FEBRUARY 2025

CURRENT PROJECTS REPORT

This report is a summary of current and completed projects for the months November, December 2024 and January 2025

ACARP

ACARP CONTACTS

PROGRAM MANAGEMENT

Suite 23, Level 9
307 Queen Street
Brisbane Qld 4000
Phone: 07 3607 3824

Matt Fellowes
Executive Director
matt@acarp.com.au

Marilyn Keenan
Levy Administrator
accounts@acarp.com.au

PROJECTS MANAGEMENT

Level 12
167 Eagle Street
Brisbane Qld 4000
Phone: 07 3225 3600

Anne Mabardi
anne@acarp.com.au

Patrick Tyrrell
patrick@acarp.com.au

Nicole Youngman
nicole@acarp.com.au

RESEARCH COORDINATORS

Peter Bergin
Underground NSW
peter.bergin@icloud.com

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

David Drakeley
Open Cut
ddrakeley@fieldcrew.com.au

Ben Gill
Coal Preparation
excaliburmining@outlook.com

www.acarp.com.au

UNDERGROUND

REPORTS PUBLISHED THIS QUARTER

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

CSIRO
Yonggang Jin
Link to download the final report:
https://www.acarp.com.au/abstracts.aspx?repId=C33069

C34010
Time Lapse In-seam Seismic and Resistivity Measurements as an Integrated Component of a Smart Coal Seam Gas Pre-Drainage Practice – A Literature Review

University of New South Wales
Hamid Roshan
Link to download the final report:
https://www.acarp.com.au/abstracts.aspx?repId=C34010

C35017
Is exposure to illite dust linked to pneumoconiosis?

University of Tasmania, B3 Mining Services
Graeme Zosky, Basil Beamish, Yong Song
Link to download the final report:
https://www.acarp.com.au/abstracts.aspx?repId=C35017

Coal Burst

C27020
Management of Coal Bursts and Pillar Burst in Deep Mine

University of Adelaide
Giang Nguyen
Murat Karakus

Value:	$380,240
Report Expected:	February 2025
Industry Monitor/s:	Brad Elvy Frank Fulham Ian Stone Patrycja Sheffield Paul O'Grady Peter Corbett Roger Byrnes Russell Thomas Sharif Burra
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:	February 2025
Industry Monitor/s:	Brad Elvy Frank Fulham Ian Stone Patrycja Sheffield Paul O'Grady Peter Corbett Roger Byrnes Russell Thomas Sharif Burra
ACARP Contact:	Peter Bergin

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

C33014
Coal Burst Research Findings

SCT Operations
Winton Gale
Yvette Heritage

Value:	$388,000
Report Expected:	March 2025
Industry Monitor/s:	Frank Fulham Ian Stone Patrycja Sheffield Paul O'Grady Peter Corbett Roger Byrnes Russell Thomas Sharif Burra
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 project 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 to
- Provide an estimate of the threshold values associated with dynamic bursts for a range of coal.

Discussions and work has been undertaken to characterise the energy associated with those outlined above. The following work has been undertaken.

Modelling 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.

Modelling 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.

Simulations of bursts in a range of seam thickness and banding has been undertaken. The main control 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; and
- 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 project 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.

A definition of the change in strength of the ribside caused by claystone bands and rib height has been determined. The effect of gas pressure, gas volume and gas desorption rate has been assessed for a range of extraction heights and claystone bands.

It has been found that the use of energy as a criteria for understanding of bursts allows a simple assessment of the risks of bursts irrespective of the cause. The energy required is constant although the generation of the energy is different albeit gas ,strain or seismic.

A review of the strength of the coal ribside has been undertaken to define energy levels required to move the coal under the confining conditions which occur.

This approach provides a clear view of the likelihood and risk of various types of bursts on the basis of the energy available to the system.

The project is in the late stage of reporting and a draft is being prepared. A final internal edit of the report is underway prior to submission to the Industry Monitors.

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:	Marc Henderson Tim Dean
ACARP Contact:	Peter Bergin

The project goal is to provide a new, more cost-effective approach for assessing the longwall caving progress and coal burst risk. It contains two research objectives:

1. Trial optic fibre cables pre-installed in geo-exploration holes for high accurate and cost efficiency longwall weighting and coal burst monitoring; and
2. Conduct a field demonstration using both distributed acoustic sensing (DAS) and geophones and investigate the optimal monitoring configuration, data processing and interpretation methods for the DAS system.

During the quarter the targeted longwall panel completed production, and the monitoring system was decommissioned. Novel methods were developed for DAS data processing. Seismicity before the collapse of the second borehole is obtained (Figure 1). The results show that seismic activity is closely related to the longwall retreatment rate. The seismic events before the first borehole collapsed are selected for source location. The distribution of these seismic events shows that the fractures were mainly located behind the longwall face and in the immediate roof (Figure 2). The depths of seismic events identified by the borehole fibre cable revealed that the fractures clustered at different geological layers. Furthermore, refractive and reflective wavefields were observed, indicating the presence of stratigraphic discontinuities where the shear wave velocities change.

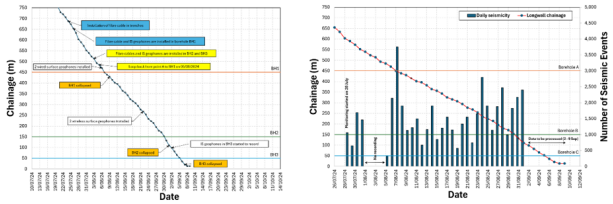


Figure 1. (left) Progress of the field installation, longwall retreatment and collapse of boreholes; (right) Daily seismicity recorded before the second borehole collapsed.

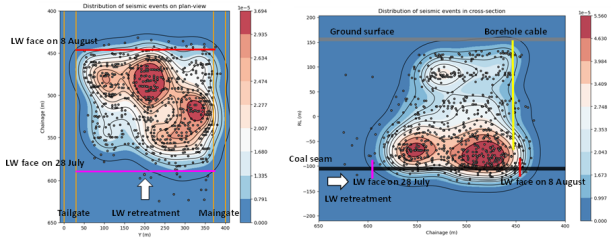


Figure 2. Distributions of seismic events before the first borehole collapsed (left) on plan-view; and (right) in cross-section.

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

Value:	$392,500
Report Expected:	February 2025
Industry Monitor/s:	David Webb Martin Mackinnon Paul Wild Peter Baker Sharif Burra
ACARP Contact:	Patrick Tyrrell

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
Sean Muller

Value:	$153,700
Report Expected:	March 2025
Industry Monitor/s:	Brad Lucke Jarod Chadwick
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.

During the quarter the project progressed as follows:
- Circuit diagram was completed;
- Obtaining testing equipment is in progress;
- Manufacturing of items for testing is scheduled for February-March.

The following steps will be addressed in the next quarter:
- Finalise all test equipment;
- Finalise test infrastructure;
- Develop work procedure and risk assessment;
- Complete Test setup; and
- Commence testing.

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:	March 2025
Industry Monitor/s:	Gary Brassington Peter Corbett
ACARP Contact:	Patrick Tyrrell

No report received.

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

CSIRO
Ramesh Thiruvenkatachari

Value:	$969,195
Report Expected:	December 2025
Industry Monitor/s:	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.

Preparation are being made for onsite infrastructure development for the pilot setup and trial. Mine water intake and storage tanks and mine water pumping pipe works have been installed. Other infrastructure such as

ground compaction at the test location on site where the pilot unit is to be installed, power supply facilities and control room setup are to be carried out. Site and equipment risk assessment has been initiated with site personnel. Instrument data logging software has been developed. Pilot test unit is being constructed.

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:	Callum Gawne Jason Fittler Michael Moore Ned Stephenson
ACARP Contact:	Patrick Tyrrell

There has been limited research on the most appropriate options for rehabilitating land subsided by longwall mining in Australia. This project is investigating the implications of retaining ponded areas from longwall mining, including their contribution to environmental values. The approach is to select a study site and conduct the research at that location over a three year period, providing a template for the assessments that are required to make decisions on rehabilitation options for ponded areas at other mines.

Three rounds of fieldwork (out of four rounds in total) have been completed. The most recent field trip was completed in November and involved collection of water samples from ponded areas, bird surveys and camera trapping. Following the installation of two additional staff gauges, mine staff are now recording pond water levels in three ponds approximately weekly. Planning for the final round of fieldwork in May is currently underway.

Preparation of the Site Characterisation Report to be delivered in mid-2025 is underway. The report will provide details of the field and analytical work undertaken for the project. Reporting on the vegetation surveys and soil sampling and analysis is mostly complete, with the remaining sections under development.

Soil hydrological modelling has commenced. The modelling will be used to predict hydraulic properties for ponded areas, which will be a key input to the water balance model. The engineering design for the free draining landform has been received and will be used to develop inputs to the water balance model for this scenario.

Maintenance and Equipment

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:	March 2025
Industry Monitor/s:	Ben McCamley Brad Lucke Dave Young Ernest Baafi Jonathan Harris
ACARP Contact:	Patrick Tyrrell

No report received.

C33009
Ceramic Wall Flow Filter Commercialisation

PPK Mining Equipment
Bradley Drury
Greg Briggs

Value:	$888,778
Report Expected:	June 2024
Industry Monitor/s:	Andrew Esdaile Steve Coffee Trevor Hartley
ACARP Contact:	Patrick Tyrrell

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

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

Vayeron
Ryan Norris

Value:	$185,000
Report Expected:	March 2025
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.

No progress made over the quarter, while project is awaiting field trials to be arranged. Vayeron is independently working with an OEM supplier on commercial implementation of units for deployment with their customers however, this is outside of the ACARP project.

C33026
Prototype Battery Electric Load Haul Dump

3ME Technology
Greg Briggs
Justin Bain
Lewis Grainger
Martin Kime

Value:	$1,431,295
Report Expected:	August 2025
Industry Monitor/s:	Brad Lucke
	Dave Young
	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:
- Certifying Body continued assessment against relevant standards;
- Continued procurement activities for large scale battery;
- Charging requirements for large scale battery identified, procurement commenced;
- Charger prototype construction commenced;
- Completed large scale battery initial mechanical design;
- Continued large scale battery detailed electrical architecture;
- Commenced review and identification of platform integration requirements; and
- Scaled enclosures built, delivered and fit out commenced.

Key tasks to be conducted next quarter include:
- Complete testing with certifying body;
- Commence large scale battery construction;
- Complete battery charger prototype construction;
- Function test battery charger;
- Finalise OEM platform integration requirements; and
- Complete fit out of scaled battery enclosure.

Mining Technology and Production

C20033
Development of a Safer Underground Explosive

University of New South Wales
Andres Castro
Duncan Chalmers

Value:	$468,000
Report Expected:	April 2025
Industry Monitor/s:	Brad Elvy
	Paul Wild
	Rob Nowell
	Russell Thomas
ACARP Contact:	Patrick Tyrrell

Underground mines resort to the use of explosives to break extremely hard materials that intrude into coal seams. Since there is no longer P5 explosive available for delay firing, mines resort to using type 1 explosive. Confusion arises as to how these explosives can be safely used. Currently permitted explosives are being used outside the recommended guidelines as published by the Buxton Testing Authority in the UK. In order that they can be used safely, mines are conducting risk assessments to manage the incendive hazard that possibly could be created by a cut off shot and additionally managing the deflagration hazard with the same risk assessment when using P1 explosives. This project developed an alternate test regime that adequately assesses the deflagration risk of an explosive. The information gained from this testing provides additional data to change the testing regime for permitted explosives.

The team witnessed the Continuity of Detonation and Velocity of detonation tests at Dhanbad in December. The P5 candidate satisfactorily passed both tests and plans are in place for testing to be conducted in March and if the explosive passes will give it a nine month shelf-life.

The Team travelled to Nagpur and held meetings with the Explosive Manufacturer, the meeting discussions included:
- The supply to Australia;
- The approval process in Australia;
- Ongoing technical support once the explosive is approved; and
- Future research including the use of electronic Carrick Detonators.

The manufacturer requested information regarding the underground coal mining environment and practices in Australia to assist in their due diligence in supplying the explosive. The requested information was collected and supplied, and the team are awaiting the outcome of their deliberations. The report writing is continuing.

C28018
Longwall Floor Horizon Sensing

CSIRO
Andrew Strange
Zak Jecny

Value:	$269,680
Report Expected:	March 2025
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. This project will develop a ground penetrating radar (GPR) sensor for installation on a production longwall and long-term trial as a floor horizon sensor.

The new stronger high-density polyethylene (HDPE) skid base was previously installed on the production longwall. The flexible rubber sheet that connects the skid base to the bracket began to tear after ten weeks of operation, however, the skid base did not sustain any damage. The skid base was removed from the face at this point.

As a result of this successful outcome, the host site is satisfied with the new skid base design. Therefore, the rubber connector sheet will be replaced and the skid base with GPR system will be re-installed so that the long term trial can proceed.

C29033
Alternative Flameproof Enclosure Protection Techniques

CSIRO
Peter Reid

Value:	$272,000
Report Expected:	February 2025
Industry Monitor/s:	Brad Lucke Colin Hoyle
ACARP Contact:	Patrick Tyrrell

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

C34003
Self-Drilling Bolt Automation: Finalisation of Development

OKA Rock Bolt Technologies
Mark Levey

Value:	$2,357,744
Report Expected:	March 2025
Industry Monitor/s:	Roadway Development Task Group
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, 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 adaptor:
- The two adaptors have been tested and ready for the trial.

The capsule and chemicals:
- The trial plastic capsules have been treated, part-assembled and will be filled with chemicals and assembly completed a few weeks before the underground trial.

The bolt:
- A drill bit trial/test was conducted, however a second test is to be conducted underground at the trial site to finalise the bit dimensions appropriate for the site conditions.

The Headplate and software:
- The modified headplates were completed and ready for installation;
- The Software has been refined and ready for testing.

General:
- The timing of the trial has been further delayed until April, and is now being held in New South Wales.
- An Innovation Policy Application was submitted, processed and cleared the way for the chemicals and complete system to be used in the trial;
- Labour on the project has been reduced to essential only to conserve funds until April.

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

CSIRO
Andrew Strange
Mark Dunn

Value:	$205,395
Report Expected:	March 2025
Industry Monitor/s:	Roadway Development Task Group
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 goal of safe remote operation of roadway development. Two issues have been identified that inhibit progress in the domain of remote development:

1. Continuous miner self-steering technology to maintain desired roadway headings has not yet reached the required level of performance required for sustained remote operation; and
2. No automated options currently exist to guide shuttle cars while tramming through roadway systems and whilst avoiding ribs, cut-through corners and other infrastructure.

An assistive guidance system based on CSIRO's ExScan technology and simultaneous locating and mapping techniques has been developed to address these issues.

The assistive guidance system has been prepared for a production trial. The system is self-contained and is powered by 12V batteries to enable temporary mounting and installation. The guidance system will be installed on a shuttle car in a temporary configuration and evaluated in production conditions when the host site is available. In the meantime, the draft interim report is currently being prepared.

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

University of Queensland
Zhongwei Chen

Value:	$312,534
Report Expected:	March 2025
Industry Monitor/s:	Brian Vorster Matt Tsang
ACARP Contact:	Patrick Tyrrell

The main project 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.

In this quarter, the following tasks have been carried out:

- Rock mechanical and physical properties (e.g. UCS, BTS, sonic velocity, porosity, slake durability, etc.) have been characterised and comparatively analysed along with weathering timelines (up to 13 months);
- Confocal laser scanning microscopy (CLSM) and scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM-EDS) tests have been performed to determine the pore structure evolution and mineral alteration; and
- XRD test has been performed on selected samples (fresh rock samples without being subjected to the weathering test and rocks after six months of weathering test).

The following activities are planned for the next quarter:

- Weathering tests for destructive test samples will be carried out for another one month, and the evolution and correlations of rock properties will be recorded periodically based on the testing schedule;
- Correlation between rock degradation rate and rock mechanical, physical and mineralogical properties, as well as geological logging data will be analysed.

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. The project utilises the flexible industry-directed project model to deliver research impacts to industry through well-scoped work packages.

The topic for Work Package #4 (WP4) is "Offline Drivage Monitoring Stage 2" and builds on the outcomes from Work package #1 where real-time offline drivage capability was incorporated into the CM navigation system previously developed by CSIRO.

The first key activity for WP4 was to develop custom stationary flag algorithms based upon EIP status flags reported by the miner CCU. Stationary flag algorithms have been developed for both Komatsu 12CM30 and Sandvik MB650 miner-bolters.

Further to the previous update, trials with the Komatsu miner with the stationary flag firmware were undertaken, now in production cutting conditions. The stationary flag was found to be not functioning due to extended network connection timeouts between the navigation system (LN270 INS) and Komatsu miner CCU (unknown at the time). The lack of stationary flag resulted in poor navigation system performance due to the LN270 performing a ZUPT whilst the miner was in motion. This outcome highlighted the importance of a reliable network communication link for this system. Repeat Komatsu trials with a work-around in place are in progress with improved network connection.

The new stationary flag was also trialled at two sites with Sandvik miners in production conditions which showed good results. At one of the sites, the trial consisted of three sequences totalling 104 metres advance. At the completion of each sequence, the cross-track errors were 65mm, 47mm and 227mm respectively and the along-track errors were -2.2, -2.5 and 1.7 metres. Whilst the first two sequence results achieved the desired performance of the system (100mm cross-track error after 100m of advance), the along-track error is of significant concern.

The data collected during the Sandvik trials have been processed using a new offline filter. The filter smooths the data in the cross-track direction which improves the visual representation of the data, however, it is unable to resolve the along-track error. The team is currently investigating the cause to determine how this can be improved. A meeting will be called in the coming weeks to present the current work package results to industry, provide recommendations and discuss topics for Work Package #5.

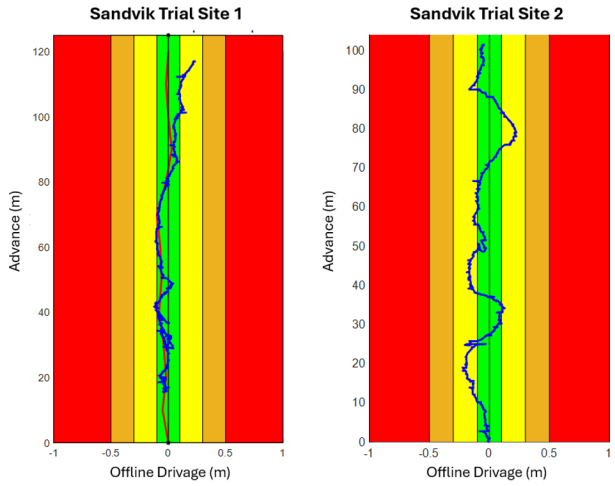


Figure: Raw offline drivage (blue line) generated by CM navigation system during trials at sites with Sandvik MB650 miners. The red line in the left image represents surveyed offline drivage data.

C35009
Longwall Remote Operations – Face Mapping Robot – Phase 1

Quantum Engineering and Consulting Group
Luke Dyer

Value:	$170,000
Report Expected:	February 2025
Industry Monitor/s:	Duane Witkowski
	Jarod Chadwick
ACARP Contact:	Patrick Tyrrell

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

C36013
Planar Reflecting Radio Antenna (PRRA) for Underground Coal Mines

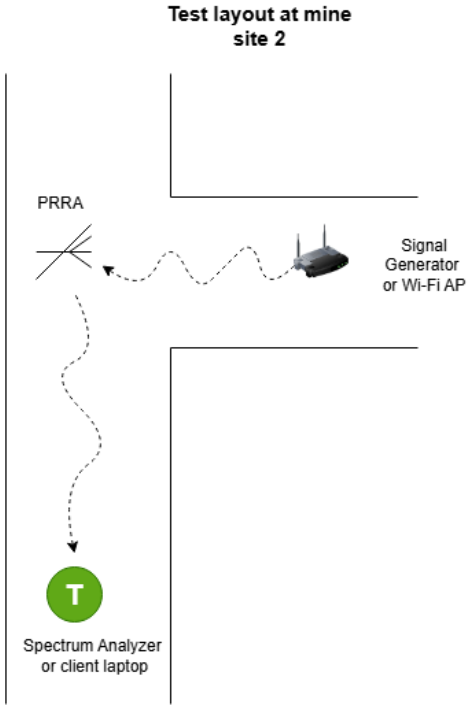
Roobuck
Naing Ba
Tommy Chaung
Dane Zielinski-Nicolson

Value:	$360,000
Report Expected:	February 2026
Industry Monitor/s:	Dave Young
	Jarod Chadwick
	Jonathan Harris
ACARP Contact:	Patrick Tyrrell

The aim of this project is to simulate, manufacture, validate and test single/multi-band planar reflecting radio antenna (PRRA) in underground coal mines to extend network coverage with minimal cost/infrastructure.

