CURRENT PROJECTS

This report is a summary of current projects for the months August, September and October 2017
ACARP CONTACTS

PROGRAM MANAGEMENT
Australian Coal Research Limited
Level 5, Suite 18
Christie Centre
320 Adelaide Street
Brisbane Qld 4000
Phone: 07 3221 0040

Mark Bennetts
Executive Director
markb@acarp.com.au

Terry Reilly
Levy Administrator
terryr@acarp.com.au

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

Roger Wischusen
Manager
roger@acarp.com.au

Anne Mabardi
Administration Manager
anne@acarp.com.au

Nicole Youngman
Administration Assistant
nicole@acarp.com.au

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

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

Bevan Kathage
Underground—Qld
kathage_minning@bigpond.com

Dave Osborne
Technical Market Support
dave.g.osborne@bigpond.com

Nerrida Scott
Coal Preparation
nscott@neluca.com

Keith Smith
Open Cut Environmental
keith.d.smith@bigpond.com

www.acarp.com.au

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UNDERGROUND

Coal Burst

C25004
Review of Australian and International Coal Burst Experience and Control Technologies: Scoping Study and Stage 1

University of New South Wales
Ismet Canbulat

Value: $404,000
Report Expected: 25/12/2017
Industry Monitor/s: Coal Burst Task Group
ACARP Contact: Roger Wischusen

The main objective of this project is to develop preliminary coal burst control guidelines for Australian coal mines. This objective will be met by:

- Conducting an international review of coal burst practices;
- Reviewing Australian coal burst experience;
- Reviewing the international and local established and/or experienced failure mechanisms;
- Identification of recommended coal burst control technologies; and
- Evaluation of control technologies against the Australian experience, regulations, mine design and operational practices.

The project work has been completed and writing of the final report is in progress.

C26006
Coal Burst Monitoring Technology Using Microseismicity

CSIRO
Xun Luo

Value: $230,500
Report Expected: 25/09/2018
Industry Monitor/s: Coal Burst Task Group
ACARP Contact: Peter Bergin

The aim of this project is to investigate possible correlations between microseismicity and coal burst events for monitoring and prediction. This first stage of the research involves three work programs: Installation of CSIRO microseismic monitoring systems at three mines; documentation of the microseismic data sets and mining process data and make it available for scientific use for coal burst research; and to perform preliminary data processing and evaluation.

The microseismic monitoring of LW708 development at Appin Mine has been restarted after stop-working for several months due to the shut-down of production. Microseismic events have been recorded since the start of monitoring in early October. A progress report on the microseismic monitoring program at Appin Mine is being prepared and will be sent to the mine after its completion.

An array of geophones has been installed on ground surface at Narrabri Mine above the longwall panel being mined. The underground geophone installation is planned in the last week of October. The underground array is designed to capture microseismic signatures for investigating the structure response in relation to pressure bumps.

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

CSIRO
Baotang Shen
Ismet Canbulat

Value: $275,520
Report Expected: 25/11/2018
Industry Monitor/s: Coal Burst Task Group
ACARP Contact: Peter Bergin

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

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

The monitoring installation is currently ongoing. It is expected that the monitoring system will be fully operational in early November when the longwall face is about 300m away from the monitoring site. The monitoring will last until early 2018 as the current longwall panel is being extracted.

Numerical modelling to predict stress conditions near the major geological structures is ongoing. The first modelling case was done with a 2D model focusing on the trust fault at Appin Mine. High stress concentration was predicted to exist in different zones near the faults. This study is currently being extended to 3D using a 3DEC model where the 3D geometries of the roadways and the trust fault are properly considered. The numerical modelling study for Narrabri Mine has also started, aiming to understand and predict the effects of the dyke on...
stress distribution. The numerical study results will be compared with the monitoring results at a later date to evaluate the risk of coal burst.

An additional numerical modelling study is being conducted by UNSW to understand the behaviour of jointed rock mass. To date, varying geological conditions have been modelled using UDEC. In these models, intact rock mass is represented by UDEC Voronoi blocks together with different horizontal, sub-vertical joints and bedding planes. Once appropriate rock mass behaviour is successfully achieved, the modelling will be extended into modelling of major geological discontinuities using 3DEC. The models will be calibrated using the geotechnical and the seismic data obtained from Narrabri Mine.

C26060
Mechanics of Gas Related Coal Bursts in Mining
SCT Operations
Winton Gale

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

The aim of this project is to identify the role of gas pressure in coal bursts. The project seeks to identify the mechanics of the process and provide a better understanding of risks, prediction and prevention of such coal burst events.

Work undertaken has been:
- Laboratory studies of gas diffusion rate of coal samples under burst conditions;
- Review of literature regarding gas induced bursts and outbursts;
- Computer modelling of the gas induced burst process;
- Discussion with key industry personnel regarding the burst fundamentals and organisation of a collaborative approach to the problem.

Results to date indicate that the energy available from gas within the coal fabric is available to induce a coal burst under a range of conditions.

Project progress will be discussed with Industry Monitors during a meeting in November.

C26061
Measurement of Fundamental Mechanical Parameters of Coal - Poisson’s Ratio and Biot’s Coefficient
Sigra
Ian Gray

Value: $150,000
Report Expected: 25/05/2018
Industry Monitor/s: Coal Burst Task Group
ACARP Contact: Bevan Kathage

This objective of this project was to set up equipment to determine Poisson’s ratio and Biot’s coefficient in coal. Biot’s coefficient describes the effect of fluid pressure on the effective stress and deformation of the material. Because the equipment and theoretical development was substantially developed by the time the ACARP funding was awarded the work focused on measurements of these parameters and in addition Young’s moduli for a number of coal samples.

In total 12 samples have now been tested. These have shown that in general the Young’s moduli are stress dependent and at realistic stress levels are a lot higher than is typically thought. Values of Young’s modulus measured vary from three to ten GPa, depending on the coal type and the stress levels. The values of Poisson’s ratio vary from zero to 0.4 while Biot’s coefficient vary from 0 to 0.35. There is some degree of anisotropy in all parameters, though not hugely so.

Current work is on making polished sections of the samples so that the different behaviours may be understood in terms of coal type.

C26062
New Outburst Risk Determination Measures Along With Data Gathering and Analysis for Coal Burst Assessment
Sigra
Jeff Wood

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

The primary objective of this project is to implement in parallel with current outburst management processes the findings of Project C23014, Outburst Risk Determination and Associated Factors. The second objective is to determine what common factors also affect coal bursts.

