and maintained temperatures significantly lower than other technology solutions. Further, carbon monoxide, a highly toxic and flammable product of partial methane oxidation, was not detected when reaction conditions were above stoichiometric values, even under elevated methane concentrations, when operated with a catalyst. Under the extreme conditions tested, indications of ignition were not measured which will be further examined to highlight the inherent safety of catalytic systems.

C36001
Open Cut Fugitive Greenhouse Gas Emissions

Australian Coal Mining Consultants
Andy Self

Value: $227,500
Report Expected: September 2023
Industry Monitor/s: David Webb, De Nicholls, Iain Hornshaw, Jim Sandford, Sandy Tickell

ACARP Contact: Patrick Tyrrell

This project will analyse the possible methods of reducing fugitive gas emissions and identify and document the next phase of research which would lead to a plan for the minimisation of fugitive gas emissions from open cut coal mines. The benefits to industry will be to develop a more detailed identification and analysis of viable predrainage strategy options in order to mitigate against fugitive open cut gas emissions which will deliver a path forward for effective open cut gas fugitive emissions management.

All tasks other than the report have been completed; which is being written and will be completed shortly.

C36002
Investigation into the Technical Feasibility of In-Pit Gas Capture for Open Cut GHG Mitigation

GeoGAS
Christian Boucher

Value: $404,000
Report Expected: May 2024
Industry Monitor/s: David Webb, De Nicholls, Iain Hornshaw, Jim Sandford, Sandy Tickell

ACARP Contact: Patrick Tyrrell

The key objective of the project is to determine how open cut mining modifies the coal seam gas reservoir and how these changes could be leveraged to provide a more cost-effective way of capturing gas from within the operating pit for the purpose of fugitive emission mitigation.

The initial part of the study has been focused on developing basin trends for gas content, composition and permeability spanning the Bowen Basin and Hunter Valley. Concerns regarding the confidentiality of industry trend information were discussed with our Project Monitors, and a path forward using representative data as the basis for modelling gas reservoir inputs was agreed. The inclusion of more comprehensive source gas data was not deemed appropriate due to the fact that it may not accurately represent each basin and could be interpreted in a manner not intended by the authors.

Utilising mine planning principles, a review of present operations and reservoir characterisation data, a dual pit mine layout has been developed for the geotechnical (FLAC) model. The configuration has been selected to identify key drivers of coal seam permeability modification based on variations in bench width, overall pit slope, and seam depth at various phases of overburden removal. The 3DFLAC modelling work has recently commenced to assess elastic stress and pore pressure changes about the opencut excavation as it is stripped. The model outputs developed will be used by GeoGAS as an input for gas emission modelling.