Work completed over the quarter includes:

- Second underground test at an operating coal mine with promising results -
  - Test conducted at mine site 2 for an intersection-based network coverage extension scenario (core application of technology);
  - Multiple signal gain levels were tested using a signal generator. In addition to consistent improvement using the PRRA at distances exceeding 100m, the PRRA demonstrated reliable signal retention even at low gain levels, where no signal would typically be received;
  - Beyond the generated signal test, two 2.4 GHz access points—one off-the-shelf and one Roobuck-designed—were used to evaluate signal retention across full spectrum of Wi-Fi frequency bands over the PRRA;
  - Discussions with mine operators to determine the most suitable PRRA mounting options with the focus on ensuring operational safety and selecting locations that would not obstruct existing infrastructure. The team also reviewed the existing underground network mounting designs to assess integration possibilities.



- The development of signal strength fingerprinting software has been completed, streamlining the signal strength measurement process for field tests and providing easily analysable visual representations.
- Conceptual designs of rotational mounting mechanism and antenna enclosure have been developed, and materials have been selected to comply with IEC-Ex standards.

Planned next steps:
- 5Ghz Single band PRRA manufacturing and initial lab testing.
- Finalise CAD designs and prepare prototypes for mounting mechanism and antenna enclosures.
- Test terminal devices with different antenna types with Roobuck LR WiFi AP, various PRRA and use case scenarios.

C36014
Roof Support Location using Wireless Ranging

CSIRO
Matt van de Werken

Value:	$212,543
Report Expected:	September 2025
Industry Monitor/s:	Brad Elvy
	Tom Hudson
ACARP Contact:	Patrick Tyrrell

This project aims to develop a prototype system for locating longwall roof supports in real time using wireless ranging, to alleviate the problem of roof support left behind.

In the quarter, work continued on the longwall simulator and the localisation algorithm. The visualisation of the longwall was enhanced, and a messaging system between the various components of the system was integrated into the simulation engine. Localisation algorithm development continued.

The design of the hardware for the Tag was started, with good progress made. Also, work on the embedded software for the tag/anchor pairs began, with two-way ranging firmware development progressing well.

The next quarter should see the localisation algorithm finalised, further progress on the hardware and software development, and commercialisation activities ramped up.

Health and Safety

C24010
Proximity Detection Systems Specification for Underground Coal Mining Machines

Simtars
Sean Muller

Value:	$565,988
Report Expected:	March 2025
Industry Monitor/s:	Brad Lucke
ACARP Contact:	Patrick Tyrrell

The objectives of this 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

A draft report will be submitted during the next quarter.

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

Lear Siegler Australasia
Peter Phaedonos

Value:	$152,1730
Report Expected:	March 2025
Industry Monitor/s:	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 exposer. It will have a very low detection limit that will meet or exceed current and anticipated exposure limits, and AS2985-2009 requirements for such continuous testing.

Status of project with latest updates are following:

- Successful IECEx certification for TEOM-Mass Transducer, and flow path heaters;
- Remaining IECEx compliance tests require full PDM3800 prototype unit (planned for March 2025);
- Battery packs revised and re-manufactured for better fit with main assembly;
- Finalisation of all PCB BOMs, and awaiting encapsulation of carrier boards; and
- Master parts list revised to reflect latest changes.

Despite some minor revisions to parts as preliminary testing takes place, there is continuous progress and a clear path towards the full certification and commercial release of the PDM3800. Most hurdles have been overcome with respect to sourcing parts, with the assembly of the first PDM3800 prototype now being the next task in line.

C33001
Silica Analysis of Dust on PDM filters: Phase 2 Optimisation and Field Demonstration of the Developed Methodology

CSIRO
Hsin Wei Wu
Yonggang Jin

Value:	$516,700
Report Expected:	April 2026
Industry Monitor/s:	Andrew Lau Kevin Rowe Sharif Burra
ACARP Contact:	Patrick Tyrrell

A methodology has been developed to enable respirable crystalline silica (RCS) analysis of PDM-collected coal dust in C33001 Phase 1. The project of Phase 2 aims to progress the developed methodology towards industry implementation through optimisation of the methodology by analysis of a variety of laboratory-generated and mine-collected dust samples, setup of dust detachment-redeposition apparatus and compact FTIR spectrometer at the mine site, and field trials and demonstration of the methodology for RCS analysis of PDM3700 samples at the end of the shift.

In the quarter, the newly sourced kaolinite samples were used to prepare the standard samples for developing calibration curves for both FTIR and XRD analysis. The calibration curves will be applied for the correction of kaolinite's interference with RCS analysis. Laboratory dust sampling with coal dust feeds containing quartz was carried out to collect varied respirable dust samples for RCS analysis. XRD analysis of dust filter samples are ongoing to develop the correction model related to other silicate contamination for direct-on-filter RCS analysis by FTIR. Field dust sampling at a coal mine has been scheduled in the following quarter. Respirable dust samples will be collected using both gravimetric and PDM3700 samplers, and the collected actual coal mine dust samples will be used for trialling and optimising the developed methodology in the laboratory.

C33012
Respirable Dust Reference Testing Method and Dust Chamber Facility

Simtars
Sean Muller

Value:	$215,950
Report Expected:	April 2025
Industry Monitor/s:	Andrew Lau 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.
- Compare the accuracy of the devices when using a different dust types and dust mixtures (stone dust, coal dust, silica).

During the quarter, the project progressed as follows:

- The re-designed and installation of the pneumatic system is nearing completion;
- The regulatory requirements related to use of a radioactive apparatus (static eliminator) have been clarified and work is underway to complete this section of the pneumatic system. Two members of the project team have undergone radiation safety officer training and will be gaining their certifications in due course;
- Implementation of the control system is ongoing and is expected to be completed within the next reporting period. The chiller unit required to maintain the temperature of air going into the chamber has been acquired and will be integrated into the system during the next reporting period.
- Preparations for commissioning and validation of the system are also underway. The project team is currently engaged with NIOSH to finalise the testing requirements and ensure the availability of the required testing equipment at both SIMTARS and NIOSH.

The following steps will be addressed in the next quarter:

- Completion of the pneumatic system for introducing air into the system;
- Completion of the control system;
- Integration of the chiller unit; and
- Design of a system for running air through the samplers.

C34006
Resilience and Mental Health in Mining Pilot Program

Macquarie University
Rebecca Mitchell

Value:	$476,099
Report Expected:	April 2026
Industry Monitor/s:	Sharif Burra
ACARP Contact:	Patrick Tyrrell

The primary objective of the project is to investigate the work-related factors that influence the resilience of coal mining employees. This endeavour aims to design interventions that bolster the resilience of these individuals, thereby improving work practices and experiences that directly contribute to employee resilience and mental well-being in the Australian coal mining sector. Concurrently, we identify and address any practices that might adversely impact resilience and mental health.

Over the quarter, we have:

- Successfully engaged multiple stakeholders who part of the resilience pilot program with have created a serious of workshops with key stakeholders in the partner mine to define a desirable, viable and feasible set of activities that form a “resilience building program”;
- Agreed a roll out of plan for the intervention which includes members of the research team being available to engage with the mine site with no negative impact on production – specifically, we are using “wet days” to engage with workforce. Notably, we have also agreed to use “wet nights” to interact with shift workers who may have different resilience and mental health challenges; and
- Completed multiple site visits in the preparation of the pilot, and we work with the Safety Manager and COO on a regular basis now.

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:	February 2025
Industry Monitor/s:	Andrew Lau Kevin Rowe Sharif Burra Tony Egan
ACARP Contact:	Patrick Tyrrell

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

C34023
Advanced Breathing Apparatus with Gas Membrane Modules

Monash University
Victor Chang

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

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

Most of the planned trial have been finished. The researchers are now preparing the fitting to host the module into Drager’s BG4. Given the project timeline, the final report to summarise the findings and new knowledge will be available in March.

C36006
Advanced Lung Function Assessments for Diagnosis of Coal Mine Dust Lung Disease (CMDLD): The Next Step Towards a Better Health Surveillance Program

I-MED Radiology Network
Katrina Kildey

Value:	$186,832
Report Expected:	April 2025
Industry Monitor/s:	Andrew Lau Kevin Rowe Shane Apps Sharif Burra
ACARP Contact:	Patrick Tyrrell

This study will investigate whether a new advanced lung function test - Lung Ventilation Analysis Software (LVAS) - can improve the diagnosis of Coal Mine Dust Lung Disease (CMDLD), compared to the current mainstay test of spirometry. Previous projects showed most individuals subsequently diagnosed with CMDLD had no lung function impairments on their spirometry and that spirometry incorrectly identified lung function abnormalities in otherwise healthy individuals. LVAS could enable the earlier detection of lung diseases and reduce the need for additional tests. If confirmed by this project, introduction of LVAS testing could lead to a more effective health surveillance program for CMDLD and minimise harm to affected individuals.

This project is currently on hold.

Roadway Development

C27076
Underground Coal Mine Gateroad Development Continuous Haulage System

Premron CHS
Mick Whelan

Value:	$9,773,528
Report Expected:	February 2025
Industry Monitor/s:	Roadway Development Task Group
ACARP Contact:	Patrick Tyrrell

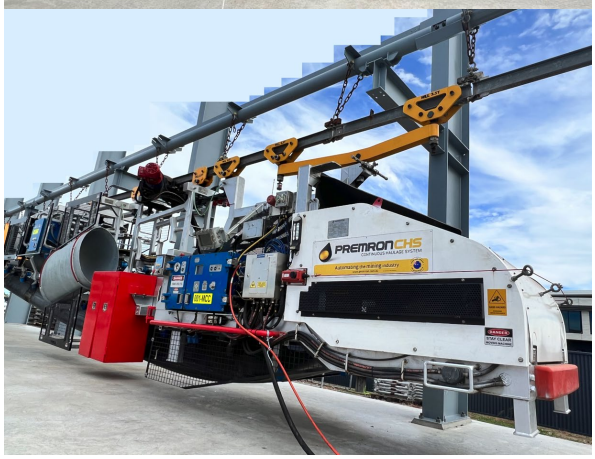
This project is a continuation of projects C22009, C23017 and C24023, which aims to develop a Continuous Haulage System for mine gateroad development, utilising the closed conveyor system of the "Premron CHS" ©. Premron is awaiting a suitable host mine to complete the project objective, namely the performance in an underground trial. Work in this space is continuing in a positive path, with several potential host mines showing real interest.

The project encompass the following key objectives during the quarter:

- Build and install a suitable Premron CHS Testing Track;
- Install Premron CHS Minibuild machine (nom 55m);
- Commission Premron CHS machine along with Sizer Feeder; and
- Trial test Premron CHS and Sizer Feeder including several open days for industry.

Premron have completed all four quarter objectives, with the commissioning of the Premron CHS (mini build) and the Sizer Feeder machines on their Mine Monorail Test Track, in Gladstone. The demonstration showed the capabilities of both machines, with the Premron CHS negotiating a 6m radius cut thru, before being loaded with rock, delivered by the Sizer Feeder machine.

The highly successful open days were held during November, with a broad range of mining companies in attendance. Several mining companies are in discussion with Premron, to see how this new technology may help their operation. At this stage we have signed CA's with all companies and are sharing information, to allow their due diligence on our technology.



C33013
Light Weight Composite Conveyor Support Structures

University of New South Wales
Ganga Prusty
Serkan Saydam

Value:	$499,804
Report Expected:	March 2025
Industry Monitor/s:	Roadway Development Task Group
ACARP Contact:	Patrick Tyrrell

This stage 2 project work aims to advance the technology readiness level (TRL) of lightweight composite conveyor support structure prototypes through a comprehensive field testing phase at a mining site.

Several key activities have been accomplished during this quarter:

- Procurement and delivery of all required structural components for field testing were completed in November. The glass fibre reinforced polymer (GFRP) columns were fabricated by Wagners in Toowoomba. Trough frames to support and guide the conveyor belt were sourced from TS Global in Newcastle.
- Installation of the GFRP frames was undertaken from December to January. The on-site installation process was carried out in four stages, as detailed below:
  - Stage 1: Assembly of GFRP columns and metallic brackets using fasteners, followed by the installation of a single GFRP frame to evaluate alignment with the on-site metallic mine frames,
  - Stage 2: Modifications to the GFRP columns to adjust alignment with the existing metallic frames and final installation of the four GFRP frames,
  - Stage 3: Installation of carry and return trough frames along with the rollers. Subsequently, physical inspections were undertaken to verify alignment and contact status between all components,
  - Stage 4: Installation of strain gauges and accelerometers at critical locations of the GFRP frames to monitor operational strains and vibrations in real-time;
- Images from the installation and operation of the GFRP mine frames are shown in Figures 1–2.

The operation and monitoring of the GFRP columns are currently underway. Data collection and processing will be conducted over six weeks, from February to March, for a detailed structural assessment of the GFRP mine frames. Additionally, the scope of work for the next stage of the project is being developed.

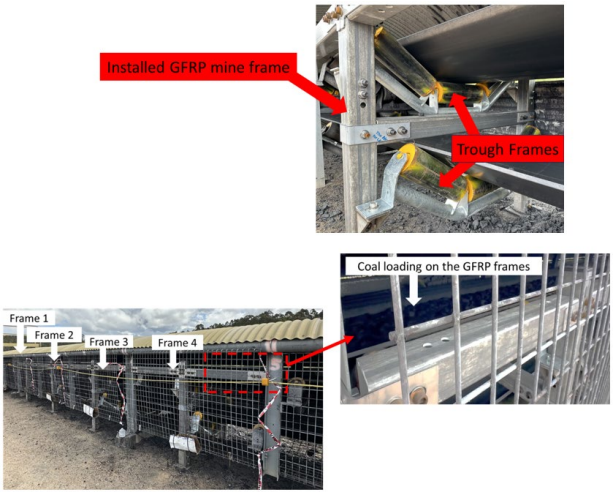


Figure 1: Installation of the GFRP mine frames.

Figure 2: Strain gauges to monitor critical locations of the GFRP frames.

C33020
Floor Horizon Control for Roadway Development

CSIRO
Andrew Strange

Value:	$80,000
Report Expected:	February 2025
Industry Monitor/s:	Roadway Development Task Group
ACARP Contact:	Patrick Tyrrell

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

Strata Control and Windblasts

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:	February 2025
Industry Monitor/s:	Brian Vorster Patrycja Sheffield Peter Corbett
ACARP Contact:	Peter Bergin

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

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:	February 2025
Industry Monitor/s:	Peter Corbett Russell Thomas
ACARP Contact:	Peter Bergin

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

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
Hossein Masoumi

Value:	$205,000
Report Expected:	February 2025
Industry Monitor/s:	Brian Vorster Elliot Tembo
ACARP Contact:	Peter Bergin

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

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 2025
Industry Monitor/s:	Bob Coutts Brian Vorster Dan Payne Patrycja Sheffield
ACARP Contact:	Peter Bergin

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

To investigate the mechanical behaviour of timber chock structures, an extensive series of experimental tests have been conducted. The experimental results have been analysed, and the most significant findings have been identified. The mechanical behaviour of timber chock structures under uniaxial compression and combined loading scenarios has been characterised. The results indicate that, apart from environmental conditions—which significantly affect mechanical performance—combined loading scenarios provide a more accurate representation of timber chock behaviour under both horizontal and vertical movement, closely reflecting real-world conditions. Furthermore, the first volume of the project report, focusing on timber chock standing support systems, is currently in preparation.

The examination of the mechanical behaviour of pumpable cribs is structured into two phases: large-scale and small-scale testing. For the large-scale testing phase, following discussions with our industry partner, DSI Underground, a total of eighteen tests will be conducted. Nine tests will be performed on pumpable cribs with dimensions of 3250mm in height and 914mm in diameter, while an additional nine tests will be conducted on cribs measuring 2640mm in height with the same diameter. These tests will be carried out using the state-of-the-art Multi-Axis Substructure Testing Device at Swinburne University of Technology. To facilitate the safe transportation and handling of large-scale specimens from Newcastle to Melbourne, three steel cages have been fabricated. These cages will be used to securely transport the specimens, position them under the testing device, and manage their disposal post-testing. The fabrication process has been completed, and the cages are currently packaged at Swinburne University, ready for transportation.

The small-scale testing phase involves casting cylindrical specimens (100mm × 200mm), both with and without cuttable bags. This phase is designed to evaluate the

material properties of unconfined and confined specimens for numerical modelling and to assess the influence of confinement on strength development over curing periods of 7, 14, and 28 days. The results will contribute to the characterisation of the mechanical properties of pumpable cribs.

The project will investigate key factors influencing the mechanical behaviour of pumpable cribs, including loading rates and aspect ratios. A comprehensive damage analysis under axial compression and combined axial-shear loading conditions is also planned. Ultimately, the experimental findings will be used to validate numerical simulations, with the objective of replicating the observed failure mechanisms.

C33024
Improved Model Upscaling of Overburden Hydraulic Conductivity for Input into Groundwater Models

SCT Operations
Yvette Heritage

Value:	$230,000
Report Expected:	March 2025
Industry Monitor/s:	Bob Coutts Gary Brassington Peter Corbett
ACARP Contact:	Peter Bergin

The key project objective 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.

Investigations into upscaling methodologies have provided changes to mining induced hydraulic conductivity of only about 1 order of magnitude. Not the minimum 3-5 orders of magnitude hydraulic conductivity reduction that the groundwater modellers need to use.

The project outcome is a proposed hypothesis that desaturation is responsible for the significant reduction in relative conductivity. Understanding that running unsaturated groundwater models with current computing power is not currently practicable for timely and cost appropriate solutions to the client, this project provides a method for determining the site specific relative conductivity to use in groundwater models, based on the limiting conductivity layer at the top of the desaturated zone. This proposed methodology is supported by two site specific models comparing the hydraulic conductivity from the rock failure model with the groundwater model inputs and site groundwater data. Reporting is nearing completion.

C34018
Carbolt – Pre Commercial Fixed Length Carbolt Prototype

Mining3
David John

Value:	$360,088
Report Expected:	March 2025
Industry Monitor/s:	Alex Wright Bob Coutts Peter Quinn
ACARP Contact:	Patrick Tyrrell

The objectives of this project are to:

- 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;
- 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.

During the quarter the cast samples underwent a comprehensive performance testing campaign, which included pull-out, shear, and double-shear tests. The test results have been collated and submitted to monitors for review. The final report is currently being finalised and is scheduled for submission soon.

C34021
Roof Beam Support Assessment Tool

Resource Geotechnical
Terry Medhurst

Value:	$230,000
Report Expected:	May 2025
Industry Monitor/s:	Brian Vorster Roger Byrnes
ACARP Contact:	Patrick Tyrrell

Previous 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.

A windows based version has been developed that can be used to assess both development and longwall abutment loads. The initial version and user guide has been developed and completed. Extension work will introduce additional options into the program following evaluation from the Industry Monitors that includes:

- Use of both bolts and cables installed on first pass development;
- Inclusion of the use of multiple TARP triggers for support upgrades, in relation to changing strata conditions on development, for secondary support and impact of stress notches; and
- Implementation of the inclusion to install centreline cables.

Coding for these extensions has now been undertaken, and a process of testing with project monitors will begin.

C34022
Risk Based Model for Forecasting Longwall Face Cavity Development

University of New South Wales
Chengguo Zhang
Ismet Canbulat

Value:	$173,200
Report Expected:	April 2025
Industry Monitor/s:	Matt Martin Matt Tsang
ACARP Contact:	Peter Bergin

Cavity development across the longwall face can cause substantial production losses and pose significant safety risks to mine workers during recovery operations. Previous research into longwall roof cavities has primarily focused on individual causes, such as equipment, shield pressures, geology, in situ stresses and geotechnical setting. In this project, researchers will adopt a holistic assessment of all causes that, in combination, can result in the formation of a roof cavity. The project aims to produce a risk based approach for assessing the likelihood of cavity development; a set of predetermined controls to mitigate the risk of cavity development; and a proposed hierarchy of longwall fall-of-ground severity linked to these controls, based on the escalating level of risk.