The two participating mines in the project are Appin Colliery and Narrabri Mine.

A great deal of information has been made available by Appin Colliery on its outburst and coal burst events. This has been supplemented by a large amount of geological, geophysical and gas content information. Much of this has been studied in detail.

Narrabri Mine has also supplied some information though not quite to the extent of that made available by Appin. Some more information is required from this mine.

The project is nearing the stage where some level of parallel outburst management implementation should be discussed. In the case of both mines this is becoming difficult. In the case of Appin there has been a major hiatus in production which is now just getting underway again albeit with some personnel changes. In the case of Narrabri, communication has effectively ceased.

For these mines and the mining industry to benefit from research it is essential that they participate fully. It is not possible for the research organisation to undertake projects such as this one without the close participation with the mines involved. Without it the projects will founder and fail to meet their final objectives.
C26066
Energy, Burst Mechanics Required for Coal Bursts and Energy Release Mechanisms
University of New South Wales
Ismet Canbulat
Winton Gale

Value: $357,500
Report Expected: 25/05/2019
Industry Monitor/s: Coal Burst Task Group
ACARP Contact: Peter Bergin

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

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

The results at this stage are consistent with expectation and the risks of bursts from these various sources have been collated.

SCT is also working with University of Wollongong (Jan Nemcik) with regard to simulation of dynamic effects of rock failure in the rock mass. Meetings and discussion of the approach have been undertaken.

Four energy sources within rock mass have been identified by UNSW researchers. These are strain energy, gas expansion energy, seismic energy and the transfer of strain energy from the surrounding rock/coal to the ejected material. To date, the preliminary analytical models to calculate the strain and gas expansion energies in the rock masses have been revised and improved. A new model to calculate the strain energy transferred from the surrounding rock/coal to the ejected material has been developed. This model is currently under review. A workshop with the industry monitors and representatives will be held early next year to review these models.

A total of 133 development coal burst cases from China have been compiled into a database. The data is currently being analysed for trends in geological structures, mining factors, measured seismic energy, distance between the event and damage range, floor heave, roof convergence and falls, coal pillar size and cover depth.

Environment - Subsidence and Mine Water

C20038
Standardised Subsidence Information Management System
NSW Department of Industry
Gang Li

Value: $655,000
Report Expected: 25/12/2017
Industry Monitor/s: Dan Payne, Phil Enright
ACARP Contact: Peter Bergin

The objective of this extension stage to the project is to develop online facilities enabling the industry stakeholders in New South Wales and Queensland to gain access to the subsidence information resource that has been established as a result of the earlier stage of the project. The team has achieved the following during this quarter.

Stage II of the project has been largely completed. We have completed the research, design and testing of the query facilities for the industry wide data, with some relatively minor tasks yet to be completed.

The query facilities (for the industry wide data) have been established. We believe the established query facilities meet the requirements under the project strategy, which has been established with the committee. We also believe the product is innovative and our work has created new knowledge in relation to subsidence engineering.

We plan to commence software development/implementation (for online use of the established query facilities) in a month’s time, once the above mentioned minor tasks are completed.

Work related to stage III has produced results that will be very useful for the users. This has helped us to develop a clear work program so that stage III can be completed as planned.

Previously reported difficulties related to missing mining data, will no longer have an adverse impact on the functions of Standardised Subsidence Information Management System. This is a very significant achievement of the project team, after six years of hard and tedious work since the commencement of the project.

C24013
Managing and Conserving Native Plant Species in the Mining Environment
Royal Botanic Gardens and Domains Trust, Sydney
Cathy Offord

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

A draft report is with the industry monitor(s) for review.
C25056
Change Detection in Complex Vegetation Communities

Biosis
Andrew Fletcher
Richard Mather
Sam Luccitte

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

Field data collection for the winter season was completed in late August using contract UAV service providers. A total of 160Gb of imagery was collected for the three target communities using three different remote sensing systems. Imagery was collected a week after field ecology measurements were made in all communities to provide ground reference data for training and validation of imagery products. All UAV imagery products included visible ground control with sub-50mm accuracy dispersed across the community. Imagery processing is continuing to generate the products required for determining the impact of camera station geometry and density on feature recognition and location. Due to limited hours of sunlight during winter it was only possible to capture each community at two times of day however variability in illumination is well captured in the products and will meet project requirements. Current activities include:

- Aligning field data with imagery products and generating training and validation data sets for reportable feature mapping activities;
- Ongoing processing of imagery products with different sensors and independent camera stations;
- Development of the final report.

Initial results indicate that camera station densities and timing have significant impacts on stability of processed imagery for community boundary features. Quantitative methods to describe and assess these effects are being investigated.

Exploration

C24025
Use of Core Scanning and Hand Held Xray Fluorescence Analysis in Coal Quality Assessment

University of New South Wales
Colin Ward

Value: $157,400
Report Expected: 25/03/2018
Industry Monitor/s : Malcolm Ives
Patrick Tyrrell
ACARP Contact: Peter Bergin

This project is aimed at developing and validating new technologies for detailed non-destructive chemical analysis of cored and in-situ coal seams, using a combination of laboratory based, core scanning and hand held, field portable, X-ray fluorescence (XRF) techniques. Successful completion will allow mapping of variations in ash percentage, ash composition and sulphur in coal seams at a much higher spatial resolution than available from conventional sampling programs, and provide an improved basis for rapid but relatively comprehensive coal quality assessment in mine geology and resource evaluation programs.

Coals with a wide range of compositional parameters have been prepared and independently analysed to develop an extended series of calibration curves and equations for both types of core-scanning instrument. Scans have been carried out with the laboratory based system using different sampling increments and measuring times, to identify appropriate balances between spatial resolution, measurement precision at low concentrations, and the time and cost of core scanner analysis. Scanning has also been carried out on these and other cores using a hand-held XRF analyser, to establish optimum scanning times and procedures for different elements and applications.

Check analyses have been conducted on samples from several scanned cores by conventional methods, substantially validating the results obtained from both the hand held and laboratory systems. Issues identified from this process that may affect such comparisons include variations in moisture content and in some cases development of coatings on core surfaces. Analyses have also been carried out on large coal blocks with the hand held unit, to simulate its use on faces in mine exposures. These show the sensitivity of the system for analysing individual lithotype bands and layers in coal seams. A final report is being prepared.