The main progress in the quarter includes the following:

- Forecast for the cavity location: Based on our preliminary results, we continued experiments on grouping shields for location forecasts, and with larger numbers of groups, the results show feasibility to compare relative risk levels despite relatively low absolute value of raw evaluation metrics on the probability of cavity. We also received geological domain information from the mine, where the tests were updated to include the information with new tests on two panel sections and the results showing incremental improvements.
- Numerical modelling: Numerical modelling has been conducted based on the presented information on the mine. We have completed calibration of numerical model in UDEC, including front abutment pressure and the failure depth into front abutment. We plan to conduct a parametric study to investigate the sensitivity of rock displacement and failure to varying geological factors, with the verified model, using the Taguchi method.
- Lastly, we received a similar set of data for a mine including master drawings with faults, hazards and chainages, as well as LVA database, for panel LW101, LW102, LW103, LW104, LW104a, and LW105. We started process the dataset.

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 seeks to develop a modified pillar load estimation methodology for optimal pillar design under increasing stress conditions. It will verify the design of main pillars based on a load less than the tributary area load, potentially providing significant financial and operational benefits.

The project report is currently being drafted and is expected to be submitted by the end of the quarter.

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 of swelling and bearing capacity floor failures through an experimental program, in-situ monitoring program, and analytical and numerical approaches and determine the timing of failure. Based on the learning from C26064 and C29041, an analytical model will be developed to evaluate 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 the assessment and prediction of floor heave. This approach will provide comprehensive guidelines to assess and predict floor heave failures.

During the quarter experiments (UCS, point-load and Brazilian tests) have been conducted to examine the strength and stiffness of core samples from the site. Quantitative X-ray Diffraction (XRD) analysis results indicated the presence of swelling clay minerals (montmorillonite) in the core samples, explaining the swelling behaviour observed in the Duncan free swell tests. Oedometric swelling tests by LoadTrac have been carried out to assess the swelling behaviour of core samples under varying loading conditions. The elemental analysis was conducted by the energy-dispersive micro-X-ray (μ-XRF) fluorescence, which determines the swelling mechanisms of the clay samples. Elemental maps generated by the X-ray instrument represent the distribution and concentration of selected elements on the sample surface. Cation exchange capacity tests were conducted on pre-pared clays (bentonite and kaolin-clay), which used chloride and sulphate salt solutions to evaluate the effects of chemical treatment on clay' swelling.

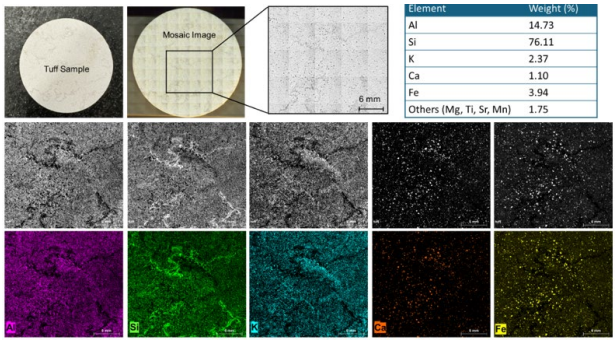


Figure 1. Elemental maps of clay samples before swelling (μ-XRF image).

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

Understanding in-situ stress conditions is paramount for the safety, efficiency, and productivity of coal mining operations. Currently, overcoring is he preferred technique to measure-situ stress in underground mining. However, it is often hindered by the considerable time, investment, operational complexities, and high costs. This challenge was tackled in a previous stage of this project by developing DilaStress to create an efficient downhole stress measurement technique and associated Tool. This study will field test the DilaStress tool for insitu stress estimation.

During the quarter, the DilaStress tool reached a significant milestone with comprehensive testing focused on its waterproofing capabilities. Multiple stress scenarios were meticulously designed and executed to evaluate the performance and accuracy of the inversion software under various conditions. Additionally, substantial improvements were made to the communication system, ensuring seamless data exchange and enhanced functionality between the DilaStress hardware and the developed software.

Looking ahead to the next quarter, the team will focus on refining the software through targeted optimisations, addressing any identified gaps, and enhancing its overall robustness. Concurrently, the project report will be compiled, summarising key findings, progress, and recommendations to guide future development and deployment efforts.

C36010
Next Generation Fibre Glass (FG) Rock Bolts with Robust Shear Strength Properties to Replace Steel Rock Bolts

University of Southern Queensland
Ali Mirzaghorbanali

Value:	$147,998
Report Expected:	June 2025
Industry Monitor/s:	Dennis Black
	Peter Corbett
ACARP Contact:	Patrick Tyrrell

This research investigates the development of novel Glass Fibre Reinforcement Polymer (GFRP) dowels with enhanced shear-bearing capacity for the industry. Three reinforcing element architectures (RE1, RE2, and RE3) will be incorporated in conjunction with three Resin matrices (R1, R2, and R3) and the combinations with varying proportions of Graphene additive to manufacture prototypes of GFRP dowels. GFRP dowels will be manufactured in three different diameters. Guillotine shear box testing will determine the optimal GFRP manufacturing dowel design that offers the highest shear strength properties. The shear performance of the optimal prototype will then be assessed using large-scale double shear tests conducted within concrete blocks simulating medium and high-strength rock strata (40 and 60 MPa).

A comprehensive review of current composite rock bolt manufacturing methods, including pultrusion, braidtrusion, and hybrid techniques, was conducted following project initiation. Three resin matrices, EP (R1), VR (R2), and UPR (R3), were acquired and characterised. Mechanical, thermal, and chemical properties were evaluated through a series of experimentations, including tensile testing, V-notch shear testing (e.g., R1

and R2), compression testing, polymer degradation at various temperatures (DSC), and functional group analysis (FTIR). These analyses were performed on samples cured for 14 and 28 days at ambient and elevated temperatures (post-cured conditions). Also, in order to manufacture different GFRP dowel prototypes, E6-type glass direct roving with a filament diameter of 24-31 microns was selected for the manufacturing procedure. The first GFRP prototype dowels (RE1), 1.2m long with an average diameter of 38mm, were manufactured by infusing the core with the R1 resin matrix within PVC pipes. The first prototype was cured under both ambient and elevated temperature conditions (two hours at 30°C, two hours at 40°C, and 100 minutes at 90°C). Single-shear guillotine box testing of the GFRP dowels yielded a shear strength capacity of 18 tonne (Figure). The results indicated that extended curing of the R1 resin increases shear deformation prior to failure.

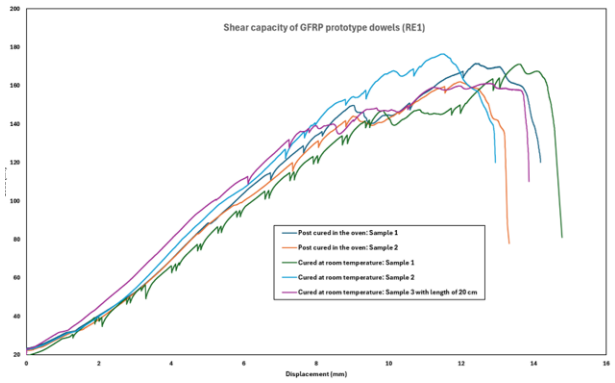


Figure. Shear strength of GFRP dowels prototype (RE1)

In the next phase, other GFRP dowel prototypes with RE2 and RE3 designs will be manufactured to understand the effects of reinforcing element architecture (RE) on strength properties. The optimum RE architecture will be determined by producing GFRP dowels using R1, R2, and R3 matrices. The shear capacity of manufactured prototypes will subsequently be tested and compared using single shear tests. The resin matrix (R) and reinforcing element architecture (RE) exhibiting the highest shear strength will be combined with the optimal graphene additive concentration to enhance the GFRP composite's shear strength properties further. GFRP dowels incorporating this optimised formulation, manufactured using the identified design parameters, will be produced in diameters of 35mm, 38mm, and 40mm, to investigate the influence of diameter on shear bearing capacity. Finally, GFRP dowels exhibiting the highest shear strength properties will be subjected to double shear testing to characterise shear load transfer mechanisms under simulated field conditions. These tests will involve encapsulating the GFRP dowels in concrete specimens with varying strengths and pretension levels. The resulting performance will be benchmarked against commercially available GFRP and commonly used steel rock bolts.

Ventilation, Gas Drainage and Monitoring

C25072
New Approaches to Mine Gas Analysis and Ratios

Simtars
Sean Muller

Value:	$416,192
Report Expected:	March 2025
Industry Monitor/s:	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 project C25072 and project C10015.
- Expand the current “Fire Ladder” to include additional alkanes below the ethylene point which can be used to give earlier warning of a developing heating/spontaneous combustion and incorporated into TARPs.

The work status is as follows:

- Validation of the X-Pid was started, however, there were instrument errors occurring and the instrument is back with Drager for repair. Return of the instrument to Simtars will be mid-February.
- Gas samples from the third coal are being reviewed for all tests conducted.
- Since the last quarter, the coal has slowly been decreasing in temperature and as of the end of January all ports were sitting between 40°C to 43°C, which is back to being at the virgin rock temperature for this coal and the start temperatures initially used.
- Coal 3 has been in the 2m column four months and not showing indications of self-heating. The decision has been made to step heat the coal until a temperature is found that will promote the self-heating of the coal.
- On 3 February the column was taking out of Mode 2 and put back into Mode 1 will all heaters set to 40C. The coal and the column will stay in this set up until the step heating plan has been established.

The following steps will be addressed in the next quarter:

- Continue validating the X-Pid once the X-Pid is returned to Simtars;
- Graph/Process the VOC data from the GC-MS data;
- Collation of the additional peak data from the general gas data set will be completed, then all general gas data will be graphed;

- Comparison of the volatile organic components from the general gas data with the GC-MS data;
- Preparation of the interim report has been delayed due to staff availability and the general gas data not being finalised;
- Process and graph the data already generated from the third test;
- Schedule and plan step heating of coal 3, with the intention of starting in the second week of March.

C27035
Automatic Leak Detection for Tube Bundle Systems

Simtars
Sean Muller

Value:	$220,000
Report Expected:	February 2025
Industry Monitor/s:	John Grieves
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
Ian Webster

Value:	$90,000
Report Expected:	March 2025
Industry Monitor/s:	John Grieves Ken Singer Patrick Tyrrell
ACARP Contact:	Peter Bergin

The overall objective of this program of research is to:
1. 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.
2. 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 in relation to objective 2:
- Testing and data analysis completed for effect of occlusion for four gas detectors under dust conditions within the purpose-built test chamber. Results of testing correlated and aligned with established terminology and methodology.
- Draft report on comparison of calibration masks, effects of blockages and occlusion by dust on the gas detectors has been completed. Draft report has been peer reviewed, with comments received for consideration. Abstracts and presentation proposals for several conferences have been prepared and submitted.

Schedule for the next quarter is as follows:
- Consider comments from peer reviewers;
- Revise draft report as and where needed;
- Submit final report to Industry Monitors for review.

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

University of Wollongong
Alex Remennikov
Timothy Jackson

Value:	$562,560
Report Expected:	June 2025
Industry Monitor/s:	David Webb John Grieves Ken Singer Paul Wild Russell Thomas Tim Huston
ACARP Contact:	Peter Bergin

This stage of work is an extension to the completed Stage 1 research component. This stage 2 work aims to characterise the threat of projectiles from mine entrances through a systematic experimental and numerical approach. The following updates are for the quarter:
- Approval to Resume Blast Tests – As part of the recommissioning process, noise level testing was conducted on the Small ABS by the acoustic consultants. The facility successfully met all noise criteria and obtained approval from university stakeholders to resume experimental blast testing.
- Processing of Experimental Results for Drift Simulation – Result processing for the drift simulation has been completed. Initial flight conditions of the projectiles were determined using motion analysis, and their final striking points (accounting for drag) were calculated through Python programming.
- Development of Guideline for Defining Exclusion Zone for Drifts (Validation Phase) – An empirical approach was successfully implemented to predict the initial velocities of projectiles, and worst-case projectile ranges were determined iteratively using Python programming. This methodology is currently undergoing validation against experimental measurements. A representation of this exclusion zone with indicative projectile mapping is presented in Figure 1.

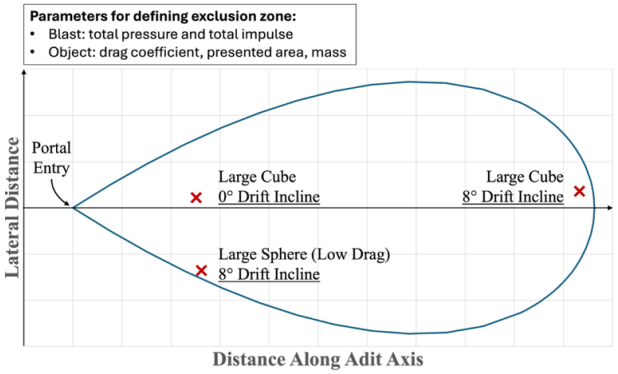


Figure 1: Exclusion zone produced based on mine-specific inputs. Indicative projectile map for drift portals shown.

- Conference Presentations/Publications – Experimental work and findings of this project have been presented at the Resource Operator's Conference 2025. The paper will be published in the conference proceedings.
- Modification of Advanced Blast Simulator for Shaft Simulation – Engineering design work for the experimental shaft setup has been completed. Fabrication of new vertical test sections is planned to begin in February and will be followed by the assembly of these sections onto the existing blast simulator. The experimental phase is expected to commence in March.
- Experimental Program for Shaft Simulation – A detailed program for the experimental shaft simulation has been developed, containing test configurations with projectiles (i.e. generic shapes and typical mining objects) and plates (designed to characterise blockage from an aboveground elbow of fan structure).

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:	February 2025
Industry Monitor/s:	David Webb John Grieves Ken Singer Paul Wild
ACARP Contact:	Peter Bergin

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

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

Sigra
Ian Gray

Value:	$2,176,576
Report Expected:	December 2025
Industry Monitor/s:	Ventilation Task Group
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-facetted as it involves drilling hardware, sensing equipment, downhole and at the drill rig sensing and electronics. This is in both IS and flameproof form and it also involves a lot of software development. The drill rig sensing has been substantially limited by the limitations placed on modifying OEM drilling equipment.

The work in this quarter has been divided into four aspects. The first is having to partially redesign the communications electronics. This became a necessity as despite having gained the blessing of one certification group acting as a consultant the actual certifying group disagreed with the former's opinion. The new design is about to be tested.

The second is in the re-design of the torque and thrust sub using some alternative geometry to improve torque sensitivity.

The third aspect to be worked on is the analysis of permeability from testing in horizontal holes. This follows Sigra's work at Potosi mine in Broken Hill with the equipment.

Finally some progress has been made on the drilling software.

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

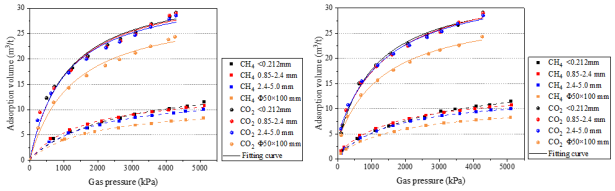
University of Wollongong
Ting Ren

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, geo-mechanical properties and gas sorption dynamics with different coals sourced from underground coal mines in New South Wales and Queensland.

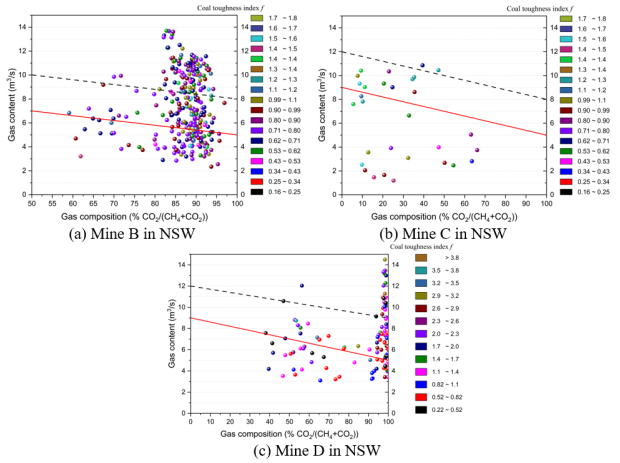
The project has completed the following tasks:

- CH4 and CO_2 adsorption/desorption tests have been conducted on intact coal (50mm in diameter and 100mm height), coarse coal (particles size ranging from 0.85 to 2.4mm and from 2.4 to 5mm), and pulverised coal (particles smaller than 0.212mm) from Mine E, with results presented in Figure 1. Further investigations are underway to analyse the correlation between gas sorption capacity and in-situ total gas content, as well as the relationship between sorption hysteresis and residual gas content Q3 for different coal particle sizes;
- Coal toughness tests conducted by using coal samples from four coal mines in New South Wales and one coal mine in Queensland, to establish a comprehensive database of the coal toughness test index, with partial results summarised in Figure 2;
- Gas sorption and rapid gas desorption test results were adopted by Mine D for a new revised outburst threshold limit value, as shown in Figure 3;
- Test results from coal samples collected from Mine B and Mine D indicate a positive correlation between coal toughness index f and apparent relative density (ARD), ash content, and uniaxial compressive strength (UCS). Conversely, a negative relationship has been observed between coal toughness index f and both volatile matter and fixed carbon;
- Ongoing efforts are focused on the development of a hybrid outburst threshold limit value by considering gas content, gas composition, gas pressure as well as coal toughness index f;
- A potential assessment method for outburst and burst risk is being developed by integrating results from gas content, coal strength, coal toughness, sorption hysteresis and rapid desorption testing.



(a) Adsorption isotherms (b) desorption isotherms

Figure 1 CH4/CO2 adsorption/desorption test results for different coal particle sizes.



(a) Mine B in NSW (b) Mine C in NSW

(c) Mine D in NSW

Figure 2 Distribution of coal toughness index f on outburst TLV map for different Mines.

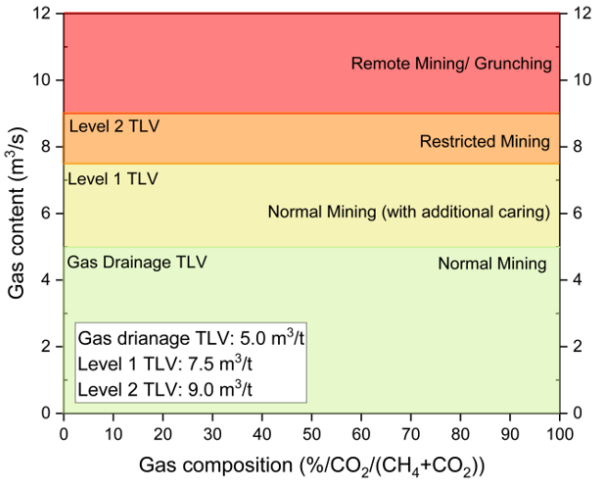


Figure 3 New outburst threshold limit values proposed and adopted by Mine D.

C36003

Practical Implications of Oxygen Deficiency on the Determination of Graham's Ratio in Longwall Goafs

Simtars
Sean Muller

Value:	$64,350
Report Expected:	July 2025
Industry Monitor/s:	David Webb John Grieves
ACARP Contact:	Patrick Tyrrell

Graham's ratio is a commonly used indicator for measuring the intensity of the oxidation of coal in underground mine atmospheres. The basis of Graham's ratio is the conversion efficiency of oxygen to carbon monoxide. Graham's ratio uses the nitrogen from a sample for the calculation of oxygen deficiency. This allows for dilution by methane and carbon dioxide seam gases. This calculation is made on the basis that nitrogen is an inert gas which is not consumed or created.

This project will investigate the practical implications for the interpretation of Graham's ratio and other indicators in the presence of an oxygen deficient atmosphere (due to natural processes and both added nitrogen or exhaust gases via inertisation).

Requests for mine data has commenced. Mine data is currently being acquired for data review.