C24065
In Seam Wireless Drill Strong Communication System: Phase 2

University of Queensland
Andrew Rojc
Eddie Prochon

Value: $330,000
Report Expected: 25/12/2017
Industry Monitor/s : Brad Elvy
Jim Sandford
ACARP Contact: Roger Wischusen

The technology facilitates real time bidirectional telemetry between the drill rig and the Bottom Hole Assembly (BHA), which will improve steering of the drill through the coal whilst also enabling tools for geological mapping of the seam.
Mechanical: All mechanical testing and inspection have been completed, with a fully assembled tool tested at the Mining3 facility. The full mechanical assembly has been disassembled, packaged and dispatched to the mine site (Tahmoor) awaiting the field deployment.

Electrical and Electronics: All electronic assemblies for the BHA unit have been potted and IS certified. The downhole tool has the latest firmware loaded with the IMU data referenced and checked and also VI data tested and verified. The DRU unit has been fully tested, with the power supply encapsulated and the latest firmware installed. Both the BHA assembly electronic modules and the DRU have also been shipped to Tahmoor awaiting the field deployment. The batteries for the BHA were shipped separately to comply with dangerous goods requirements.

Intrinsic Safety Certification: On 28th August SIMTARS issued IECEx Unit Verification Certificate of Conformity (CoC) for the Advanced Logging Tool (ALT). Mining3 received the following documentation from Simtars:
- IECEx Certificate of Conformity IECEx SIM 17.0001X-0;
- IECEx Test report AU/SIM/ExTR17.0001/00;
- Notification letter.

This information has also been forwarded to Tahmoor mine Electrical Engineering Manager, along with updated risk assessment documentation/schematics and detailed test plan.

Field Deployment: Mining3 originally locked in a deployment window of mid-to-late August with Tahmoor Underground Mine, during which the drilling department will undertake drilling of cross-measure holes (TGW1 up to 1500m). We have been in frequent contact with the mine (2 – 3 times per week) to follow the drilling schedule.

Due to unforeseen issues Tahmoor did not commence drilling the first 2 cross-measure holes until the end of September. Following on from this delayed start to drilling, the rate of drilling progress has been slow, until there was a drill rig failure with the rig requiring a replacement motor. The TGW1 holes have now been completed, however, due to the ripple effect of issues, these holes are now critical to both the process and production schedules. David Corbett, Tahmoor Tech Services Manager, has decided that “being behind schedule and the criticality of the TG long holes getting accurately to distance, they are not the holes to be experimenting with.” As an alternative, Kathryn Ryan, Tahmoor Gas Drainage Officer, has advised “We are revisiting the schedule in the next week or two and will let us know about the timing around the start of the 7ct Balgownie holes (hole lengths 500-600m).”

The likely start of drilling these Balgownie holes will be the beginning of December. All equipment for the field trial is now at site and we are able to get to site at reasonably short notice, once the holes suitable for testing have reached critical depth.

No further project work will be undertaken at this time until the actual field trial commences. It is expected that based on the current time schedules the final report will be completed around the end of January 2018.

C25067
Seismic Diffraction Imaging for Improved Structural Detection in Complex Geological Environments
CSIRO
Binzhong Zhou
Value: $178,000
Report Expected: 25/12/2017
Industry Monitor/s : Patrick Tyrrell Paul O'Grady
ACARP Contact: Bevan Kathage

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

C24007
Longwall Hydraulic System Over Pressurisation Hazards Prevention
Asset Performance Improvements
Henry Bartosiewicz
Value: $292,250
Report Expected: 25/11/2017
Industry Monitor/s : Jarrod Sampson Shayne Gillett
ACARP Contact: Bevan Kathage

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

C25054
Distributed Acoustic Conveyor Monitoring - Phase 2
University of Queensland
Fernando Vieira Karsten Hoehn Paul Wilson Saiied Aminossadati
Value: $430,886
Report Expected: 25/04/2018
Industry Monitor/s : Brad Lucke Clinton Vanderkruk Kevin Rowe
ACARP Contact: Peter Bergin

The objective of the project is to convert the basic principle of identifying malfunctioning idlers on underground conveyors in their early stages of failure, (developed during C24014), into a viable and commercialisation ready technology.

The immediate focus was to trial the DAS technology on a conveyor at an operating underground mine at Moranbah. The trial has now been completed and the DAS interrogator been retrieved from site to perform system upgrades. Discussions regarding a re-start of the trial, which would include enhanced involvement of the site maintenance team are currently ongoing.

Development of Automated Reporting Software to detect different failure modes based on their spectral signatures is complete. Validation and verification of the failure detection performance is ongoing and executed through site trials.
The Alternative DAS Interrogator Research task has been completed. In total seven DAS interrogator models from four different manufacturers have been trialled, resulting in the identification of three suitable interrogators from different manufacturers. Consequently, the company commercialising this conveyor monitoring technology will be able to select the interrogator based on the best business terms, as all three interrogators are compatible with the Mining3 processing algorithms (patent pending).

To improve the fibre installation process new clamping methods with G-clamps and spring clamps, replacing the previously used cable-tie method, have been developed and are currently under trial to assess the system performance in terms of:
- Speed of installation;
- Material cost;
- Signal transfer function; and
- Other operational considerations.

The research team has previously requested assistance from the Monitors to facilitate a site to host the second trial of the DAS project. Despite tremendous interest from mines and mining companies (coal and hard rock) in trialling the system, so far only one of these opportunities could be transferred into a trial agreement with an underground diamond mine. This trial is currently in the planning phase, and, in absence of a coal mine trial site, might act as the second trial for this project.

C25063
Photocatalytic Destruction of Diesel Particulate Matter
CSIRO
Yonggang Jin

Value: $178,400
Report Expected: 25/01/2018
Industry Monitor/s: Brad Lucke, Greg Briggs
ACARP Contact: Bevan Kathage

The main objective of the project is to evaluate the feasibility of photocatalytic destruction of diesel particulate matter (DPM) for better control of tailpipe DPM emissions at underground coal mines. This proof-of-concept study is based on the laboratory tests of photocatalytic oxidation of model DPM.

Optimisation of photocatalytic efficiency of DPM oxidation has been carried out over the last three months. Remarkably enhanced reaction rates of DPM oxidation have been obtained with co-catalyst loaded titanium dioxide (TiO2) photocatalysts. Two other types of TiO2 based photocatalysts with superior oxidative activity were prepared in the laboratory and tested for DPM oxidation. One was the heterostructure of brookite and rutile TiO2 with tunable ratios of two phases, the other was the nanosized anatase TiO2 with oxygen vacancies. Photocatalytic tests with these two types of photocatalysts under varied humidity conditions are underway to further enhance the reaction rate and determine key materials characteristics of TiO2 based photocatalysts and operational parameters for high-efficiency DPM oxidation. The obtained new insights into engineering photocatalyst materials and configuring efficient photocatalytic system for high-efficiency DPM oxidation are important to the future development of DPM photocatalytic destruction prototype unit. The concept design of DPM photocatalytic destruction reactor is also being conducted for practical applications to underground coal mine vehicles.

C25071
Towing Force Measurement of Various Mining Equipment: Part 2
BMT WBM
Daniel Carpenter

Value: $41,600
Report Expected: 25/12/2017
Industry Monitor/s: Graeme Relf
ACARP Contact: Peter Bergin

No report has been received.

C26056
Optimisation of Low and High Pressure Longwall Hydraulic Systems
Quantise Consulting Engineers
Russell Smith

Value: $80,000
Report Expected: 25/04/2018
Industry Monitor/s: Jarrod Sampson, Neville Bunn
ACARP Contact: Peter Bergin

The objectives of this project are to optimise a split between high and low pressure longwall hydraulic systems. Aims include quantifying potential benefits in terms of safety, productivity, roof security, and component life. Numerical modelling will be the primary analysis and assessment tool. Project deliverables include design of an in-service evaluation test program.

Numerical models of the fluid supply system, including pumps, accumulators, and hoses, are currently being debugged. Modelling of the fluid demands are scheduled for completion during December, with initial system model results anticipated during January 2018.

C26057
Electrically Safe Variable Speed Drive for Underground
University of Newcastle
Galina Mirzaeva, Peter Stepien

Value: $158,202
Report Expected: 25/04/2018
Industry Monitor/s: Barrie Alley, Brad Lucke
ACARP Contact: Peter Bergin

No report has been received.
Known Power Supplies

University of Queensland
Enver Bajram

Value: $114,767
Report Expected: 25/09/2018
Industry Monitor/s: Greg Briggs
Peter Henderson
ACARP Contact: Bevan Kathage

The EST proof of concept project started early September. Current activities include gathering IS power supplies for testing and visiting manufacturers and test house to promote the device. Currently also updating the hardware and software of the device to overcome a few issues with regards to ease of use and demonstrations. In the coming months the project team will be gathering further devices for testing and evaluation.

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

Orbital Australia
Nick Coplin

Value: $839,215
Report Expected: 25/02/2018
Industry Monitor/s: Andy Withers
Bharath Belle
Shayne Gillett
Steve Coffee
ACARP Contact: Bevan Kathage

The use of conventional wet type disposable filters is a significant cost for the underground coal sector and there are issues with the filters maintaining performance due to a range of operational reasons.

This second stage project seeks to industrialise the proof-of-concept system developed in the earlier project. The industrialisation activities include:

- Design and validation of the thermal and mechanical design suitable for installation as a retrofit upgrade;
- Develop and validate the requisite electronic monitoring and protection systems, including vehicle integration;
- Achieve certification from the NSW Department of Industry (DRE).

This quarter has seen further refinement to the design of the mechanical and thermal systems to incorporate feedback from the surface testing undertaken earlier at Centennial Coal’s Newstan mine. Milestones include:

- Updates to the design to incorporate site learnings and feedback from reviewers;
- Fabrication of the updated system with the expected improvements implemented;
- Support for preparation of the permits required to trial the system in an underground working mine; and
- Review of the thermal and emission data recorded at site, and updates to the electronic monitoring system algorithms based on these findings.

In-house dyno testing of the wall-flow DPF will continue over the next quarter, plans for which will now include tailpipe emissions with the wet scrubber installed, as pre-certification assessments are undertaken and reviewed.

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

Updated system incorporating changes and feedback from surface trials at site (setup shown on engine dyno at Orbital).

CAD Image showing the components expected in the kit to convert from a disposable wet filter system to a wall-flow DPF.
C20033
Development of a Safer Underground Explosive
University of New South Wales
Andres Castro
Duncan Chalmers

Value: $323,500
Report Expected: 25/12/2017
Industry Monitor/s: Brad Elvy
ACARP Contact: Roger Wischusen

Despite the best efforts of the project leader the testing cannon is no longer available to finish the test work, and the report will be written up as soon as is practical. Should the NSW DPI re-establish the test facility as was offered then ACARP will consider restarting this important work.

C21021
Full Panorama View (360) Video and Laser Flameproof Enclosure
CSIRO
Ron McPhee
Zak Jecny

Value: $251,760
Report Expected: 25/11/2017
Industry Monitor/s: Brad Lucke, Mark Perry, Peter Henderson
ACARP Contact: Bevan Kathage

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

C21022
New Manufacturing Technique for Radio Transparent (Dielectric) Flameproof Enclosures
CSIRO
Peter Reid
Ron McPhee

Value: $196,980
Report Expected: 25/11/2017
Industry Monitor/s: Brad Lucke, Mark Perry, Peter Henderson
ACARP Contact: Bevan Kathage

The aim of this project was to investigate new materials and manufacturing techniques which could be employed to produce a flameproof enclosure which is essentially transparent to radio frequency radiation. The enclosure would be used to take advantage of the benefits available from modern wireless and radio-frequency enabled equipment such as high frequency radio communications, and all of the many forms of radar sensing techniques.

A suitable enclosure has been designed and developed and a prototype was successfully tested at CSIRO laboratories for pressure, impact resistance and dielectric properties across a wide temperature range. The dielectric material used in these tests was high strength polyurethane. Documentation suitable for certification has been prepared and three test enclosures have been manufactured.

One critical specification required for Ex (d) certification is the ‘Thermal Index’ (or Relative Thermal Index) of the dielectric material. Unfortunately the project has not been able to identify a polyurethane manufacturer which can confidently quote this specification for their product. Consequently the project has contacted the United Laboratories Testing Centre, located in the United States, in order to investigate the possibility of independently obtaining this data. The direction of the project rests with the outcome of these enquiries.