C36005
Optimisation of Goaf Management Strategies

CSIRO
Krishna Tanguturi
Qingdong Qu
Rao Balusu

Value:	$1,443,557
Report Expected:	February 2028
Industry Monitor/s:	Ventilation Task Group
ACARP Contact:	Patrick Tyrrell

The objective of this project is to develop optimum goaf management strategies to maximise goaf gas drainage, reduce oxygen ingress into the longwall goaf, and minimise fugitive emissions. The main focus of the project studies is to: obtain a fundamental understanding of goaf gas distribution; obtain an understanding of the impact of various geological, mining and operations parameters; investigate the feasibility of various goaf gas drainage designs and strategies to maximise gas drainage and minimise oxygen ingress; develop optimum inertisation strategies to minimise oxygen ingress on both maingate and tailgate sides of the longwall goaf; examine the impact of various additional goaf management strategies; and develop optimum adjacent goaf gas drainage strategies to minimise greenhouse gas emissions into the main return airways.

In the quarter, parametric studies have been carried out to investigate the impact of various geological, mining and operational parameters on goaf gas distribution and oxygen ingress patterns. The parametric studies included changes in goaf gas emission rates, seam gradients, and ventilation configurations under different gas emission scenarios. In the current quarter, extensive goaf gas drainage studies are being undertaken to investigate the impact of various goaf gas drainage strategies on goaf gas drainage efficiency and goaf gas distribution, including oxygen ingress patterns. These goaf drainage studies include changes in goaf holes, total drainage rates, ventilation layouts, face airflow rates and perimeter goaf wells. Modelling studies are continuing, and results are being analysed to assist in the development of optimum goaf management strategies.

C36011
Borehole Tools – Caliper Log

Sigra
Ian Gray

Value:	$424,160
Report Expected:	January 2026
Industry Monitor/s:	Ventilation Task Group
ACARP Contact:	Patrick Tyrrell

This project objective is to produce a caliper log to permit the logging of boreholes. The reason for building this is to detect overbreak such as may occur due to the washout of gouge material, indicative of outburst conditions and breakout which is indicative of high stress. The latter being important from a rockburst and general stability viewpoint. In non-intrinsically safe near vertical holes these measurements would be made using an acoustic televiewer. This is not an option in gassy horizontal boreholes.

Work in this quarter has been divided into three aspects:

- The general mechanical design of a 12 arm caliper. This has been divided into two designs. One a staggered set of six arm calipers and the other a single 12 arm array.
- Considering how to adapt existing electronics from project C34014 to the maximum extent for the purpose of measuring the movement of the caliper arms.
- Considering how to handle the comparatively large amount of data that will come from twelve measurements that need to be made every two centimetres of the hole. This affects the logging speed.

C36012
Rotary Steering System Field Trial and Developments

Sigra
Ian Gray

Value:	$449,600
Report Expected:	April 2025
Industry Monitor/s:	Ventilation Task Group
ACARP Contact:	Patrick Tyrrell

This project is to enable field trials and necessary modifications to be made to the Sigra rotary steering system (RSS) tool that was developed as part of project C28022 and was completed in 2020 during covid lockdowns and hence without an underground field trial. During this period a drilling trial was conducted using a civil engineering horizontal directional drilling rig and many changes have been implemented as a result of this.

The Sigra RSS is designed to replace down hole motors in underground in seam drilling and in particular to overcome problems faced with 'boggy ground'. The latter is caused by cuttings bed build up around the drill string. The rotary steering system involves the use of a rotating drill string with a non-rotating sleeve fitted with pads that deflect the drill bit. The rotating drill string has been shown, in oilfield use, to prevent cuttings buildup. The RSS should also permit greater power at the bit compared to downhole motors that are currently used underground. It is hoped that this will enable faster penetration rates when drilling through stone.

Very little progress has been made on this project this quarter as other ACARP drilling projects have taken priority.

C36015
Intelligent Integrated Distributed Fibre Optic Sensing Technologies

CSIRO
Wayne Stasinowsky
Yi Duan

Value:	$568,317
Report Expected:	May 2026
Industry Monitor/s:	Ben Yang Dennis Black Peter Corbett
ACARP Contact:	Patrick Tyrrell

Temperature, strain and seismicity monitoring are crucial for geotechnical hazards (e.g., spontaneous combustion, pillar failure, strata instability) management in underground coal mines. This project aims to advance remote underground mining operation capabilities by targeting specific technology developments in areas of high strategic need and opportunity for industry. The key components of this project are:

- Continuous temperature profiling using distributed temperature sensing (DTS);
- Combined continuous pillar strain and microseismic measurement using optic fibre; and
- Real-time distributed acoustic sensing (DAS) data processing based on deep learning pipelines.

During the last three months of the project, the main activity for each key component include:

- The DTS measurements are compared with the readings from a weather meter at different time and locations. The preliminary comparison results indicate that DTS temperature measurements are reasonably consistent with ambient temperatures recorded by the weather meter, with a temperature difference of ±1˚C. More comprehensive, well-controlled experiments are being designed to further validate the reliability of the DTS measurement and develop the real-time temperature calibration procedure. Ambient temperature and relative humidity are measured with the weather meter to investigate how to correlate the DTS measurement with wet-bulb temperature.
- Design of the physical test rig has been developed so that it will fit into the temperature-controlled chamber. Originally, fibreglass rods were thought suitable, but it is now apparent that these are too rigid. Several other materials are being tested for the best combination of being flexible enough to bend into a tight enough arc while being rigid enough to support the optical fibre.
- A seismic event detection workflow including data pre-processing, input preparation, deep convolutional neural network (DCNN) model training and calibration, reference of new DAS data and performance review have been developed for seismic event detection. One month of DAS data collected from a longwall coal mine has been processed using the developed workflow. The results demonstrate that the DCNN model can achieve an overall 85% accuracy for event discrimination without increasing the number of hyperparameters or fine tuning. Source location methods were under development for event location.

C37006
Frictional Ignition – Water Spray Standards, their Basis and Effectiveness with Modern Mining Environment

CSIRO
Craig Harbers
Xing Li
Yong Sun

Value:	$89,814
Report Expected:	April 2025
Industry Monitor/s:	David Webb Steve Winter
ACARP Contact:	Patrick Tyrrell

This project aims to identify the requirements for which drums/sprays should be designed to optimise the use of water sprays to minimise the FI risk, highlighting situations where the operating parameters of modern mining equipment will reduce the effectiveness of nominally compliant water spray systems.

Progress over the quarter:

- Relevant literature has been searched and collected. We have started the literature review to identify critical factors, with a focus on rock cutting with picks and water sprays in longwall mining. More attention was given to those original fundamental (experimental) research articles. As a part of the literature review, a note on the effect of cutting speed on frictional ignitions has been prepared and provided to a mine.
- With the help of industry monitors, we have collected information regarding the current conditions of longwall mining in Australia from several mines. Some information regarding the conditions of longwall mining in the UK has also been collected, noting that the standards were written for these conditions.
- In order to investigate the basis of the UK standards for water sprays, we have contacted a member of the committee who drafted the UK standards. We are negotiating a meeting/interview in the UK with the key person and other relevant mining engineers with FI experience.

OPEN CUT

REPORTS PUBLISHED THIS QUARTER

C26020
Preventing Fatigue Cracking Via Proactive Surface Dressing

Bureau Veritas
Simon Krismer, Eddy Constable
Link to download the final report:
https://www.acarp.com.au/abstracts.aspx?repId=C26020

C33036
Radar Tyre Monitor System

CSIRO
Luke Powell, Chad Hargrave
Link to download the final report:
https://www.acarp.com.au/abstracts.aspx?repId=C33036

Geology

C34020
Guideline for Standardising Structure Interpretation in ATV/OTV Logs

University of Queensland
Mojtaba Rajabi

Value:	$163,415
Report Expected:	March 2025
Industry Monitor/s:	Brian Vorster Matt Tsang
ACARP Contact:	Anne Mabardi

This project aims to develop a guideline for processing, analysis, and interpretation of geological features in image logs. Such 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.

All aspects of the project work have been completed, and the draft of the report is finalised. After proofreading, the final report will be sent to the Industry Monitors for review.

C35023
Recovery of Critical Minerals from Coal and Coal Production Waste

CSIRO
Clint McNally
Nerrida Scott

Value:	$154,000
Report Expected:	March 2025
Industry Monitor/s:	Andrew Lau Caroline Lang Shaun Booth
ACARP Contact:	Patrick Tyrrell

No report received.

C35025
CSR Predictions and Correlations Definition

McMahon Coal Quality Resources
Chris McMahon

Value:	$35,880
Report Expected:	May 2025
Industry Monitor/s:	Alison Burke Maurizio Tonelli Tomoaki Nagata
ACARP Contact:	Patrick Tyrrell

This project seeks to take the published equations, chart data (that can be converted to formulas), and data attained from MCQR's ACARP studies, multiple projects and estimators produced in those projects, and industry supplied data to compare against each other and define the effectiveness of each CSR predictor for product coals of varying coal quality characteristics. Several deposits/coal types will be evaluated.

In order to minimise standard error of outcomes (the chosen metric for precision/variability assessment), MCQR plans to test both historical data and MCQR attained data via a "proportional" coal quality approach. The "proportional" approach will allocate percentage contribution to each coal quality test from an optimisation engine process with the goal of minimising standard error outcomes. This approach is in contrast to almost all prior predictive models which were largely based on polynomial equations constructed to give the highest correlation coefficient for the coal quality tests examined.

A request for information memorandum was issued in September and November 2023. One borecore database was received. Two other borecore databases, and three shipping databases were initially promised and repeatedly sought, with notice of rejection of the data requests being received prior to the last update due to market confidentiality issues.

Use of the one supplied borecore database and other borecore database(s) from McMahon Resources available data will be utilised for the review.

Data processing and review is underway, though no outcomes are yet available.

The outcomes of this project will be the definition of accuracy (precision and bias) information for varying CSR Estimators (both published and MCQR developed) with differing coal types. This will benefit the industry by providing predictive formulae and ranges of CSR outcomes for a range of coal types, and potentially add to correct resource representation and/or lower analysis costs. The outcomes then will provide a financial risk reduction and / or evaluation enhancement.

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

CSIRO
Matt van de Werken
Wayne Stasinowsky

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

The project objectives are to:
- 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;
- Extend and mature the technology and engineering developed in Phase II;
- Develop a prototype to the stage that the technology is ready to engage a commercial partner.

Progress during the quarter:
- Some problems with antenna configuration and the battery power supply prevented a mine site test in November. These have now been rectified;
- Some problems with availability of electronics personnel delayed the project in 2024 but additional people have been assigned to the project this year and all identified electronics issues have been rectified;
- A decision was made to rewrite the control and processing software to avoid any intellectual property issues. A team has been assigned to this task and they are repurposing their existing software to meet this goal. Completion of this is expected by June;
- Due to these problems and delays, the Industry Monitors were informed that the project is delayed by three months. Expected completion is now the end of June;
- Prototype 2 has now been assembled into a drill stabiliser and successfully tested;
- Antenna configuration is currently working but is still being optimised;
- The top sub assembly housing the Wi-Fi relay unit has been constructed and tested successfully; and
- The instrument is now in the final testing stages for a mine site TRL 7 trial and we are waiting on the mine to give us a date when they are drilling to the top of coal and can accommodate the trial.

C36022
Validation of LIBS Technology for Downhole Resource Evaluation

CSIRO
Joe Perkins

Value:	$276,020
Report Expected:	April 2026
Industry Monitor/s:	Jason Schumacher
	Mark Laycock
	Sudipta Nag
ACARP Contact:	David Drakeley

This project aims to further validate Laser-Induced Breakdown Spectroscopy (LIBS) as a rapidly deployable technology through expanded lab testing and field trials; following from project C34029 Laser Induced Breakdown Spectroscopy (LIBS) as a Rapidly Deployable Field Technology to Estimate Coal Quality.

The project aims to.
- Using state-of-the-art laboratory LIBS hardware and multivariate analytical methods, build upon the preliminary findings of project C34029 to develop a comprehensive coal core derived calibration model.
- Integrate LIBS spectral information into washability models using processed core samples.
- Conduct field testing using a prototype/pre-commercial LIBS downhole tool to determine the potential and challenges of optimising LIBS technology specifically for the evaluation of coal resources.

During the quarter lab testing and washability modelling have continued. Coal quality results have been obtained in the lab, but the use of the commercial LIBS core scanner has been delayed due to issues with the dust extraction system. A solution is expected to be in place mid-February and data acquisition can continue. It is unlikely that the overall project schedule will be affected at this time.

Efforts are continuing alongside the lab work to secure a site for the field trial. A potential site has been identified, but approvals are still outstanding.

Drilling and Blasting

C35018
Reactive Ground Testing

Queensland Magnetic Research
Alastair Torrance
Gary Cavanough

Value:	$340,000
Report Expected:	July 2025
Industry Monitor/s:	Andrew Micallef Mark Laycock
ACARP Contact:	David Drakeley

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

Environment

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

Edith Cowan University
Mark Lund

Value:	$1,089,226
Report Expected:	March 2025
Industry Monitor/s:	Andrew Lau John Watson
ACARP Contact:	David Drakeley

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:

1) 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.
2) 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.

We are currently in the process of writing up the results from the study and preparing the Design Guidelines.

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 project objective is to test and develop the newly developed SSSPAM landscape evolution model and SIBERIA (LEM) so that they can be used easily to evaluate both constructed and proposed post-mining landforms. The models will be tested across a range of sites in Queensland and New South Wales.

The testing and evaluation of both models continues with case studies in Queensland and New South Wales. 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. A paper has been published in the journal Geomorphology. Further weathering work is now being undertaken using fresh waste material. For the coal mine materials examined weathering is rapid and is not a major influence on landscape evolution. It also confirms the robustness of the weathering model in SSSPAM. Further weathering work is now being undertaken for coal mine waste rock.

The development of model input parameters has continued with more sites in Queensland and the Hunter Valley with validated sets of parameters available. Continued testing and development of the SSSPAM model continues for a range of both mining and pasture sites. A recent issue with the SSSPAM model has been the updating of the Python code and compatibility when compiling on new computers particularly with Windows 11. This is currently being addressed. A focus at present is on the Hunter Valley where high quality LiDAR data has allowed the identification of erosion features such as rills and gullies. This data is being used to parameterise and evaluate both the SIBERIA and SSSPAM models. Recent outputs include an assessment of DEM grid spacing needed to reliably capture erosion features as well as above ground features such as contour drains. A paper has been submitted to an international journal based on this work.

A new capability in the SSSPAM model has been the inclusion of a landscape uplift capacity. This now allows SSSPAM and SIBERIA to be used as a landscape design tool. This work is currently being prepared as a peer reviewed journal paper.

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:	$2,159,848
Report Expected:	March 2025
Industry Monitor/s:	Andrew Lau Jason Fittler John Watson Trudy Mazucco
ACARP Contact:	Patrick Tyrrell

The objective of this stage of this project is to fast track the scale-up of micro-algae cultivation as a post mining land use for final voids. These micro-algae systems would generate economic opportunities, regional jobs, lower operational CO2eq emissions, manage void water salinity, extract heavy metals and support adjacent agricultural applications. This is stage three of the project, which has already produced extensive foundational work and is focused on scaling downstream micro-algae biomass processing methods.

This stage of the project will:
- Confirm pilot scale microalgae production and desalination performance;
- Assess effective microalgae harvesting, determine biomass composition and processing methods;
- Validate and characterise pilot scale salt extraction;
- Optimise process control based on pilot scale system performance;
- Refine technoeconomic simulations for guiding pre-commercial cultivation and biorefinery process delivery for an anticipated pre-commercial stage; and
- Develop a valid commercialisation pathway and value chain to market.

During this quarter, the following work was undertaken:
- Pilot scale trials have been undertaken over summer to complete the collection of microalgae production for all four seasons;
- Biomass production and ion removal data evaluation: ongoing;
- Techno-economic simulations: The production data is being fed into the techno-economic simulations for large scale production and downstream processing factories. Downstream processing modules to simulate the economics of cascaded biorefinery systems are being developed to support techno-economic systems evaluation. These techno-economic simulations will support fast-tracking of systems optimisation, de-risking scale up and development of robust business cases;
- Product development: Biomass harvested from approximately 4000L of culture was frozen or freeze dried for further processing. Product specific processing steps are being designed to provide data

for biorefinery case studies. Results will be used as inputs for the techno-economic evaluation of biomass derived products and biorefinery concepts. Lab scale production trials to test our cascaded biomass production process are being planned to support the above techno-economic assessment work;
- Commercialisation: The project has engineered and drafted a Commercialisation Pathway report that draws on engagement undertaken with value chain stakeholders, government, and potential investment partners to identify regulatory barriers and opportunities and develop value chains and paths to market.

C34035
High Interest Native Plant Pittosporum Angustifolium for Mine Rehabilitation: Key Strain Identification and Germplasm Propagation Investigation

RNA Environmental Services
Ryan Anderson

Value:	$197,401
Report Expected:	March 2025
Industry Monitor/s:	Andrew Lau Andrew Micallef
ACARP Contact:	Patrick Tyrrell

No report received.

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
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. The case study site located in the Gloucester Basin, prepared to finish coal extraction in 2024 and will transition to closure upon completion of mining operations.

In the quarter, the focus has been on three activities:
- An updated numerical model has been developed in response to the field profile and climatic circumstances (e.g., temperature and annual rainfall) at the specific mine site, and a simulation spanning ten years has been conducted with local heterogeneities.
- The column with electrodes and associated instrumentation have been ready for geoelectrical tests, the experimental setup has been established, and rock measurements will be performed in the frequency domain using spectral induced polarisation (SIP).
- The comprehensive literature review is progressing steadily, including the characteristics of waste rock dumps, physical and geochemical processes, and forecasts of acid and metalliferous drainage, which will be incorporated into the future report.

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 Craig Bushell Hardy Wincen Morné van Zyl
ACARP Contact:	Patrick Tyrrell

The primary project objective is to develop strategies to effectively manage the invasive species leucaena (Leucaena leucocephala) in rehabilitation on coal mine sites in Queensland. 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 sub-tropical and tropical regions, including on several coal mine sites in central Queensland.

A foliar herbicide experiment was established at the University of Queensland (Gatton Campus) in April/May 2024 to evaluate 11 herbicides for their effectiveness in controlling Leucaena (Figure 1). The final assessment is expected to take place in May 2025, but several herbicides are already showing promising results. A rate response trial of the most effective herbicides is in preparation and scheduled for April/May. Additionally, we have prepared 650 seedlings at the Tropical Weeds Research Centre in Charters Towers, where we will conduct a pilot test to assess the feasibility of aerial application for Leucaena control. A glasshouse trial investigating the efficacy of Dazomet (Basamid®), a soil fumigant, in reducing the viability of Leucaena seeds in the soil has been completed at the Ecoscience Precinct in Brisbane. No reduction in seed viability was observed with Dazomet application. Consequently, adjustments will be made, and a second trial is planned for this year. Monitoring of a residual herbicide trial has also continued, entering its 12th month, whereby ten herbicides are being evaluated for their ability to prevent seedling recruitment of leucaena from the soil seed bank.

Fire research on leucaena is continuing near Rockhampton in collaboration with the Department of Environment and Science (figure 2). This includes determining the effect of fire on leucaena plants and soil seed reserves. A competition trial has also been established to see what pasture species are most competitive against leucaena.

Figure 2 Foliar herbicide trial implemented on leucaena.

Figure 2 Leucaena fire trial implemented near Rockhampton.

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
	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 current project aims to verify that the soil loss rates calculated using the GIS-based RUSLE tool accurately represent site conditions at different catchment scales and land uses and that the guidance provided in project C29046 is applicable and reflects approaches that ensure compliance.

Disturbed and undisturbed soil samples from site 1 have been analysed and used to calculate K factor values for the site. The experimental design for field trials and flume erosion experiments is currently being developed in consultation with Site 1 personnel. SMI's rainfall simulator will be taken to site to measure soil loss rates for selected materials and controls that have been implemented on site. The flume erosion experiments will be carried out at UQ's erosion lab facility. Four sediment fences were installed at Site 3 in December. Plans are currently underway to collect soil samples from Site 2 in March. The sediment traps installed on this site will also be assessed and repaired if required during this field trip.

C36018
Predicting the Long Term Erosional Behaviour of High Walls

University of Newcastle
Greg Hancock
Sue Henderson

Value:	$443,980
Report Expected:	March 2026
Industry Monitor/s:	Andrew Lau
	Chris Quinn
	Jason Fittler
ACARP Contact:	Patrick Tyrrell

The project objectives are to:

- Better understand the process and rates of mine highwall erosional failure;
- Develop parameters for input into numerical models for high wall erosional failure; and

- Calibrate and validate a predictive model (SIBERIA) for the erosion of highwalls.