C22015
CM Self Guidance: System Hardening and Underground Deployment
CSIRO
David Reid
Mark Dunn

Value: $1,092,765
Report Expected: 25/12/2017
Industry Monitor/s: Jim Sandford, Roadway Development Task Group
ACARP Contact: Roger Wischusen

The objectives of this project are to:
- Further develop the CM navigation and control technology which was developed and demonstrated during the ACARP C18023 project for installation on a production roadway development CM; and to
- Provide a convincing demonstration of the performance and practical advantages of this advanced navigation technology in this specific underground mining application to the stage where mining companies and mining equipment manufacturers will have the confidence to take up and integrate the navigation technology into their equipment.

A fit for purpose installation of the CM guidance technology has been developed and installed on a Sandvik machine operating at the Ulan mine.

The current navigation data is being analysed. Data has been acquired for 2 x 100m drives (including reversing and a cut through), with another pillar being recorded currently. Due to commissioning of an FCT system, the roadway development ceased for a time, but is back in operation with communications from end July 2017.

Underground testing and validation has continued through August-October 2017 and the final report is now being prepared for submission. Negotiations with mine sites and OEMs are continuing for further trial and commercialisation opportunities.

C24023
Gateroad Development Continuous Haulage System
Premron
Mick Whelan
Value: $1,960,000
Report Expected: 25/11/2017
Industry Monitor/s: Roadway Development Task Group
ACARP Contact: Roger Wischusen

No report has been received.

C25058
Self Drilling Bolt Automation Trial

OKA Rock Bolt Technologies
Mark Levey
Paul Charlton

Value: $1,396,000
Report Expected: 25/12/2017
Industry Monitor/s: Jim Sandford Roadway Development Task Group
ACARP Contact: Roger Wischusen

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

Progress to date:
- A review was carried out of the findings from the 500 bolt underground trial held 2016 using an airtrack bolting rig with the retro-fitted prototype to install vertical, inclined and horizontal bolts;
- Design of the production standard prototype chemical pumping and delivery system is complete;
- Procurement and manufacture of all components is complete;
- The host mine released and delivered the continuous miner for modifications to adapt the OKA technology late July;
- Assembly of the chemical injection modules will be complete on 11th August;
- The software control system components had been further delayed to end of October. At this time, the injection modules and control system will be installed on the miner materials pod; and
- Testing and commissioning in the workshop will follow. The underground trial will begin after the testing is complete.

C25064
Longwall Floor Coal Horizon Sensor

CSIRO
Jonathon Ralston

Value: $213,736
Report Expected: 25/01/2018

Industry Monitor/s: Paul Buddery Rae O'Brien
ACARP Contact: Roger Wischusen

This project aims to develop a coal thickness sensing capability to support the delivery of automated horizon control systems for longwall or roadway development. The main objectives are to:
- Evaluate and validate radar technology in an outbye or NERZ area with similar geology and structure expected to be found on an operating longwall face;
- Undertake engineering tasks to design and package the radar sensing system into a form that is suitable for underground evaluation; and
- Install the sensor on equipment for a short-term evaluation period and assess performance.

Progress has continued in the past quarter towards project conclusion. Major outcomes include:
- A new dielectric flameproof concept was designed and a proof-of-concept developed. This design has a greatly reduced form factor and weight profile from previous designs, and represents a significant engineering step towards radar being deployed as a practical solution post project;
- A short-term LW radar evaluation been agreed and scheduled by Glencore at Ulan West based on the use of a custom portable radar package design. The evaluation is planned for late November or December and scheduled to run for two to three weeks;
- A custom all-in-one portable radar package has been designed to meet unique space and operational requirements for the evaluation. The custom system has been built and tested in preparation for the underground evaluation;
- An underground evaluation was undertaken Ulan West mine in October to evaluate the portable radar package under realistic operational conditions prior to LW installation. A separate full multi-radar system was also utilised as a means of secondary validation. Basic ground truth measurements were also undertaken.

Current activity includes ongoing preparation and coordination with mine site to manage the short-term evaluation of the radar on the longwall. Development of the final report is also underway.

C25069
Optimising Electrical Protection System Strategies and Technologies

ResTech
Clint Bruin

Value: $174,350
Report Expected: 25/11/2017
This project develops a systems-level architectural framework that describes the roles, interaction and maturity of major roadway and related underground vehicle system components. The outcome is a reference document to help inform the priority, selection, sequencing and integration of future automation project developments. This project will develop an open automation reference to provide a clear hierarchical description of the system process, structure and elements involved in the automation of underground roadway development processes. The specific objectives are to:

- Analyse processes and interactions on typical roadway development environment;
- Undertake a gap analysis between existing technologies and requirements for automation; and to
- Develop an architecture as a reference for wider industry and research use for mining automation.

Outcomes:
- A matrix mapping vehicle class and desired automation level to a preferred automation architecture and system technology readiness;
- Precursor design for stage 2 implementation. Specific vehicle class likely to be a shuttle car but other vehicles are also considered.

The following work is ongoing.

Process and integration:
- Process maps;
- Equipment interaction;
- Environment;
- Human interaction factors.

Technology gaps:
- Terms of reference;
- Functionality;
- Sensing - infrastructure-less;
- Processing and control;
- Primary vehicle interfacing;
- Exception management.

Architecture and selection roadmap:
- Automation architecture;
- Navigation method;
- Automation package configuration;
- Implementation approach;
- Vehicle-automation selection matrix.

C26051
Machine Bolting and Geotechnical Monitoring System
CSIRO
Jonathon Ralston

Value: $275,490
Report Expected: 25/05/2018
Industry Monitor/s: Roadway Development Task Group
ACARP Contact: Roger Wischusen

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

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

The project will utilise a laser scanner system to measure the 3D roadway profile in the immediate vicinity of the development face. These profiles will be used to provide a measure of local roadway deformation and to determine the location and type of installed roof bolts.

Progress in the quarter has focussed on primary data acquisition in order to establish a performance baseline for ongoing measurements. Detailed in-house data collection activities were conducted using two different classes of laser scanners for comparison. The first class of laser sensor provided very high accuracy and resolution data to generate “idealised” measurement outcomes. The second laser scanner had similar measurement performance to that planned for use in the actual underground scenario. Both lasers were deployed in a static sensing configuration and used CSIRO’s simulated coal tunnel as the imaging target. This generated a rich data set with known bolt feature locations for ground truth validation and sensor comparison.

An underground laser data collection campaign was also successfully conducted at Glencore’s Oaky North underground mine using a manually hand-held (non-IS) laser sensing configuration. The outcome generated very useful profile measurements of both the rib and roadway. Current activity is focussing on robust feature detection algorithm development and validation, which will be progressively evaluated under stationary and non-stationary sensing configurations.

C26052
Low Cost Laser and Video 3D Imaging Equipment
CSIRO
Peter Reid

Value: $196,261
Report Expected: 25/08/2018
Industry Monitor/s: Brad Lucke
The objective of this project is to design, manufacture and certify a flameproof enclosure that is suitable for mounting 3D laser and video based sensors underground in an explosive atmosphere. At the completion of this project it is expected that a number of these enclosures will be fully manufactured and certified as Ex.D, ready for use underground with a range of sensor payloads.

All components of the enclosure have now been designed and documented. A mock up version of the enclosure was sent to industry for feedback. Based on feedback received changes were made to the design and the revised design has subsequently been prepared for manufacture. Suitable manufacturers have been identified for the two key components of this enclosure, the enclosure body, and the transparent injection moulded dome lens. The manufacturing process for these parts has begun and delivery of initial samples is expected by mid-November. The project is currently on track and expected to deliver the certified enclosures by Q2 2018 as per project proposal.

**Occupational Health and Safety**

**C24009**
**Establish 'At Risk' Distance from Hydraulics**

*University of New South Wales*
David Wainright  
Gary Nauer

- Value: $26,908  
- Report Expected: 25/12/2017  
- Industry Monitor/s: Paul Gill  
- ACARP Contact: Roger Wischusen

Clint Maynard has assumed Glencore commitment to the project. University has pump box and will do testing early in new year.

Test rig is being modified at Ulan (to increase response time of a valve). Plan is to get this to UNSW for tests by end of the month.

**C24010**
**Collision Awareness - Capability of Underground Mine Vehicle Proximity Detection Systems**

*Simtars*
Andre De Kock

- Value: $482,300  
- Report Expected: 25/12/2017

**Industry Monitor/s**: Brad Lucke  
Jim Sandford  
Peter Nelson

**ACARP Contact**: Roger Wischusen

The objective of this project is to provide an independent assessment on the effectiveness of existing proximity detection systems for use in underground coal mines against a range of relevant vehicle related interaction scenarios. The project comprises three phases, with a decision point to continue before phase 3. The first phase is the accumulation and evaluation of presently available information relating to proximity and collision detection systems for use in underground coal mines. During the second phase the test specifications for evaluating the different systems will be developed. The final phase will be the testing of the different available systems against the developed tests.

A draft report was submitted for editing and comment from the industry monitors at the end of September. Once feedback is received and included a meeting will be held to decide how to address feedback received from the proximity detection suppliers.

**C26047**
**Real Time Dust Monitor**

*University of New South Wales*
Charles Harb  
Duncan Chalmers

- Value: $184,300  
- Report Expected: 25/03/2019  
- Industry Monitor/s: Bharath Belle  
Jim Sandford  
Brad Lucke

**ACARP Contact**: Peter Bergin

Cassella have donated two mini cyclones for the project and they will be sent to the lab to be incorporated in the test units. These cyclones have been selected as they provide the most compliant cut of respirable dust of the cyclones on the market. Preliminary designs have been developed for the fixed, mounted dust instrument and the development and testing of this prototype will be conducted in the upcoming quarter. New lasers have been ordered to assist in the miniaturisation of the device.

**C26048**
**Improving Respirable Coal Dust Exposure Monitoring and Control**

*University of Queensland*
David Cliff  
Mark Shepherd  
Nikky La Branche

- Value: $250,000

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

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

Work to date has continued on:

- Collection and collation of literature relating to dust control technology;
- Collection and collation of literature relating to the science behind the setting of exposure standards for respirable dust;
- Collection and collation of literature relating to respirable dust monitoring techniques;
- The second phase of trials involving the deployment of various real time dust monitoring devices in mines; and
- Workshop on respirable dust will be run at Ventilation Conference in Brisbane.

In the next quarter:

- The literature review will continue;
- Initial comparative trials of the real time monitors will continue;
- Exposure data will be collected from DNRM and Coal Services to initiate analysis, following the overhaul of the Coal Services database.

### C26065 Dustless Longwall and Development Face

**University of Wollongong**

**Peter Wypych**

**Value:** $339,700

**Report Expected:** 25/10/2018

**Industry Monitor/s:** Peter Davidson

**ACARP Contact:** Peter Bergin

The objective of this project is to develop ‘dustless’ mining operations in key areas of the longwall and development face. Particular objectives include:

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

Good progress has occurred in relevant areas, as follows:

- Development of a simplified CAD model of a typical longwall for use in the CFD model;
- Initial set-up of the CFD model – some analyses of air flow patterns caused by different configurations along the longwall have been completed;
- Set-up of an experimental rig to simulate the air flows that will be experienced by the dust suppression systems (with new fans, platform, pump and elevated mist curtain);
- Set-up of a new device to collect large quantities of airborne dust during longwall and development face operations; and
- Underground induction course has been completed in Lithgow by Jon Roberts.

The following work is being planned for the next quarter:

- Underground site visits will be undertaken to take dust and air flow samples for analysis (and for comparisons with the CFD models);
- CFD modelling will continue with the introduction of dust and spray modelling;
- Testing of sprays will occur and results compared with the CFD models; and
- Development of concept solutions will commence – resulting in confirmation of component/equipment requirements.

### Roadway Development

**C25068 Automated Long Tendon Installation System**

**Conway Engineering**

**Des Conway**

**Value:** $184,500

**Report Expected:** 25/02/2018

**Industry Monitor/s:** Roadway Development Task Group

**ACARP Contact:** Roger Wischusen

Currently struggling to finish the manufacture of the system and not getting much progress.