Discussions with mines are ongoing and permission given for use of existing DEMs that the team has. Several provided DEMs have found not to be suitable.

Some sites for high wall analysis have been identified and model input files prepared for both the Hunter Valley and Queensland. Initial modelling for a site in Queensland has been conducted with positive outcomes in terms of model application.

Further sites have committed to providing materials and landscape data for analysis. The data is now being processed with needs for additional data being prepared. Additional field and GIS data needs are now being determined.

A Research Fellow is developing high level knowledge of Landscape Evolution Models and the management of large spatial data sets. The Research Fellow is now proficient in the application of Landscape Evolution Models for the project.

C36020
Semi Autonomous Bulldozers for Mine Site Rehabilitation

University of Queensland
Carl Hendricks
Eric Reiners
Jason Pagnotta
Ross McAree

Value:	$498,218
Report Expected:	April 2025
Industry Monitor/s:	Andrew Lau Brian Neilsen Jonathan Miln Ned Stephenson Simon Zillman Teo Di Pasquale
ACARP Contact:	Patrick Tyrrell

SATS (Semi-Autonomous Technology Solution) is Caterpillar's platform that enables D11 bulldozers to operate semi-autonomously through remote mission planning and optimised material movement, reducing manual intervention. ACARP funding has supported its development across multiple years. This project extends that work to develop and demonstrate semi-autonomous bulldozers based on SATS for significantly reducing emissions and costs in mined land rehabilitation. The project objectives are:

- Specification and Design: To capture critical knowledge to enable semi-autonomous dozing capabilities for mined land rehabilitation. This includes documenting the complete rehabilitation process through a use-case framework and employing Systems Theoretic Process Analysis (STPA) to identify and mitigate potential risks, ensuring identified risk is understood and controlled to the extent possible through the system design. To summarise these by a concise requirements specification for SATS rehabilitation.
- System Development: Develop an autonomous mission planning system that enhances the Caterpillar semi-autonomous dozing system (SATS) to efficiently manage material movement for land rehabilitation based on identified requirements.
- System Evaluation: Quantify the benefits of the semi-autonomous dozing system by measuring improvements in productivity, fuel efficiency, and emissions reduction.

In the quarter, the system specification and design phase was completed. This delivered a comprehensive use case analysis for rehabilitation operations and bulldozer deployment across both linear and geomorphic final profiles. The analysis covers both manual operation and SATS implementation. A Systems Theoretic Process Analysis (STPA) was conducted based on the Use Case Analysis to guide necessary SATS design modifications. The learnings developed have been consolidated into a Requirements Specification detailing the required functionality of a SATS for Rehabilitation system, specifically addressing rehabilitation work executed through parallel slot pattern pushing.

The project has now obtained post-mining surveys and final surface profiles of rehabilitation area. This data acquisition had previously delayed progress on planning algorithm development, which is now advancing effectively with the required information in hand.

While initial testing was originally planned for January, it has been rescheduled to March based on mine site availability. These preliminary trials will evaluate current SATS capabilities in rehabilitation applications and assess the effectiveness of sequence planning.

C36042
Validation of a Landform Design and Management System for Sloped Grazing PMLU

Valarion
Leigh Trevaskis

Value:	$688,080
Report Expected:	February 2027
Industry Monitor/s:	Andrew Lau Hardy Wincen Morné van Zyl
ACARP Contact:	Patrick Tyrrell

This project will address knowledge gaps in the effect of grazing on sloped rehabilitated land. The work aims to help mining companies to justify the approval of grazing as a post mining land use (PMLU) based on stability indicators, rather than a one-size-fits-all slope gradient ceiling. Currently there is little confidence in grazing as PMLU on slopes greater than 12% in the Bown Basin, and this project aims to obtain robust data on livestock

behavioural patterns and their impact on slope gradients up to 30%. The project will also assess the feasibility of developing a grazing PMLU landform evolution model that accounts for the impact of livestock behavioural patterns on a range of slopes up to 20% and develop best practice guidelines for managing livestock on sloped grazing PMLU.

There has been no progress during the quarter.

C36043
Using Large Floating Islands to Promote Aquatic and Terrestrial Biodiversity in Pit Lakes

Edith Cowan University
Mark Lund

Value:	$697,290
Report Expected:	March 2027
Industry Monitor/s:	Andrew Lau John Watson Ned Stephenson
ACARP Contact:	David Drakeley

Our previous projects (C27043 and C29049) have demonstrated that closure of pit lakes as aquatic ecosystems is likely a viable, sustainable, and economically responsible option for post-mining land use. Riparian vegetation and littoral areas are critical ecosystem components that cannot be established before the lake is full.

Artificial floating islands (AFIs) can provide habitat for waterbirds and other fauna. Therefore, AFIs may be used to encourage waterbird usage, create habitat for fauna (including turtles, fish, frogs, macroinvertebrates, and terrestrial organisms) and as a source of plant propagules, and general habitat for fauna (aquatic and terrestrial) in pit lakes. Waterbirds are particularly important to aquatic biodiversity because they are vectors of plants, invertebrates, bacteria, fish eggs, and major sources of nutrients (N and P) through excreta. Propagules from AFIs can continually seed the pit lake during filling, potentially removing the need for companies to return after the lake fills to plant a riparian zone, especially as the upland vegetation is normally well-established by then limiting access to the shore.

The broad goal of this research is to develop the use of large-scale AFIs as a tool that can deployed by miners to develop or improve biodiversity in their pit lakes making them suitable for closure as aquatic ecosystems or demonstrating improvement for NUMAs.

We will investigate the effectiveness of AFIs by testing pairs of pit lakes across Western Australia, New South Wales and Queensland. In each pair, one lake will be treated with an AFI and the other left as a control. Using previous data collected at the sites in C27043 and C29049and extending this monitoring in this project we can test the effectiveness of AFIs using a Before/After/Control/Impact (BACI) study design.

During the quarter islands have been installed at all three sites in Western Australian, Queensland and New South Wales. We have also completed the first round of monitoring of all pit lakes and by the end of February will have completed the second round of sampling.

Rock Mechanics

C29005
System for Rock Fall Analysis Field Trial

CSIRO
Marc Elmouttie
Peter Dean

Value:	$321,268
Report Expected:	July 2025
Industry Monitor/s:	Matt Tsang
ACARP Contact:	Patrick Tyrrell

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

This project will field trial a prototype system which, in response to industry monitor feedback, now consists of a trailer-based solution for housing the sensitive electronics, software and computing hardware to integrate data from microseismic monitoring and vision systems. Ideally, third party radar when available is fused with this seismic and vision data.

Further, technical discussions with the geotechnical department and various site experts occurred to progress planning for the seismic and vision sensor deployments, networking and communications. Site testing of the system at CSIRO under extreme heat conditions identified limitations in the cooling system which would certainly have been exposed given this particular site's location. Further modifications are therefore being implemented. CSIRO and the site are continuing consultation to finalise logistics and suitable timing. Given the delays, the current plan is to complete all field work, analysis and final reporting by June 2025.

C33040
Machine Learning for Rockfall Analysis

University of Newcastle
Anna Giacomini
Klaus Thoeni
Marc Elmouttie

Value:	$342,240
Report Expected:	November 2025
Industry Monitor/s:	Matt Tsang
ACARP Contact:	Patrick Tyrrell

The project proposes using machine learning (ML) for rockfall analysis. The objective is to identify a rapid and reliable method for estimating the location and energy of rockfall events at the base of a highwall, effectively mitigating the associated risks without the need to run specific rockfall simulations. The main outcome for the industry will be an ML-based tool to manage rockfall hazards at the base of highwalls.

Over the quarter, several different machine learning (ML) models were tested on the new dataset with the material layers. All scripts were updated to automatically generate 2D profiles based on the 3d point clouds with material layers. This involved defining the materials with their properties and assigning the correct material to each segment along the generated profile. After generating the profiles, all simulations were re-run to create a new dataset. Various ML models, including Linear Regression, K-Nearest Neighbours (KNN), Random Forest, and Extreme Gradient Boosting (XGB), and Artificial Neural Network (ANN), were then fitted to this dataset using three features extracted from the profiles: height h, mean slope angle α, and slope roughness σ. The results showed a similar behaviour compared to the results obtained without the material layers. Hence, the team decided to investigate a new method based on an Artificial Neural Network (ANN) with several hidden layers and no predefined features. After a few attempts, it was realised that the dataset was too large, so Principal Component Analysis (PCA) was used to reduce the dimensionality of the input from around 11,000 features to 100. This not only improved efficiency but also surprisingly enhanced accuracy. The new model achieved much higher accuracy for distance at first impact d_1. The analysis of the results of the final run-out d_f is currently ongoing but results are also expected to improve. Figure 1 shows an example of how the predictions of d_1 have been improved by implementing the new approach. It can be seen that the model with the predefined features had issues with predicting d_1 above 8 m. The new model does not have this issue and also decreases the amount of underpredictions substantially. An additional preliminary analysis showed that the number of blocks used in the simulations is insufficient to reflect the model's variability. Currently, 100 blocks are being used at each seeder, consistent with Stage 1 of this project. However, the addition of layers has raised the number of random variables within the models. Therefore, more samples are necessary to accurately represent the distribution of the results. A sensitivity analysis on the number of blocks revealed that around 500 to 1,000 blocks must be utilised. Hence, in the next quarter, the simulations will be re-run to incorporate these findings.

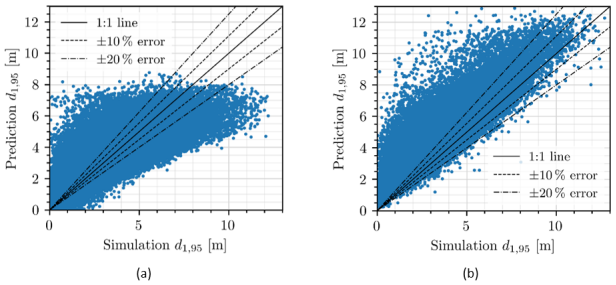


Figure 1. Simulated vs. predicted results for the position of first impact d_1 for analysis with: (a) predefined features, and (b) ANN with whole profile as features.

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:	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 to establish an effective guide for the definition of D in slope stability analysis.

This quarter, we have developed a method for defining disturbed zones through Peak Particle Velocity (PPV) modelling, with quantification based on changes in p-wave velocity. The process includes the application of HSBM models using consistent settings (geometry, blast hole configuration, rock properties, etc.) to controlled blasting experiments conducted in our laboratory. This is helping us validate the PPV modelling approach.

Post-blast p-wave velocity measurements from our experiments are being used to investigate the relationship between blasting-induced damage, as indicated by PPV, and reductions in p-wave velocity. This relationship is being proposed to predict the Hoek-Brown Disturbance factor (D) distribution. The aim is to create a more objective and practical tool for field applications.

Currently, we are compiling and summarising the final analysis and results for the report, while also focusing on gaining support to transition the project into the field validation phase.

C36017
From Open Pit to Pumped Hydro Energy Storage, a Focus on Low Wall Stability

University of Newcastle
Anna Giacomini
Jubert Pineda
Olivier Buzzi

Value:	$405,500
Report Expected:	October 2026
Industry Monitor/s:	Andrew Lau Shaun Booth Troy O'Reilly Tyron Domenici
ACARP Contact:	David Drakeley

The project objectives are to identify the fundamental failure mechanisms of a low wall in the context of pumped hydro energy storage (PHES), and provide guidance to mitigate the geotechnical failure risks.

In the quarter, we have:

- Started collaboration with a coastal engineer to interpret the preliminary results of the laboratory erosion tests. The objective is to identify the most appropriate model to relate slope angle, material properties and wave shape so that we can identify the safe low wall angle.
- Progressed with crushing and characterising the material delivered by the Mine site to UoN. The material delivered to us consists of large sandstone blocks which cannot be tested in the laboratory. Given the logistical difficulties encountered in sourcing and delivering the material, the monitors agreed that a way forward was to crush the blocks received to create a material that could be used for the rest of the experimental program of this project. About 1 m^3 of material needs to be produced. Half of the required material has now been produced and tested with the remaining currently under preparation due to unexpected equipment issues faced before Christmas closure. Particle size distribution of different fractions (coarse and fine) and Atterberg limits of the fine fraction produced have been obtained.
- Requested some Cat 2, fine-grained, spoil material (volume of about 1m^3) to the mine site. The crushed material is predominantly coarse grained and it is relevant to test fine grained material.

C36021
Measuring the Tensile Strength of Thin Units in Coal Measure Rocks using a Comminution Approach

University of Queensland
Dion Weatherley
Joan Esterle
Katerina Savinova

Value:	$214,100
Report Expected:	July 2025
Industry Monitor/s:	Andrew Lau Jianping Li Matt Tsang
ACARP Contact:	David Drakeley

While testing for strength is typically done by compression, there is a need to measure intact tensile strength to develop site-dependent properties. A solution can be borrowed from comminution with the potential to derive rock tensile strength from drill chips (i.e., crushed rocks) and drilled mini-core (<20mm in diameter and at 1:1 ratio of width to height) of a representative sample and applied to the mining/geotechnical sector. The project aims to demonstrate the utility of the Short Impact Load Cell (SILC) instrument for testing coal measures overburden rock types, including sandstone, siltstone, and claystone, and link this information to geological variability, texture and mineral composition. This project will also develop a refined methodology for coal measures, particularly around sample selection, preparation, and testing, to provide reliable indices for translation into reasonable approximations of intact rock properties for tensile strength.

Work to date:

- Ongoing consultation with the Industry Monitors;
- Together with contract students completed all sample preparation, data recording and digital photography of samples;
- Completed a set of samples from the sandstone, siltstone and claystone intervals (drilled out more than 1,500 cylinders) to conduct breakage tests. These include mini cores with diameters of 6mm, 8mm, 10mm and 15mm and drilled perpendicular and parallel to bedding.

Work planned for the next quarter:

- Complete all breakage tests and finish collating the data;
- Test select rock intervals with traditional tensile strength methods for validation/cross-reference;
- Link the SILC breakage tests to geological variability by acquiring hyperspectral imagery data (likely send samples to a lab in Norway) across all broken samples and completing in-house SEM/MLA analysis on several representative samples;
- Refine numerical modelling of the results; and
- Ongoing consultations with the Industry Monitors.

C36023
"SCANDY" - A handheld Imaging System for Real Time Spoil Categorisation

University of New South Wales
Simit Raval

Value:	$178,050
Report Expected:	April 2025
Industry Monitor/s:	Jacques Strydom Ned Stephenson Tim Vangsness
ACARP Contact:	Patrick Tyrrell

This project is aimed to develop a user-friendly mobile AI application for spoil characterisation, leveraging computer vision and advanced deep learning techniques to enable real-time predictions. The app is trained using smartphone images from waste dump sites across New South Wales and Queensland, and it is designed to function offline. A primary focus has been on improving data preprocessing, annotation, user feedback and the integration of Explainable AI (XAI) models to enhance the model's interpretability and performance, drawing upon insights from the completed project C29048.

During this quarter, the mobile application has been made available for testing through iOS TestFlight and the Android SDK, allowing deployment across multiple mine sites for initial testing. Key improvements include login, sign-up, and redeem-code-based access restrictions to regulate usage among different user groups. The annotation functionality has been further extended to annotate relevant attributes including Rock Density (RD), Particle Size Distribution (PSD), and Fabric structure and plasticity characteristics, enhancing the data collection process for more refined model retraining. Additionally, a custom-built edge AI device, as shown in the figure, has been assembled, integrating a Raspberry Pi, a high-resolution camera, and a touchscreen interface. This portable system enables on-site spoil analysis without requiring constant cloud connectivity, offering a robust and user-friendly solution for too remote sites. The development of this hardware aligns with ongoing efforts to enhance real-time processing capabilities and reduce dependence on external computing resources.

Fig. Hardware Implementation.

Maintenance and Equipment

C33034
Dozer Suspension Seat to Reduce Body Vibration

University of Queensland
Danellie Lynas

Value:	$83,107
Report Expected:	April 2025
Industry Monitor/s:	Shane Apps Tim Gray Troy O'Reilly
ACARP Contact:	Anne Mabardi

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 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.

Progress to date:
- Field testing of the prototype seat has been completed;
- Awaiting complete analysis of results by seat provider;
- Once results received draft report will be submitted.

C36019
In-situ Slew Bearing Scanner for Shovels

Ascribe Engineering
Matthew Robinson

Value:	$190,300
Report Expected:	February 2025
Industry Monitor/s:	Brendan Wilkins Tim Gray Tyson Burkitt
ACARP Contact:	Patrick Tyrrell

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

C37007
People and Process: Case Review on Human Systems Integration and OTR Tyre Handling Mobile Plant in Mining Operations

ViVA! Health at Work
Sara Pazell

Value:	$150,162
Report Expected:	September 2025
Industry Monitor/s:	Brendan Wilkins Rob Fraser Tim Gray Tony Egan
ACARP Contact:	Patrick Tyrrell

The aim of the project is to understand the organisational decision making processes when selecting, using, and integrating OTR tyre handling equipment (prime movers and attachments) in mining maintenance work systems.

The project objectives are to:
- Examine decision making and role accountabilities in participating mine sites for their OTR tyre handling work systems, including -
  - work bay design,
  - mobile plant equipment and attachment selection,
  - technician team selection,
  - operational risk assessments,
  - and the alignment with leading practice frameworks, and to
- Develop recommendations on improving these processes if gaps exist.

During the quarter the research team met with industry domain experts to examine roles and responsibilities in tyre maintenance work system design and management. Together, they reviewed and drafted a revised industry problem statement. The group detailed the stages of tyre maintenance lifecycle (from selection and purchase through to retirement). Additionally, they focused on the importance of engagement of key roles, such as the technicians, in work system design and planning. Subsequently, the lead researcher classified seven levels of engagement to use in the study design (from informing to empowering). The research team organised the feedback from the industry domain experts into an empathy map which led to five key 'pain points' requiring further examination and two 'gain points' to review in the study.

The lead research team developed two future wheels and future wheel matrixes with three tiers of outcomes based on the idea that effective work outcomes arise from:
- Consulting with diverse stakeholders in the design of tyre maintenance work systems; and
- Developing a proper use case and design brief for tyre handling equipment selection and integration.

The research team met with the digital software solutions partners, Beamible, to commence the survey framework on process flows and role accountability. Also, investigations have begun on social network versus task or information network studies that may be useful to the study. A general literature review is also underway.

Health and Safety

C36033
Live Monitoring of Workplace Exposures In Surface Mobile Equipment

SafeOperate
Andrew Westaway

Value:	$152,000
Report Expected:	March 2025
Industry Monitor/s:	Shane Apps
ACARP Contact:	Patrick Tyrrell

This project primarily aims to establish real-time whole body vibration monitoring of operators in mining equipment, with secondary objectives of real-time seat suspension and haul road health monitoring. This achieved through the creation of seat covers containing embedded accelerometers fitted to equipment, accelerometers mounted to the cab of equipment, and all collected data to be GPS tagged.

Quarter progress:
- Improved process for embedding accelerometers into seat covers completed and 12 units constructed. Estimate to have 12 systems online collecting data MAR 2025;
- Construction of additional 12 full systems 75% completed, additional units expected to be online in May 2025; and
- Re-design of cab sensor mounting process underway.

COAL PREPARATION

REPORTS PUBLISHED THIS QUARTER

C29065
Wash Plant Fines Testing Methods Enhancement
McMahon Coal Quality Resources
Chris McMahon
Link to download the final report:
https://www.acarp.com.au/abstracts.aspx?repId=C29065

C34041
A Coal Spiral for the 2020s
Mineral Technologies
Wendy Nutt
Link to download the final report:
https://www.acarp.com.au/abstracts.aspx?repId=C34041

C35019
Feasibility of Utilisation of Coal Mine Tailings in Australian Cement Production
Central Queensland University
Hassan Baji, Zhong Tao, Nariman Saeed, Andrew Hammond, Brendan Donnelly and Peter Sleep
Link to download the final report:
https://www.acarp.com.au/abstracts.aspx?repId=C35019

Maintenance and Equipment

C35036
Autonomous Stockpile Dozing: Quantifying Viability

University of Queensland
Ross McAree

Value:	$352,797
Report Expected:	February 2025
Industry Monitor/s:	Chris Huth Chris Jackson Frank Mercuri Jimmy Pollack Peter Shumack
ACARP Contact:	Patrick Tyrrell

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

C36028
Continuous Stockpile Cavity Warning System - Feasibility Assessment

CSIRO
Wayne Stasinowsky

Value:	$191,600
Report Expected:	April 2025
Industry Monitor/s:	Kevin Rowe Michael Booth Naresh Racha
ACARP Contact:	Ben Gill

The project objectives are to:
- Conduct a feasibility assessment for a system that will allow the mine to monitor the stockpile continuously in real time and give real-time warning of a developing void to the dozer operator;
- Model the responses numerically to determine that there is sufficient resolution to detect dangerous voids; and to
- Test the technique using scale models.