### Strata Control and Windblasts

**C23008 Definition of Coal Mine Roof Failure Mechanisms**

**SCT Operations**

**Winton Gale**

**Value:** $430,000

**Report Expected:** 25/01/2018
The main objectives of this project are to:

- Review a range of mechanisms noted in the literature and in personal experience;
- Conduct field monitoring sites for detailed instrumentation of the roof during mining. A site has been completed at Appin West mine;
- This site will has involved monitoring of roof displacement, stress changes, bolt forces and bending strains;
- A review of past measurement data from SCT is underway to extend the data base for assessing the rock failure mechanisms measured in the field;
- Detailed assessment of failure mechanisms has been undertaken and computer modelling of the effect of various combinations of stress and rock properties is underway.

The project is now being written up and is expected to be completed end December.

C24012
Shear Testing of the Major Australian Cable Types under Different Pretension Loads

University of Wollongong
Najdat Aziz

Value: $389,600
Report Expected: 25/12/2017
Industry Monitor/s : Roger Byrnes
ACARP Contact: Peter Bergin

The main objectives of this project are to:

- Evaluate the shear behaviour of cable bolts based on the cable bolt construction structure, hollow tube core, solid core, plain surface and spiral rib and plain or compound cable, cable diameter and number of wires; and to
- Establish shear characteristics of the cable bolt with respect to the level of axial loading (pretension). All tests are to be carried out using Megabolt Single Shear apparatus.

The project is progressing as follows:

- Experimental testing of the cables is complete;
- Modelling simulation is complete and currently undergoing fine-tuning;
- The final report is progressing satisfactorily, with report submission on track for mid-December.

C24015
Convergence Based Roof Support Design

PDR Engineers
Terry Medhurst

Value: $245,800
Report Expected: 25/06/2018

This stage of work is an extension to the original project in which a roof beam based support design model was produced for development conditions but needs to be extended for secondary support. The work program includes the review and analysis of roadway instrumentation data in relation to longwall extraction influences. Initial studies have been undertaken regarding stress changes around longwall panels and some initial development of input parameters for the roof beam model for maingate and tailgate loading conditions using information from central Bowen Basin mines has been undertaken. The project is now awaiting further instrumentation data from Appin mine, which is expected in the coming months.

C25057
Review of Rib Failure Mechanisms and Performance of Rib Support

SCT Operations
Yvette Heritage

Value: $186,500
Report Expected: 25/12/2017
Industry Monitor/s : Jason Emery
ACARP Contact: Peter Bergin

This project aims to review the mechanics of rib deformation over the life of the mine and to investigate effective support design to control the different mechanisms of rib deformation in order to minimise the occurrences of rib failure. The work program consists of a combined approach of deformation monitoring at underground sites and modelling to understand the mechanics of rib deformation and support interaction.

The monitoring instrumentation installed to measure rib deformation on development and retreat consists of an array of instrumented bolts, shear strips and extensometers. The instrumentation is monitored throughout the change in stress distribution throughout the continuous miner advance or the retreat longwall. Results from the completed sites to date are summarised below.

Moranbah North monitoring sites are at a depth of approximately 340m. Assessment of monitoring data has highlighted the contribution of the Tonstein Band (claystone/siltstone) as a driver for the deformation within the ribs. Both development and retreat conditions identify the Tonstein Band as the key contributor. There is also evidence on development for time dependent deformation about the Tonstein Band.

Ulan West longwall monitoring site is at a depth of 160-190m. The key driver for rib spall on the walk side of the belt road was identified as a combination of shear fracture, forming from the longwall abutment load, and the discontinuities created by the cleat. Ulan West development site showed minimal deformation indicative of the shallow depths of the mine.

The next site for rib monitoring is South 32’s Appin West Mine at approximately 500-550m depth. Due to unforeseen delays at
Appin Mine there have been delays to the project, and this component is now likely to occur in Q4 2017.

**C25059**

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

**SCT Operations**

Stuart MacGregor

- **Value:** $339,787
- **Report Expected:** 25/04/2018
- **Industry Monitor/s:** Brian Vorster, Peter Corbett
- **ACARP Contact:** Peter Bergin

No report has been received.

**C25060**

**Borehole Shear Monitoring Device for Routine Application in Roadways**

**SCT Operations**

Stuart MacGregor

- **Value:** $149,863
- **Report Expected:** 25/12/2017
- **Industry Monitor/s:** Brian Vorster, Peter Corbett, Roger Byrnes
- **ACARP Contact:** Peter Bergin

No report has been received.

**C25062**

**Roadway Stability Monitoring System**

**CSIRO**

Chad Hargrave

- **Value:** $189,435
- **Report Expected:** 25/12/2017
- **Industry Monitor/s:** Jason Emery, Jim Sandford, Paul Buddery
- **ACARP Contact:** Bevan Kathage

The project objectives are to:
- Adapt a CSIRO prototype radar system for the purposes of roadway monitoring;
- Trial this radar unit for small-change detection in a CSIRO custom-built test tunnel facility; and
- Based on the results of these in-house trials, carry out underground trials at a suitable mine site.

The goal is to fulfil these objectives to the stage where this new rapid survey capability has been established as viable, and can be demonstrated to the mining industry for future take up and integration into their underground mine management processes.

In consultation with the Industry Monitors, and based on successful results from the Moranbah North trial in the previous quarter, it was resolved that no further field work was required to complete the objectives. The project team has therefore focused efforts on processing data from the field trial, with an emphasis on characterising the performance of the system in light of the different scenarios trialled.

Results from the processing to date are very promising. The system exhibits good stability from scan to scan, so establishing a baseline for change detection is clearly viable. The introduced changes in the roadway were also detectable in the data, and the measured quantum of change correlated with the known perturbation of the target region. Deliberate gross movement of the sensor frame was easily detectable, and the compensation algorithms for this scenario appear to be working. Additional testing with the ‘test tunnel’ facility is also planned to further test these capabilities.

The project is due for completion at the end of 2017. Work will now focus on finalisation of the results from data processing and preparation of the final project report.

**C26054**

**Modelling of Dynamic Fracture Mechanisms for Improved Strata Control**

**University of Wollongong**

Jan Nemcik

- **Value:** $197,500
- **Report Expected:** 25/12/2018
- **Industry Monitor/s:** Bharath Belle, Jim Sandford, Rae O'Brien
- **ACARP Contact:** Peter Bergin

Using dynamic fracture modelling techniques in FLAC 2D, provide capability to examine the contributing mechanisms of rock/coal bursts, enabling quantification of conditions and intrinsic material properties favouring their occurrence.