Progress during the quarter:
- Some numerical modelling with open-source modelling software, GPRmax continued this quarter. Results of this modelling has indicated that a cavity of 2m diameter should be detectable in a dry coal stockpile. It suggests that a frequency of 40MHz can be used which should give good penetration of both dry and wet coal.
- Numerous scale model tests have been conducted and the results are being analysed and documented. Scale models have continued with positive results continuing to suggest that a cavity of 2m diameter should be detectable in a dry coal stockpile.
- Ground probing radars with suitable different frequencies have been purchased by CSIRO. A site for testing over a full-size stockpile to test signal penetration is still to be arranged. (This is in addition to the originally specified project scope, but will add to the feasibility assessment.)
- No results to date have indicated that this technique will not work.

Dewatering

C29060
Tailings Management - Dewatering Flume Site Trials

University of Newcastle
Craig Wheeler

Value:	$278,500
Report Expected:	February 2025
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 reduce, or eliminate, the use of secondary flocculant in the tailings dam.

Original onsite testing is complete and further testing at a new site is progressing under a project extension. New feed material has been tested over a range of concentrations and flowrates to optimise solids recovery. Further testing with various flocculant dosage levels is planned.

C33049
Emerging Pulsed Power Technology for Dewatering Mineral Tailings

University of Queensland
Mansour Edraki

Value:	$277,630
Report Expected:	February 2025
Industry Monitor/s:	Dan Delahunty Jack Lauder
ACARP Contact:	Ben Gill

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

C33050
Dewatering Efficiency of Fine Flotation Concentrates by De-Aerating Froth Products - Plant Demonstration

University of Queensland
Yongjun Peng

Value:	$627,923
Report Expected:	March 2025
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.

During the quarter, researchers from the UQ and DADI engineers conducted extensive plant trials on the large-scale mechanical deaerator. The trial results were presented to industry monitors, demonstrating the deaerator's effectiveness in disrupting stable coal froth fed to a filter during continuous on-site operation. The results showed a substantial reduction in slurry volume and enhanced dewatering efficiency during filtration, enabling the expansion of plant capacity and the increase of coal production.

The trials also established the device's capacity to treat flotation concentrates and evaluated the impact of spinning speed on froth deaeration. Continuous testing confirmed the deaerator's ability to operate autonomously, adjusting smoothly to varying slurry inlet conditions.

Based on trial data and feedback, the mechanical deaerator underwent a redesign to better suit site conditions and future full-scale applications. Key improvements included optimising froth separation to minimise water inflow into the inner tank. This was achieved by determining an optimal liquid level through trials, which is now maintained by a PLC control system that synchronises the inlet and outlet rates. Additionally, to address excessive water inflow from the re-feed pump, which had been reducing deaeration efficiency, the re-feed point was relocated, improving the deaeration process. These modifications have significantly enhanced overall deaeration efficiency and ensured the system is well-suited to meet the operational requirements for large-scale deployment.

C33051
Hybrid Microwave Technology for Dry Stacked Tailings Applications

University of Queensland
Christian Antonio

Value:	$121,335
Report Expected:	March 2025
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 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:

- The energy measurements taken during the experimental work are being analysed which is required for the techno-economic analysis of the process. This work is still ongoing.
- A number of concepts are being developed for a microwave-assisted dewatering system.
- Report writing is ongoing.

C34051
Cost Effective Approach for Coal Tailings Dewatering using Semi Inverted (SIV) Hydrocyclones

University of Queensland
Christian Antonio

Value:	$174,500
Report Expected:	March 2025
Industry Monitor/s:	Jenny Goh Naresh Racha Tom Wilson
ACARP Contact:	Ben Gill

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 focussed on the coagulation/flocculation testing of the feed, overflow, and underflow products produced from the SIV testing was completed and the results being analysed. The results for the project are now being collated and report writing is being undertaken.

A draft report is expected to be submitted to the Industry Monitors within the next quarter.

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

University of Queensland
Yongjun Peng

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

The objectives of this project are to:
- Understand how micro-nano bubbles are stabilised in fine coal tailings and evaluating their effects on the settling, filtration/centrifugation and compaction of solid suspensions;
- Evaluate physical and chemical methods in collapsing micro-nano bubbles in enhancing the settling, filtration/centrifugation and compaction of solid suspensions; and to
- Demonstrate the benefit of breaking micro-nano bubbles to fine coal tailings dewatering.

During this quarter, researchers developed an innovative in-line mixer system that utilises high pressure within the tailings pipeline. This system offers a potentially more energy efficient solution, as it eliminates the need for external energy inputs. The results demonstrated that the in-line mixer improved the centrifugation dewatering efficiency without compromising the solid content in the centrifugation overflow.

Additionally, dewatering tests were conducted to assess the effects of physical and chemical methods on the solid content in the overflow during centrifugation. The findings revealed that a high dosage of flocculant effectively reduced solid content in the overflow water by aggregating fine particles. In contrast, the use of various agitators and stirrers did not significantly impact the solid content in the overflow. However, chemical treatments applied to the tailings led to an increase in solid content, especially under high speed stirring conditions. To mitigate this issue, it is recommended to combine flocculants with chemical treatments for optimal results.

C36025
Green and Effective Reagents for Centrifugal Dewatering

University of Queensland
Liguang Wang

Value:	$198,982
Report Expected:	January 2026
Industry Monitor/s:	Chris Denyer Jenny Park Naresh Racha
ACARP Contact:	Ben Gill

The objectives of this project are to:
- Screen and develop green reagents for dewatering of coals and tailings over a broad size range to achieve low product moisture level and high solids recovery; and to
- Provide a guide for reagent selection in dewatering of Australian black coals and tailings.

During this quarter, we continued measuring particle settling with various dewatering reagents. A laboratory Single Leaf Filtration (SLF) test unit was set up to investigate the effects of flocculants on vacuum filtration of coal slurries. The optimal flocculant dosage for maximising filtration performance and improving dewatering efficiency was identified for each reagent tested. Nine more flocculants were subjected to the particle settling tests at different dosages. Some reagents were then selected for further testing using the SLF test unit to assess their performance in vacuum filtration. Turbidity measurements for the filtrates were performed to further evaluate filtration efficiency.

In the following quarter, more dewatering reagents and their blends will be tested for coal samples sourced from different coal mines, and centrifugal dewatering tests will be commenced.

Environmental Improvement

C29042
Tailings to Topsoil

University of Newcastle
Ken Williams

Value:	$765,300
Report Expected:	September 2026
Industry Monitor/s:	Bill Baxter Paul O'Loughlin
ACARP Contact:	Patrick Tyrrell

The original Tailings to Topsoil project commenced in 2020 to develop a co-utilisation and soil improvement program that addresses the environmental challenge of tailings management for mining operations. This transformational alternative for tailings management research optimises existing technologies for dewatering,

delivery, and soil remediation processes into an integrated "pit to paddock" mobile plant emplacement and cultivation system. An extension of this project (Stage 2) began in September 2023.

The setup for the Mine 2 field trial site is now complete, and monitoring of the site will commence.

Planning and setup for glasshouse trials are underway. The soil, waste rock, and coal tailings have been collected. The trials will consist of (1) coal tailings and (2) coal tailings that have undergone pyrolysis. These will be compared across different levels of coal tailings, i.e., 0:100, 5:95, 10:90, and 25:75 tailings:soil, and 49.3 : 49.3 : 1.5 Tailings : waste-rock : cow manure. These levels of coal tailings follow those that were used for the field trial at mine 1. The experiments conducted will include a plant growth study using Dodonaea viscosa, as well as pot trials (no plants) involving soil DNA (16s) and enzyme testing.

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
Chenming Zhang
David Williams

Value:	$259,000
Report Expected:	March 2025
Industry Monitor/s:	Naresh Racha
	Peter Shumack
ACARP Contact:	Patrick Tyrrell

The objectives 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; and to
- Verify the monitored results with those obtained using concurrent technologies.

During the quarter:
- The sliding gate of the dam break apparatus has been upgraded so that the facility operators does not need to manually handle tailings during operation –
- Dam break tests were conducted using coal tailings slurry;
  - The slurry flow status during the entire dam break test were monitored using the ERT system.
  - A new image reconstruction algorithm has been applied to quantify the conductivity distribution of the obtained images, improving interpretation capabilities.
  - The slurry flow velocity can be adjusted by controlling the size of the sliding gate outlet.
- A February field test is scheduled. Preparations are ongoing, including pipeline reformation, installation of a protective shed for the ERT system, power supply setup, and confirmation of the test dates.


Figure 1 Dam break test using coal tailings slurry

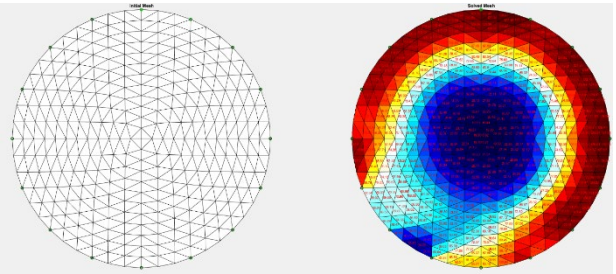


Figure 2 Quantified conductivity distribution image

C35048
Cost Effective Rehabilitation of Tailings Dams

CSER Research
Banjo Major
Callum Vizer
Carmen Castor
Greg Major
Mike Cole

Value:	$973,580
Report Expected:	March 2027
Industry Monitor/s:	Andrew Lau
	Brooke York
	Shaun Booth
ACARP Contact:	Patrick Tyrrell

This project develops the research undertaken in C27009, C29041 and C34030 towards cost effective rehabilitation and closure of tailings dams. It aims 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.

The quarter focused on setting up the latest round of field experiments for the mine site used in C27009, monitoring existing experiments and environmental parameters. Survival of existing experimental trees is very stable with few new deaths occurring and anecdotally, the sub-surface roots have been observed

spreading through large areas in the tailings. This will contribute to the stability of the crust around the experiments (see photo below of those exposed during sheet/gully erosion). Soil testing on this site showed minor improvements of tailings for vegetation growth. Salt levels are reduced slightly, some nutrient levels, such as nitrogen, have increased. Other variations are what would be expected from the interaction of roots with vegetation.

Water loss rate data of 'wild' M. quinquenervia was collected with the Porometer. Analysis of this data against experimental plants, nursery plants and established dam-plants will compare and contrast plant function across the differing environments.

An experiment is being set up to detect the change in leaf transpiration in young fully expanded leaves compared to older leaves that have been 'hardened off' at nurseries as this is expected to reduce their capacity to contribute to the Vegetative Water Pump.

Fine Coal

C34002
Full Scale Beneficiation of Coal Fines by Novel Agglomeration

University of Newcastle
Kevin Galvin
Daniel Borrow

Value:	$4,568,256
Report Expected:	July 2025
Industry Monitor/s:	Ben Gill
	Jason Schumacher
	Jenny Goh
	Kevin Rowe
	Luke Dimech
	Paul Sainsbury
ACARP Contact:	Patrick Tyrrell

The project objective 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 500m^3/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.

This project involved a substantial scale-up from a 25mm diameter pipe configuration to a 350mm diameter pipe system requiring the flow of the slurry and binder through a single hole in an orifice plate to produce agglomerates. The early results suggested that the system does not scale directly, and that the collision efficiency with the emulsion binder is impacted negatively. Additional funding was secured to develop further understanding of the scale-up of the technology. The current standard pipe configuration, with a diameter of 350mm, was replaced by a new design based on a 100mm diameter pipe configuration. The performance should be improved by introducing better conditioning of the binder prior to the main pipe, via dilution with an inline mixer. The new work also permits a higher salt concentration for the binder, and a more viscous binder. Our goal will be to secure the best possible economic binder dose for producing the agglomerates, and to also establish peak performance for a binder like that used previously.

The new pipework was installed, and other standard hire items secured, and site approvals were obtained, and commissioning completed. The experimental work was undertaken based on a systematic plan. The new set up offered key levers for generating a more effective binder. The experimental work was driven firstly towards successful agglomeration, and then towards more economic conditions, keeping the operation as simple and well controlled as possible. The window for the experimental work was highly constrained, but fortunately an additional configuration involving an orifice plate with multiple holes was also assessed on the final day. Due to the end of year closure period the hire items were returned. The assessment of the samples was then conducted.

The main part of the study was based on an orifice plate with a single hole, designed to achieve a specific pressure drop. The results from the program of work showed the technology could readily generate product ashes of approximately 10% ash. The combustible recoveries were variable and satisfactory, increasing as the oil dose increased. Towards the end of the experimental study the orifice plate was replaced with a new plate containing seven holes. Some air was also introduced with the feed. The results from this experiment were impressive with very high combustible recovery and low product ash. The work was also replicated. The oil dose was significantly lower than that achieved in the larger scale study. The work strongly indicates the potential for separation at an even lower oil dose. Therefore, this program of work has been successful in reducing the project risk, and for understanding the likely conditions needed to secure a strong separation. The research team will therefore develop a plan for up-scaling, introducing multiple 100mm diameter pipes.

C34040
Optimising the Diesel Droplet Size in Coal Preparation Plants

University of Queensland
Yongjun Peng

Value:	$231,157
Report Expected:	March 2025
Industry Monitor/s:	Chris Denyer 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; and to
- 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.

During the quarter, researchers from the University of Queensland (UQ) conducted an on-site plant trial at Mine Site 1 to evaluate the impact of emulsification on flotation performance. The trial demonstrated that ultrasound-induced emulsification produced smaller and more uniform diesel droplets compared to traditional physical emulsification methods. It also investigated how the degree of emulsification and diesel dosage after emulsification affected flotation performance, with the goal of determining the optimal conditions for both. Currently, UQ researchers are analysing the samples collected during the trial. Once the analysis is completed, the findings will be shared with project stakeholders and communicated to site engineers for further review and potential implementation.

The next phase involves testing the emulsification device at Mine Site 2, where the plant processes a different coal type and has a distinct water salinity compared to Site 1. Following delivery of emulsification device, UQ researchers will conduct plant trials using statistically designed ON/OFF tests to assess the effects of emulsification degree and diesel dosage on flotation efficiency.

C34043
In Plant Demonstration of the Next Generation Flotation System

University of Queensland
Liguang Wang

Value:	$258,347
Report Expected:	May 2025
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 prototype system at UQ was inspected by representatives from the participating site in mid-November 2024. Some suggestions on electrical safety have been made by them. We followed these suggestions and commenced building a control panel. A novel sparging system recently constructed at UQ has been integrated into the prototype system.

In the following quarter, the prototype system is expected to be ready for the site trial and a plan for the site work will be with the participating site for approval.

C34045
Real Time Automatic Measurement of Frother Distribution in a Coal Preparation Plant

University of Queensland
Liguang Wang

Value:	$124,560
Report Expected:	July 2025
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.

During this quarter, we refined the formulation to further improve the level of operation safety of the current prototype unit. Samples of the formulated liquid have been sent to an external laboratory for precise determination of the flash point. The test results will help determine whether the formulated liquid can be classified as a non-flammable liquid, ensuring it is safe to operate.

Additionally, we conducted long-term stability tests on various formulations. The results indicate that the updated formulation maintains its performance for over 40 days without noticeable degradation, demonstrating improved stability and safety.

Fine tuning of the prototype unit is ongoing. During testing, we identified several minor issues, which are currently being addressed through software and hardware upgrades.

In the next quarter, we will complete testing of the prototype unit and other preparation work as per the recommendations made by the participating site. This includes developing a pre-start checklist and standard operating procedures to ensure smooth deployment and operation during the site trial. We anticipate that the site trial will commence near the end of the next quarter.

C35024
Froth Flotation Predicted v Actual Definition

McMahon Coal Quality Resources
Chris McMahon

Value:	$41,360
Report Expected:	May 2025
Industry Monitor/s:	Jason Schumacher Jenny Goh Mel Robbins
ACARP Contact:	Patrick Tyrrell

This project seeks to collate and evaluate data in froth flotation raw ash and product yield / ash outcomes from borecores and actual coal handling and preparation plants. Several froth flotation methods from borecores, including the pseudo-density method (with efficiency factors trialled to fit data) will be evaluated against actual data. Several deposits will be evaluated.

A request for information memorandum was issued in November 2023 ,and a further request for information was made in February 2024, May 2024 and July 2024, with just one database received to date, and a second partial database.

Data processing is well advanced on one database, and initial review of the partially received second database has commenced. No outcomes are yet available for review.

The second part of the second database is expected imminently. Additional MCQR data and research (that have approval for release) will also be included in the reporting.

The outcomes of this project will be the definition of accuracy (precision and bias) information for varying coal types, in yield and product ash, with notes on methods relevant to the accuracy of outcomes. This will benefit the industry by providing a guide for use and defined accuracy of outcomes for the data and methods evaluated, and potentially saving very expensive mine, coal handling and preparation plant design and resource misrepresentation. The outcomes then will provide a financial risk reduction and / or evaluation enhancement.

C35031
Demonstrating Better Classifying Cyclones

Elsa Consulting Group
Andrew Vince
Andrew Swanson

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 funded research on better classifying cyclones, to build and demonstrate the industrial benefits of the new Rong Classifying Cyclone Concept (RCCC) at an appropriate scale, namely 380mm 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 is to determine how small detail RCCC design adjustments impact on capacity/pressure/metallurgical performance characteristics prior to unit construction and testing. Western Sydney University (Centre for Infrastructure Engineering, School of Engineering) have developed a discrete element model, and the results of using said model suggest that unexpectedly high alpha values can be expected. These simulations were used to identify dimensions for a 380mm unit that was designed and built.

Initially it was thought there would be a need for extensive, and expensive, fine coal float/sink work to be included in the project. However, given the surprisingly good alpha values from simulation work, it has been concluded that more modest testing will satisfactorily demonstrate the new design of 380mm unit. If the alpha values are confirmed to be high, supported by sizing and some conventional float/sink work, then the demonstration is complete. The simulations also indicated that low Rf values are possible.

The nature of the demonstration trials and the resultant sample testing have been extensively discussed with our project monitors and the originally proposed and budgeted analytical procedures will be followed.

The initial pilot run was aborted because of an equipment malfunction. The second set of trials commenced on 13 November 2024 with the monitors and other interested parties in attendance.

The analyses of the samples collected from that test campaign are expected in February; with the project on schedule.

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

University of Queensland
Anh Nguyen
Ngoc Nguyen

Value:	$200,304
Report Expected:	March 2025
Industry Monitor/s:	Ed Provan Jack Lauder Jason Schumacher Luke Dimech
ACARP Contact:	Ben Gill

The objective of this project is to investigate effective measures (clay suppressants and wash water) to reduce ash (clay) content and increase recovery of fine coal flotation. Specific aims include:

- Characterise clay types and compositions in coal flotation feed, clay-coal liberation, and surface properties;
- Screen (design) and test clay suppressants to remove clay slime coatings;
- Design and conduct experiments to evaluate the effect of wash water hydrodynamics on reducing clay entrainment; and to
- Conduct experiments using mechanical cell, Microcel, and Jameson cell for evaluating and benchmarking effective of clay and ash removals. The ultimate goal is to deliver higher-quality products and opportunities to increase overall plant recovery by avoiding high ash/clay entrainment.

In this quarter all samples from agreed mines have been received by our team at UQ. Test work in clay depressants is underway. A project review meeting has been scheduled for the end of February to discuss the results and findings.

The research team expect to submit the draft final report in the next quarter.

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

University of Newcastle
Rohan Stanger

Value:	$81,730
Report Expected:	March 2025
Industry Monitor/s:	Araz Ejtemaei
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.

Work in the quarter has revolved around the consolidation of results and final report preparation. The second suite of flotation samples have been received, dewatered and then analysed with micro-CT. We have found that this particular coal contains small amounts of high density mineral which interferes with the scanning. We have conducted a number of trials to remove this issue, with the most successful being to float/sink the sample in a solution of LST at a density of 2.2 g/mL. This has resulted in a delay to finalising the report.

C36026
Side-by-Side Analysis of Coal by Automated Micro-CT and Commercial Laboratory Testing

University of Newcastle
Rohan Stanger

Value:	$167,432
Report Expected:	April 2025
Industry Monitor/s:	Mel Robbins Michael Saxby Tom Wilson
ACARP Contact:	Ben Gill

This project aims to trial an automated sample carousel for a laboratory micro-CT instrument and compare data with standard testing for float/sink and petrographic analysis. The intention is to determine the speed and accuracy of micro-CT derived coal tests. If successful, it will provide an automated 3D analytical test method with faster turn-around times and potentially lower costs. This automation trial will develop the work-flows needed to test the automated scanning, image reconstruction, particle recognition and analysis.

In this quarter, we have observed communication issues with the micro-CT and the carousel. The issue appears to have been resolved but this has slowed progress. This quarter has focussed on sized fractions of spiral feed/product/reject samples; with effort focussed on obtaining sufficient particles in the largest fraction

(1-2mm). We have found that the smaller sample holders only utilise ~10% of the scan volume and aim to re-scan with larger 3D printed sample holder to optimise the process.

C36029
Testing a Novel Flotation Concept for Coal

CSIRO
Nerrida Scott

Value:	$88,204
Report Expected:	September 2025
Industry Monitor/s:	Frank Mercuri Jenny Goh Michael Saxby
ACARP Contact:	Ben Gill

No report received.

Gravity Separation

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

CSIRO
Clint McNally

Value:	$155,488
Report Expected:	March 2025
Industry Monitor/s:	Chris Denyer Frank Mercuri
ACARP Contact:	Ben Gill

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

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

CSIRO
Andrew Taylor
Nerrida Scott

Value:	$204,432
Report Expected:	April 2025
Industry Monitor/s:	Chris Denyer Frank Mercuri
ACARP Contact:	Ben Gill

No report received.

C36024
DMC Efficiency Improvement Using an Applied Magnetic Field

University of Queensland
Quentin Campbell

Value:	$205,050
Report Expected:	November 2025
Industry Monitor/s:	Araz Ejtemaei Frank Mercuri Jack Lauder
ACARP Contact:	Ben Gill

Previous studies in other commodities have shown that applying a magnetic field around a DMC can reduce the density cut-point, improve separation sharpness, and increase yield – all objectives of the Australian coal producers. This project aims to assess the economic and performance benefits of integrating a magnetic field into a magnetite medium DMC process. Expected benefits:

- Lower density cut-points: Achieving lower ash products with better or similar yield;
- Improved separation sharpness: Additional control to enhance yield; and
- Cost efficiency: Potential use of coarser magnetite with lower associated losses and reduced viscosity medium, while offsetting the stability issues of coarse medium.

Progress during the quarter:

- SOP, risk management/hazard identification and start-up/shut down procedures: Complete.
- Radio tracers: Received January 2025, Magnetite: Received November 2024.
- Existing DMC rig: The rig from South Africa is installed at JKMRC Brisbane. After some modifications, a water commissioning was done, showing some design and construction deficiencies. These are currently being attended to by the vendor.
- Baseline and subsequent tests: To be delayed until after the structural modifications are complete (approx. 1 month delay).
- Design of larger redesigned DMC plant: Drawings and design complete, fabrication to commence.

C36030
Measurement of DMC Wear using 3D Laser Technology

CSIRO
Andrew Taylor
Nerrida Scott

Value:	$175,422
Report Expected:	December 2025
Industry Monitor/s:	Dan Perkins Kevin Rowe Luke Winkelman
ACARP Contact:	Ben Gill

No report received.

Process Control

C34039
Soft Sensor for Predicting Dense Medium Cyclones Performance

University of Queensland
Gordon Forbes

Value:	$189,300
Report Expected:	March 2025
Industry Monitor/s:	Araz Ejtemaei Frank Mercuri Peter Shumack Rick Jeuken
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. The soft sensor will provide site personnel with estimates of process parameters that cannot be directly measured.

The development of the initial Excel based soft sensor for the primary and secondary DMCs is complete. This allows for the modelling of the circuit, adjusting to changes in washability when different coal types are processed. The model runs by solving for four parameters (washability scaling, primary screen efficiency, primary pump speed and secondary pump speed) to identify a solution that best matches the observed measurements from instrumentation.

Over the quarter, efforts have focused on further validation of the DMC soft sensor, fine-tuning, and writing the final report. Further investigation into the initial study of using machine learning to better predict ash content of product streams suggests that the results were likely affected by leakage, meaning that an online implementation would be unlikely to perform as well as expected. Alternative machine learning methods are being investigated to address this issue.

Additional spigot wear data has been provided by site, allowing additional validation of the DMC soft sensor. Results to date indicate that there is superior performance of the DMC soft sensor when the spigot wear of the DMCs in the circuit is considered.

C34044
Real Time Monitoring and Control of Froth Flotation

University of Queensland
Liguang Wang

Value:	$262,437
Report Expected:	August 2025
Industry Monitor/s:	Chris Denyer Chris Huth Josh Kowalczuk Rick Jeuken
ACARP Contact:	Ben Gill

The objectives of this project are to:
- Further evaluate and demonstrate a simple, cheap and fast sensor for monitoring the efficiency of multiple flotation cells; and to
- Develop remote control strategies corresponding to the sub-optimal operation identified by the sensor.

During this quarter, we were focused on identifying the cause of the unexpected signal drift observed in the drag sensor. We systematically tested several hypotheses to determine the root cause and were able to narrow down potential factors. Based on our findings, we upgraded the design to improve measurement robustness and sensitivity while minimising signal drift. The new design has been finalised, and multiple drag sensors and their holders are currently under construction.

Next quarter, we will continue preparing for long term site testing to ensure all sensors and electronics can operate reliably under harsh weather conditions. We will also be visiting the site to finalise plans for the upcoming site trial and long term deployment. During the visit, we will review the previously identified issues related to the machine vision system installed on-site and find ways to ensure proper data collection during the long term site testing.

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:	April 2025
Industry Monitor/s:	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.

All the site work for this project has been completed, involving 80 surveys of industrial TBS units at two coal processing plants. These surveys were performed of three different designs of TBS fed six different feed types at two different coal processing plants operated under different operating conditions. The analysis of samples from one of the plants has been received but results from the second plant is still pending. Feed samples were also collected during the campaign and transported to the JKMRC for fluidisation and washability analysis. As previously reported, all CFD models have been developed and are ready for validation using survey data.

During the quarter, two feed samples were sized and submitted for washability analysis. Laboratory fluidisation test work was completed. The experimental data received from one of the sites has been mass balanced. Additional assessment of the CFD simulation methodology has been performed with “dummy feed” data.

On receipt of the remaining site data, mass balancing and regression analysis will be performed to determine drivers of TBS performance. On receipt of the feed washability analysis, CFD simulations will be performed and compared to the full-scale TBS data and laboratory fluidisation tests to validate the CFD methodology.

General

C28061
Quantitative Based Structural Integrity Evaluations Using Modal Parameters Estimation

Mincka Engineering
Fidel Gonzalez

Value:	$363,651
Report Expected:	February 2025
Industry Monitor/s:	Chris Jackson Kevin Rowe Peter Shumack
ACARP Contact:	Patrick Tyrrell

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

TECHNICAL MARKET SUPPORT

REPORTS PUBLISHED THIS QUARTER

C34054
Scoping Study: Design of Cokes from Biomass-Coal Blends for Sustainable Blast Furnace Ironmaking
University of New South Wales
Pramod Koshy
Link to download the final report:
https://www.acarp.com.au/abstracts.aspx?repId=C34054

C34058
Strength Development in Fouling Deposits
The University of Newcastle
Liza Elliott, Stathis Tsiricopoulos
Link to download the final report:
https://www.acarp.com.au/abstracts.aspx?repId=C34058

C35037
Examination of Contraction Pre and Post Resolidification Using a High Temperature Dilatation Rig
The University of Newcastle
David Jenkins, Salman Khoshk Rish, Arash Tahmasebi
Link to download the final report:
https://www.acarp.com.au/abstracts.aspx?repId=C35037

Metallurgical Coal

C34063
International Round Robin for Coke Reactivity Index, Coke Strength after Reaction and I600

CSIRO
Lauren Williamson

Value:	$77,800
Report Expected:	February 2025
Industry Monitor/s:	Caroline Lang Graeme Harris
ACARP Contact:	Ashley Conroy

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

C35038
Microalgae Blending for Low Carbon Metallurgical Coke Production

University of Newcastle
Arash Tahmasebi

Value:	$172,000
Report Expected:	March 2025
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.

Progress in the quarter is as follows:

- The biocoke gasification reactivity tests in TGA with data analysis were completed.
- The microtexture analysis results in polished biocoke samples were received from Pearson coal petrography.
- The experimental and analysis work in the project is complete.
- Draft report is being prepared for submission in March.

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:	February 2025
Industry Monitor/s:	Graeme Harris Stephen Brant
ACARP Contact:	Ashley Conroy

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

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:	November 2025
Industry Monitor/s:	Cameron Tasker Caroline Lang James Bottle Oliver Scholes
ACARP Contact:	Ashley Conroy

With the steel industry under pressure to reduce CO_2 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.

Drop Tube Furnace tests and TGA analysis are all underway. Significant issues with the drop tube furnace are ongoing and rectification has been difficult. Investigations to replace the furnace are underway.

The TGA was found to be unsuitable for reactions containing H2 as the reaction is expected to occur away from the sample pan. An alternate methodology has been developed, and we are awaiting safety approvals before experimentation can begin.

The TGA to be used for ammonia containing reactions has had a catastrophic failure of the furnace. A replacement is being sought.

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 CO_2 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 CO_2 neutral as the CO_2 emitted during combustion is equivalent to the CO_2 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.

A recent 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.

TIMA analysis of the coal is complete, as is chemical fractionation of the biomass samples. Combustion of the coal in coal only tests is complete, with collection of the ash including the ultrafine portion. Combustion of biomass-coal blends is complete and only two repeats are left of the biomass only combustion tests. SEM ESD analysis of the ash from the combustion tests and particle size determination is progressing.

C35042
Physical and Chemical Interactions Between Charcoal and Coal During Coking

University of Queensland
Karen Steel

Value:	$135,694
Report Expected:	April 2025
Industry Monitor/s:	Graeme Harris
	Morgan Blake
ACARP Contact:	Ashley Conroy

This project addresses the demand from coke makers to add high proportions of biomass to cokemaking blends whilst not compromising on coke strength.

It has been recognised for some time that addition of biomass decreases coke performance in terms of the both CSR and CRI. One of the major adverse effects is reduced fluidity. It has been established that converting biomass to charcoal at high temperature (800°C) in the first instance reduces the adverse effect. Given that oxygen content decreases as charring temperature increases, it is strongly suspected that high temperatures are preferred due to the loss of oxygen from the char; oxygen is already well known to decrease fluidity through condensation reactions.

This project investigates the blending of biomass with high fluidity coals to deliberately interact with biomass at low temperature, thereby mitigating the adverse effects caused by biomass and preserving the function of the prime coking coal. The project involves studying three high fluidity coals, three biomass types (sugar cane bagasse, bamboo, and Jarrah), and two coking coals.

We have completed all small scale work, the first round of larger scale test work, and started preparing the final report. Results and interpretations from the small scale work have been presented to the Industry Monitors and prepared into a journal paper for Fuel, which will be coming out under the title “Biocoke: Carrying capacity of coking coals for sugarcane bagasse char in terms of viscoelastic behaviour during co-carbonisation.” We plan to present the major findings at the upcoming International Conference on Sustainable Cokemaking and Ironmaking as part of the broad discussion on establishing the potential of biomass in cokemaking.

The second round of larger scale test work is the only remaining work to be completed. Due to delays around splitting the work into two phases (due to unexpected results changing the focus of the work) and underestimating the time needed to prepare charcoals for larger scale studies, this project has been granted an extension.

C35043
Abrasion Resistance of Coke Under Hydrogen Reduction Blast Furnace Conditions

University of Newcastle
Hannah Lomas

Value:	$159,416
Report Expected:	March 2025
Industry Monitor/s:	Nick Andriopoulos
	Oliver Scholes
	Stephen Brant
ACARP Contact:	Ashley Conroy

The hydrogen enriched blast furnace (BF) is emerging as a viable alternate technology to reduce the carbon footprint of BF ironmaking, during which injected hydrogen reduces the ferrous burden, generating water vapour as a by-product. It is thus important to understand how the degradation of coke under such conditions differs in comparison with conventional ironmaking, and thereby identify the impact of a hydrogen enriched BF on coke quality requirements.

This project has focused on the impact on coke abrasion resistance, which was evaluated using high temperature tribological testing. Six RCO cokes were selected.

The project objectives included:

- Evaluation of the impact of partially pre-gasifying cokes with CO2 or with H2O on coke abrasion resistance at elevated temperature (950°C).
- Link abrasion resistance determined by tribological testing to:
  - coke microtextural components, and the rank and maceral composition of the parent coal or blend,
  - conventional coke quality indices, including ASTM Hardness, I600, CSR, and CRI.

Analysis of the tribological test data was completed in the quarter, including (i) determination of the mean coefficient of friction over time, (ii) SEM imaging and analysis of the abrasive wear mechanisms, and (iii) determination of the severity of the abrasive wear as a function of coke microtexture, coke type, and pre-gasification environment.

The draft final report is ~ 70% complete and will be submitted following an internal review.

C35044
What We Now Know about Coking Coals and Coke

CSIRO
Lauren Williamson

Value:	$96,284
Report Expected:	March 2025
Industry Monitor/s:	Lauren North 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; and to
- Review the effects of adding biomass and hydrogen into the iron making process.

The team is currently finalising the draft project report.

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:	February 2025
Industry Monitor/s:	Lauren North Nick Andriopoulos
ACARP Contact:	Ashley Conroy

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

C36004
Physical and Chemical Structure Characterisation of Biomass for Biocoke Production

University of Newcastle
Arash Tahmasebi

Value:	$54,100
Report Expected:	February 2025
Industry Monitor/s:	Cameron Tasker Lauren North Morgan Blake Nick Andriopoulos Shaun Booth Stephen Brant
ACARP Contact:	Ashley Conroy

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

C36031
Structural Optimisation and Reactivity Evaluation of Ferro Coke Produced using Australian Coals

University of Newcastle
Arash Tahmasebi

Value:	$167,000
Report Expected:	November 2025
Industry Monitor/s:	Cameron Tasker Graeme Harris Nick Andriopoulos Stephen Brant
ACARP Contact:	Ashley Conroy

The project aims to examine the suitability of Australian coals for ferro-coke production and to develop a new understanding of the mechanism of microstructure formation and reactivity of ferro-coke. Specific objectives are to:
- Evaluate the coal properties and blend strategies suitable for ferro-coke production.
- Explore the use of high-fluidity Australian coal as a binder during ferro-coke decarbonisation.
- Analyse the impact of iron ore addition level on thermal decomposition behaviour and thermoplasticity development in coal blends.
- Evaluate the impact of iron ore on microstructure development during the carbonisation of ferro-coke.
- Improve the understanding of factors underpinning the reactivity of ferro-coke under simulated blast furnace reaction conditions.
- Identify the governing factors driving the strength and reactivity of ferro-coke.

Progress in the quarter is as follows:
- A total of 25 ferro-coke samples (each with 4 repeats) were prepared with varying ferrous and biner contents.
- The Shimadzu AGS-X 50kN at NIER was used to measure the mechanical strength of samples. The impact of blend design, the type and amount of binder, and ferrous components (iron ore and DRI) in the blend were analysed.
- Representative ferro-coke samples were imaged at the Australian Synchrotron. The 3D microstructure analysis is currently underway to link with strength.
- TGA carbonisation tests on pelletised blends were also completed this quarter to study the mechanism of interaction between blend components.
- Next quarter will involve ferro-coke TGA gasification testing and further micro-CT image analysis.

C36032
Impact of Biomass on Coke Microstructure Evolution and Gas Diffusion During CO2 Gasification

University of Newcastle
Arash Tahmasebi

Value:	$169,000
Report Expected:	April 2026
Industry Monitor/s:	Graeme Harris Lauren North Morgan Blake Nick Andriopoulos Sean Flanagan Shaun Booth
ACARP Contact:	Ashley Conroy

The project investigates the impact of biomass on coke reactivity and microstructure evolution during CO_2 gasification. The specific objectives are to:

- Study impact of biomass species and pre-treatment method on the mechanism of reactivity of biochar.
- Compare gas diffusion in biocoke microstructure with the progression of gasification using a developed reaction-diffusion mode.
- Investigate the changes in biocoke microstructural evolution and structural degradation during gasification.
- Develop new mechanistic understanding of biocoke gasification, i.e., volumetric vs. diffusion-controlled gasification.
- Determine the degree to which biomass pretreatment influences biocoke degradation.
- Investigate the onset as a means of benchmarking biocoke reactivity with conventional coke.

During the quarter the project was delayed due to awaiting RCO biocoke samples to commence CT imaging and TGA reactivity tests.

C36034
Sugar Coated Coal: Determining if Glucose Addition Can Improve Coke Quality of Coal-Biomass Blends

ALS Coal
Callum Mainstone

Value:	$111,622
Report Expected:	March 2025
Industry Monitor/s:	Caroline Lang Graeme Harris Lauren North Morgan Blake Nick Andriopoulos Sean Flanagan Shaun Booth
ACARP Contact:	Ashley Conroy

This project seeks to determine if glucose in the form of dextrose monohydrate can be blended with coal to produce coke at higher concentrations than other types of biomass. Two coal samples were tested, one high ash coking coal will be used to also determine the ability of glucose to reduce ash content of the subsequent coke and an otherwise non-coking, thermal coal will be used in an effort to produce a competent coke utilising the fluidity properties of glucose.

A progress meeting with industry monitors in September led to another coal being included in the project, an export quality hard coking coal. This was to determine the carrying capacity of an existing coal product for sugar with an intent to seek the maximum concentration of biomass for coke to achieve a CSR of 50.

During the quarter, the remaining coke making and testing was completed, coke lumps were photographed and analysed and the remaining coal and coke quality samples were prepared. The draft report is well underway with several ash analysis pending. Draft submission should be expected within this quarter.

C36035
Microstructure Characterisation and Simulation of Bio-additives in Coke

University of Newcastle
David Jenkins
Edward Bissaker

Value:	$114,200
Report Expected:	January 2026
Industry Monitor/s:	Graeme Harris Lauren North Morgan Blake Nick Andriopoulos Sean Flanagan Shaun Booth
ACARP Contact:	Ashley Conroy

The project objectives are to:

- Develop a capability, based on statistical characterisation of coke microstructures, to relate the properties of bio-additives in coke to the mechanical properties of coke (i.e. coke strength);
- Use the capability to identify the specific properties of bio-additives that affect coke strength; and to
- Investigate the range of possible microstructures that could be created using bio-additives to optimise the coke strength, for specified bio-additive demand (e.g. mass fraction added).

To date, no micro-CT images of bio-additives in coke are available, which precludes progress on the project.

C36036
Biochar-Coke Integration for Improved Coke Strength and Performance

University of New South Wales
Pramod Koshy

Value:	$244,400
Report Expected:	January 2026
Industry Monitor/s:	Graeme Harris Lauren North Morgan Blake Nick Andriopoulos Sean Flanagan Shaun Booth
ACARP Contact:	Ashley Conroy

This project between UNSW Sydney, UoN, CSIRO, and ANSTO is focussed on understanding the impact of higher biochar addition levels and coal type on the quality of the resultant cokes for ironmaking. This project forms part of a series of ACARP projects that are taking place concurrently to investigate different key aspects related to the addition of biochar to coals. The aims of the project are as follows:

- Understand the impact of biomass addition (5-20 wt%, possibly 25-30 wt%) to coals (with varying vitrinite contents) on the resultant macrostructural, microstructural, and microtextural features of the cokes;
- Analyse the physical, microstructural, and interfacial features of the biochar-coal components in blended cokes through fractography and microtextural analysis after mechanical testing; and
- Develop associations between biomass addition levels with coal type and coke performance under potential blast furnace conditions using standard coke quality indicators.

C36037
Exploring the Effects of Bio-char and Torrefied Biomass Addition on the Microtexture of Bio-coke

Royal Melbourne Institute of Technology
Soonho Lee

Value:	$155,000
Report Expected:	April 2026
Industry Monitor/s:	Graeme Harris Lauren North Morgan Blake Nick Andriopoulos Sean Flanagan Shaun Booth
ACARP Contact:	Ashley Conroy

The objective of this project is to investigate the chemical interactions between bio-char/torrefied biomass and coal macerals within bio-coke microstructures using Pearson's anisotropy quotient (AQ) colour-coded bireflectance mapping technique. Additionally, the project aims to develop a code-based image analysis method to quantify microtexture compositions surrounding biomass particles and assess their interactions. Two coals, premium coking coal and semi-hard coal, with different vitrinite content (~60% and ~75%) and fluidity but similar coal rank (~1.2% MMVR), are used to examine the effect of coal properties on these interactions.

During this quarter, the two coking coals and two blends, the premium coal blended with 10% bamboo char and 10% sugarcane bagasse, were carbonised in a 400 kg pilot-scale recovery coke oven (RCO) at QCAT CSIRO. CSR-sized lump coke samples were then prepared for each bio-coke and sent to Pearson Coal Petrography for AQ mapping. Three coke-sized lumps were embedded in a resin block, cross-sectioned, and polished to expose the surface for bireflectance scanning. In parallel, using preliminary AQ maps of bio-coke, a MATLAB code was developed to quantitatively analyse surrounding materials such as fused vitrinite and inertinite. This involved identifying rough interfaces between biomass particles and surrounding materials, selecting surrounding materials with varying interspace thicknesses, and extracting microtexture compositions based on AQ histogram analysis.

Looking ahead to the next quarter, the developed MATLAB code will be applied to new AQ maps provided by Pearson Petrography to further study the impact of different biomass types and coal properties on chemical interactions, with a particular focus on residual gases within carbonised macerals.

C36038
Effects of Ash Minerals on Coke Reactivity under Hydrogen Injection, Low CO2 Blast Furnace Conditions

University of Wollongong
Ray Longbottom

Value:	$51,290
Report Expected:	April 2025
Industry Monitor/s:	Cameron Tasker Nick Andriopoulos
ACARP Contact:	Ashley Conroy

The primary objective of this project is to quantify the impact of mineralogy on the reactivity of metallurgical coke using a coke analogue at temperatures of 1100°C and higher using H_2 containing gas mixtures.

To assess the mineral effects on coke reactivity with H_2-containing gases, selected cokes and coke analogues containing targeted minerals will be reacted at temperatures from 1100-1600°C under blast furnace conditions representing H_2 injection, low CO_2 operation. These results will then be compared against the reactivity of coke with CO-CO_2 gas mixtures, helping to evaluate the effect of changing from traditional to H_2 injection blast furnace operation on coke performance.

The outcomes from the proposed project will directly improve the understanding of the impacts of hydrogen on coke quality requirements and coke performance in the BF in H_2 injection, low CO_2 operation.

Characterisation of the unreacted coke and coke analogue samples has been completed. Preliminary testing under pseudo-CRI (100% CO_2) conditions has demonstrated that the newly prepared samples have similar reactivities to samples produced in previous projects. Issues with the TGA furnace and gas control system have temporarily prevented further reactivity testing from occurring.

C36039
Alternative Thermal Processing of Coal Pilot Extruded Coke and Supercapacitor Demonstration

University of Newcastle
Rohan Stanger

Value:	$157,178
Report Expected:	April 2025
Industry Monitor/s:	Graeme Harris Lauren North Morgan Blake Nick Andriopoulos Peter Austin Sean Flanagan Shaun Booth
ACARP Contact:	Ashley Conroy

This project aims to conduct pilot trials on our extrusion system to produce a final “annealed” coke product; suitable for CSR evaluation. The project will also continue development of our coal-based supercapacitor to produce a larger proto-type system for energy storage. Specific to the pilot extrusion system, the test work will involve an evaluation of final annealing temperature and the addition of “bio-fluids” to the feed mixtures (as opposed to biomass derived solids like biochar).

This quarter has been focussed on commissioning the extruder furnace system. We have conducted a number of early trials and found that we are able to extrude two coals (fluidity 1500, 640 ddpm) and blends of each coals with 10% biochar and 20% biochar. However, we have observed that the extruded material tends to fill the coupling to the furnace producing a “thermo-formed” semi-coke product up to 70mmOD which ultimately results in a blockage. This is now a repeatable failure suggesting that changing feed material or temperature profile are not driving influences. This level of plastic behaviour was not expected based on the feed coals fluid properties, but is expected to be due to the higher extrusions pressures produced int the process. Overall, this is considered a positive feature that must be engineered for. A longer die insert is being manufactured to transport the extruded coal directly into the furnace.

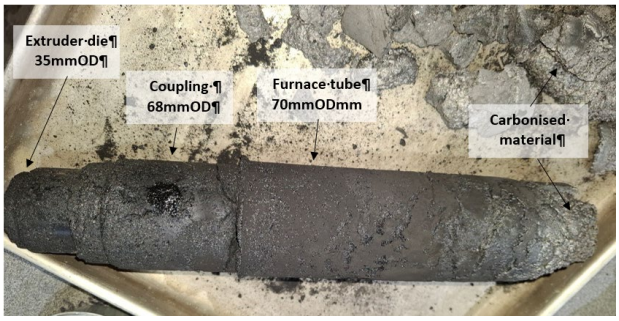


Figure 1. Thermal extrusion of coking coal blend with 10% biochar; pulled from system after causing blockage.

C36040
Tracking the Carbonisation Performance of Vitrinite Macerals

University of Queensland
Karen Steel

Value:	$108,664
Report Expected:	April 2025
Industry Monitor/s:	Lauren North Oliver Scholes
ACARP Contact:	Ashley Conroy

This project builds on previous research where different vitrinite maceral subgroups were examined before and after pyrolysis/carbonisation using optical microscopy. While the pyrolysis product of collotelinite bands comprised large spherical pores with thin pore walls, the pyrolysis product of collodetrinite was markedly different, comprising smaller pores and thicker pore walls. Given that pore structure influences coke quality indices, knowledge on the specific vitrinite properties that give rise to the best quality coke would be beneficial for cokemakers developing blend formulations. The objective of this project is to apply the ‘before vs after’ technique developed by Tara Congo to examine coals of different rank and from different Australian coal measures. Additionally, we aim to characterise molecular structure using XPS and 13C NMR and relate this to the observations made. This work addresses the research priority to relate coke performance to coal property information.

During this quarter we have presented results on the first three samples (low rank of 0.8-0.9) to industry monitors and carried out XPS and 13C NMR test work to characterise the molecular structure of these coals. The thick collotelinite bands in these low rank coals undergo considerable expansion with pores having thin pore walls, while pores in the collodetrinite regions are smaller and comprise thicker walls. The oxygen functional groups have been found to be different across the coals and different when comparing the vitrinite regions to the whole coal. This information is being used to explain the viscoelastic measurements obtained. We have started studying the next group of three samples that have a higher rank.

C36041
Quantifying Biochar Interactions with Coal for Coke Making

CSIRO
Lauren Williamson

Value:	$141,683
Report Expected:	July 2025
Industry Monitor/s:	Graeme Harris Lauren North Morgan Blake Nick Andriopoulos Sean Flanagan Shaun Booth
ACARP Contact:	Ashley Conroy

The project objectives are to:

- Prepare cokes for consistent analysis of different aspects of biomass addition (including coke standard coke quality determinations) for use across a suite of biomass related projects commenced in 2024 and retain material for future projects in the ACARP Coal Bank; and to
- Quantifying the relationship between biomass char surface area, size distribution and their impact on coke properties.

Six of the cokes required were produced in December, work is ongoing to characterise and despatch them to researchers are required. Further biomass is required from Roundhill engineering, to complete coke making on a further ten cokes.

Thermal Coal

C35005
Feasibility Study, Upgrade and Commissioning of ALS-ACIRL Pilot Scale Combustion Test Facility

ALS Coal
Luke Beattie

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 the 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.

Stage 1 – Feasibility – Complete
Stage 2 – Upgrade – Complete
Stage 3 – Commissioning – In Progress

The ALS-ACIRL Pilot Scale Combustion Test Facility has begun the commissioning stage of this project. All materials (coal and char) for this phase have been delivered, and ALS has conducted extensive coal quality analysis on each sample. The samples have been milled to Standard PF fineness, and trial burns in the upgraded boiler have commenced, comparing the performance of subcritical and supercritical boilers, and finally, co-firing coal with a biochar material. The trial burns are expected to be completed by the end of March, with the report due in April.

General

C25053
Coal Sample Bank

CSIRO
Aedita Crouch
Lauren Williamson

Value:	$451,801
Report Expected:	November 2024
Industry Monitor/s:	Technical Market Support Committee
ACARP Contact:	Ashley Conroy

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

This project started on 1st March 2017, in October 2021 Stage three of this project commenced, extending the coal bank for a further three years. To date, 98 coal samples have been delivered, stored at -18°C and their details recorded in a database, there are also 39 cokes, 7 biomasses and 1 fly ash stored. Of the coal samples stored coal quality data has been provided by coal producers for 79 of the samples.

During the quarter six coke samples were provided to projects C36031, C36032, C36037 and C36041. In calendar 2024 to date 25 samples (coal/coke/biomass) have been provided to projects. A fourth stage of this project has been approved for a further three years.

C26003
Management of SA and ISO Coal Technical Committees Work Programs

Carbon Connections Consulting
Barry Isherwood

Value:	$497,750
Report Expected:	December 2026
Industry Monitor/s:	Graeme Harris Kevin Rowe Lauren North
ACARP Contact:	Anne Mabardi

SA Committee MN/1/1 Coal Analysis (mirror to ISO TC27/SC5) held its four monthly meeting by hybrid/videocon in November, reviewing newly released 2025 Systematic Reviews plus the following issues.

As previously noted, ISO rules allow any Standard's Test Report to include clauses covering "any deviations to the Standard" and "any unusual observations". Our objections have been accepted and although we will need to request an exception to the rules, for each and every TC27 Standard using the identical justification, it is a win but introduces additional effort to follow ISO bureaucracy.

Additional discussions were held with ISO CS regarding the ISO London Protocol and the attempt to "greenwash" Standards and it was noted that TC27 was a test case and our objections have been noted and many will be incorporated into the ISO Guide 84. Further acknowledged by ISO, that all recommendations are just that, recommendations only.

Further discussions were held with India regarding the next TC27 meeting which was scheduled to be convened in September in India. A deadline was set for a response regarding firm details for the meeting logistics and outlining the extensive delays and unfulfilled promises dating back over two years. The deadline passed without a suitable response and India were advised that the backup plan would now be implemented and the meeting transferred to the USA. India strongly objected to this decision firstly requesting a reconsideration, which was refused and then attempted to have the decision overturned by approaching ISO senior management, which to date has also been refused. The meeting will now be held in New Orleans in November, 2025.

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

Standards Australia
Ben Russell

Value:	$508,625
Report Expected:	December 2026
Industry Monitor/s:	Graeme Harris
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: 8th August 2024 (Online meeting)
Next meeting: 24th July 2025 (Venue: SA Office, Sydney)

MN-001-01 (Coal analysis) —Mirror Committee for ISO/TC27/SC3 and SC5
Chairman: Barry Isherwood
Last meeting: 28th November 2024 (ACPS Office, Newcastle)
Next meeting: 20th March 2025 (ACPS Office, Newcastle)
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: Darren Mathewson
Last meeting: 12 November 2024 (BV Lab, Newcastle)
Next meeting: 11th March 2025 (ACARP/BV Lab/NIER Newcastle).
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.

C33065
Digital Petrographic Atlas of Australian Coals - Maintaining the Knowledge

University of Queensland
Joan Esterle

Value:	$197,537
Report Expected:	March 2025
Industry Monitor/s:	Graeme Harris 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 minescale 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.

No activity in the quarter.

MINE SITE GREENHOUSE GAS MITIGATION

CURRENT PROJECTS

C28078
Technical Development Unit (TDU) for Catalytic Conversion of VAM

University of Newcastle
Michael Stockenhuber

Value:	$1,040,592
Report Expected:	March 2025
Industry Monitor/s:	Jim Sandford Russell Thomas
ACARP Contact:	Patrick Tyrrell

Growing pressure to reduce greenhouse emissions has resulted in the need to develop technology to process fugitive methane emissions associated with mining. Ventilation air contains very low concentrations of methane at very high flow rates making it very difficult to process. Current thermal technologies require elevated temperatures, well above the ignition temperature of methane. Catalytic technologies have emerged as a potential alternative which in addition to requiring a smaller footprint and significantly decreased energy requirement, are proposed to be inherently safe; operating at much lower temperatures and oxidising the methane via surface reactions as opposed to typical combustion pathway. The current study aims to examine the intrinsic safety of the catalytic system by examining how the system behaves under abnormal conditions.

Suitable oxidation catalysts were coated on structured supports and stability and activity examined over a wide range of methane concentrations from 0.1 – 10% in humidified air. High levels of activity were observed across the entire range tested and importantly, no carbon monoxide was observed in the product stream even under high levels of methane. Under typical operating temperatures, no indication of ignition was observed even with methane concentrations above the LEL. Further, it was found that even in the presence of an uncoated (non-catalytic) structured support, a higher temperature was required to combust the methane than a purely thermal system.

C33068
Airbag Inspired Explosion Suppression System for Mitigation of VAM Explosions

University of Newcastle
Behdad Moghtaderi

Value:	$583,073
Report Expected:	April 2025
Industry Monitor/s:	David Webb Jim Sandford Russell Thomas
ACARP Contact:	Patrick Tyrrell

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 a large-scale demonstration system design for assessment and concept validation.

All tasks associated with this project have been successfully completed in alignment with the project structure plan and objectives. The outcomes are presented as follows:

- The theoretical study and simulation assessing the feasibility of using RAINBOES to mitigate methane fires and explosions are fully complete. Simulations were conducted across various scenarios, including different duct diameters and airbag quantities.
- The engineering design for a 4-meter diameter duct is fully complete.
- All port dimensions and configurations required to accommodate the measuring accessories have been fully defined.
- The detailed engineering design for the duct mounting skid is fully complete. The skid facilitates the transportation of the duct and its accessories to various sites.
- The appropriate hardware for operation, including detection systems (e.g., sensors) and prevention and mitigation systems (e.g., burst panels, fast-acting pneumatic valves), has been identified, and the evaluation is fully complete.

C35049
Optimisation of Operational Parameters of Catalytic Reactor for the Oxidation of Ventilation Air Methane

University of Newcastle
Michael Stockenhuber

Value:	$238,464
Report Expected:	April 2025
Industry Monitor/s:	Jim Sandford Russell Thomas
ACARP Contact:	Patrick Tyrrell

Fugitive methane emissions are becoming of significant concern owing to the considerable global warming potential when compared to carbon dioxide. In mining, the major source of fugitive emissions is associated with ventilation air methane (VAM), where very low concentrations of methane (<1%) are emitted from ventilation shafts at high flowrates (600m^3/s). The low concentration and high flows make this a difficult stream to process, however catalytic units show promise in being able to oxidise the majority of methane in the stream. Catalytic units offer several advantages over competing thermal technologies: operating at much lower temperatures, requiring minimal energy input and a much smaller physical footprint. However, the most significant hurdle to industrial implementation is demonstrated extended stability. This is being examined in a technical development unit (TDU), which operates a mitigation reactor at an increased scale from lab scale micro-reactors.

Structured supports have been examined to allow for high levels of gas-catalyst interaction without any significant pressure drop. Variations in support geometry has been examined by significantly increasing the aspect ratio (length:width), which would normally result in unfavourable pressure drop being developed, however this was not the case under the current orientation. Catalyst have shown extended stability, with high levels of methane conversion (>90%) being maintained in excess of 500 hours. The response of the reactor under varying methane concentrations and conditions is currently being examined to better understand operation paradigms.

C36007
Assessment of Sensors and Airflow Modelling for their Suitability to Quantify Methane Emissions in Open Cut mines

University of New South Wales
Simit Raval

Value:	$534,880
Report Expected:	March 2026
Industry Monitor/s:	Ben Klaassen Iain Hornshaw Jim Sandford John Grieves Ned Stephenson Sandy Tickell
ACARP Contact:	Patrick Tyrrell

The project aims to establish evidence-based guidelines for the coal industry, covering the selection of sensors, strategies for data capture, and the influence of airflow modelling, leading to the utilisation of machine-learning-based mathematical models to estimate total methane emissions. The project consists of five work packages (WP).

Following a comprehensive review of available sensors and methodologies for methane observation (WP1), a gas sensing LiDAR that combines lidar and gas absorption spectroscopy was selected for experimental purposes. We are now working on WP2, i.e. controlled release setup to test the sensor's capabilities (see Figure).

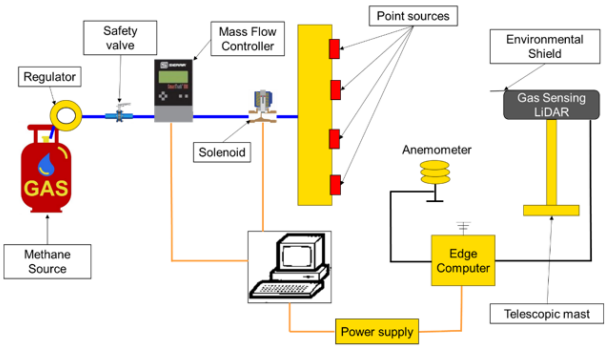


Figure: Schematic design of control release facility.

All the necessary components to release, detect, and quantify methane emissions in a controlled environment have been procured. In the next quarter, we will conduct controlled release of methane at various gas emission rates in different environmental conditions.

Meteorology plays a key role in estimation for a dispersed and continuous emission. We are in discussions with established technology providers to address this issue and define the associated uncertainties, which remain a challenge in the case of surface coal mine emissions.

C36008
Low Cost Precious Metal Free Honeycomb Monolithic VAM Catalysts and their Catalytic Activity and Stability Under Water and Dust Bearing Conditions

CSIRO
Yonggang Jin

Value:	$352,820
Report Expected:	October 2026
Industry Monitor/s:	Jim Sandford Paul Wild Russell Thomas Victoria Longley
ACARP Contact:	Patrick Tyrrell

The objective of this project is to develop low-cost honeycomb monolithic catalysts (HMCs) based on the high-performance precious-metal-free catalyst material newly developed by CSIRO in project C29069 and evaluate HMCs' catalytic activity and stability with a simulated VAM stream containing water vapour and simulated ventilation air dust. Success of the proposed project is a stepping-stone to progressing the development of low-cost high-performance VAM catalysts for the structured catalytic VAM mitigator.

Optimisation of the washcoating process for HMCs synthesis was focused on investigating the effects of the type of secondary support and the composition of washcoating slurry on both catalyst activity and mechanical properties. A series of HMCs were prepared with different methods and evaluated by catalytic tests with dry and vapour-saturated VAM. Experimental results show that the prepared HMCs exhibit good washcoating strength onto the surface of ceramic substrates and have achieved 90% methane conversion using simulated VAM at approximately 500°C under both dry and wet conditions. Further optimisation of the HMC is underway to enhance the porosity of the washcoating layer for enhanced mass transfer and catalytic activity. A subcontract is under development to engage with an external partner on trialling fabrication of large-scale HMCs by washcoating of CSIRO's low-cost catalysts onto a full-size honeycomb monolithic ceramic substate.

C37002
Methane Matters: Updates on Relevant Advances for Coal Mine Emissions

University of New South Wales
Simit Raval

Value:	$161,890
Report Expected:	June 2026
Industry Monitor/s:	Mine Site GHG Mitigation Committee
ACARP Contact:	Patrick Tyrrell

The aim of this project is to monitor advancements in methane emission estimations across three broad categories:

- Sensors for detection, including ground-based, airborne, and satellite-based systems;
- Models for emission estimations, focusing on efforts to reduce associated uncertainties;
- Policy frameworks that influence monitoring protocols.

In the quarter, a system has been developed to methodologically search various relevant sources. A report submitted in November 2024 highlighting interactions with various technology providers, policy makers and research groups working in the methane detection and quantification during two conferences in the US. The report was well received by ACARP.