**Current progress:**
- A simple theory describing the coal burst concepts have been developed and confirmed using numerical model;
- The coal burst mechanism that mirrors the occurrence in the Austar mine has been identified and successfully modelled;
- This work has been submitted to the journal for publication;
- The reported numerical modelling work is simple in nature and can be replicated by other researchers.

**Milestones:**
- Preliminary logical analysis and dynamic simulation trials clearly indicate that the ejection of a large coal mass from the rib side is only possible if the stored compressive energy within the pillar is released and accumulated as the compression wave that travels towards the rib face. Stemming from the ‘Newtons Cradle’ idea, this is only possible via the conservation of momentum $p=mv$ where energy release in the compressed coal begins several metres into the pillar and propagate towards the relatively unconfined rib side.
- Using numerical dynamic analysis, preliminary numerical models successfully simulated fast ejection speeds of coal rib material and thus identified a probable common cause of coal burst in mine roadways. Modelled mine roadway mined within 3m thick seam at a depth of 550m successfully simulated coal burst laterally ejecting 3.92 tonnes of coal from the rib with velocities ranging up to 2.3 m/s.
- Several mechanisms to trigger the coal burst were discussed and a fault plane slip was modelled to
demonstrate its capability to initiate coal – rock interface failure to trigger the coal burst.

C26063
Reliable Estimation of Horizontal Stress Magnitudes from Borehole Breakout Data

University of New South Wales
Joung Oh

Value: $123,000
Report Expected: 25/09/2018
Industry Monitor/s: Rae O'Brien
ACARP Contact: Peter Bergin

The primary objective of this project is to develop a simple and reliable method to predict in situ horizontal stress magnitudes from existing borehole breakout data. Stress measurement techniques currently available in the mining industry are expensive and time consuming. The results of this project will produce an inexpensive and reliable method that can be included in stress measurement programs to identify high risk areas where the mining conditions will be adversely affected. To achieve this objective, the project involves four areas of investigations, namely, literature review, lab testing, numerical modelling, and back analysis.

As discussed in the last review meeting, a cost-effective custom made true tri-axial apparatus has been designed. It enables further laboratory work to be carried out at The University of New South Wales. This will save the cost of travelling and mitigate uncertainties associated with sample transportation and equipment availability at another institution. The apparatus is expected to be delivered towards the end of the year.

As planned, numerical study via PFC has also been undertaken. Numerical calibration against experimental results of uniaxial compression and Brazilian tests has completed. The development of a numerical true tri-axial test model has commenced and a discontinuum analysis will be carried out in the next phase according to the plan.

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

University of New South Wales
Serkan Saydam

Value: $298,940
Report Expected: 25/03/2019
Industry Monitor/s: Jason Emery, Paul Buddery, Peter Corbett
ACARP Contact: Peter Bergin

The main objective of this project is to conduct a comprehensive multidisciplinary investigation into floor failure mechanisms and controlling factors using experimental, numerical and analytical methods leading to a reliable prediction model. In addition, definitive guidelines will be provided at the end of the project to mitigate and/or eliminate floor failures. The guidelines will be supported with a combination of effective monitoring and instrumentation techniques, innovative mine design strategies and new ground support technologies. A floor classification model that describes the floor performance will also be developed.

Discussion with Industry Monitors on monitoring options for floor was conducted in October and it has been agreed that all of the following options will be tried depending on the installation locations:
- Option A: Telltale + Shear Strip;
- Option B: Sonic Probe + Shear Strip;
- Option C: Laser measurement.

Monitoring sites will be Springvale in New South Wales, and one in the Moranbah operations in Queensland yet to be confirmed. The specific installation locations will be discussed with each mine shortly. Initially four sets of shear strip and sonic probe for each mine will have been prepared by December. Borescope will be purchased as well.

While two underground mines, Blakefield South in March and Springvale in June, were visited so far, the research team will...
also visit Moranbah North and Grosvenor either at the end of November or the beginning of December.

Following up on the collection of floor heave cases across the world from literature, a review on floor heave modes, mechanisms and the major contributing factors for each mode and mechanism is underway.

**Monitoring Options**

**Ventilation, Gas Drainage and Monitoring**

**C23009**

**Improved Efficiency of Gas Capture From Boreholes Under Active Longwall Panels**

**SCT Operations**

Winton Gale

Value: $380,000

Report Expected: 25/11/2017

Industry Monitor/s: Brad Elvy, David Webb

ACARP Contact: Roger Wischusen

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

**C24019**

**Field Trials of Nitrogen Injection into UIS Directional Boreholes to Enhance Gas Drainage in Low Permeable Seams**

**University of Wollongong**

Ting Ren, Frank Hungerford

Value: $336,152

Report Expected: 25/12/2017

Industry Monitor/s: Bharath Belle, Brad Elvy

ACARP Contact: Peter Bergin

The main objective of this project is to conduct field trials of the nitrogen flushing technique using UIS directional boreholes to define and determine various parameters associated with this technology, and to field demonstrate the effectiveness of such technology for enhanced gas recovery in hard to drain and low permeability seams. The research team reported the project outcomes to Industry Monitors at the review meeting in August. The research team is completing the final project report.

**C25001**

**Ventilation and Gas Management - Underground Coal Mines: Stage 2**

**Bruce Robertson Sole Trader**

Andy Self

Bruce Robertson

Value: $270,000

Report Expected: 25/03/2018

Industry Monitor/s: Bharath Belle, Brad Elvy, Jim Sandford, John Grieves, Peter Brisbane

ACARP Contact: Roger Wischusen

The objective of this project is to implement a number of recommendations from the earlier project (C23001) mainly preparation of guidelines and scoping reports. The researchers are progressing with documentation of guidelines and reports. The project will be completed by March 2018.

**C25065**

**Specific Gas Emission Patterns from Different Coal Seams**

**CSIRO**

Rao Balusu

Value: $277,340

Report Expected: 25/03/2019

Industry Monitor/s: Bharath Belle, Jim Sandford, John Grieves

ACARP Contact: Bevan Kathage

The objective of this project is to characterise goaf gas emissions patterns from different coal seams and develop appropriate gas emission prediction models for Australian mining conditions. The project work will involve simulation of gas emissions from different coal seams during longwall extraction using numerical and empirical models, and field studies to obtain post-mining residual gas contents of different coal seams in Hunter Valley and Bowen Basin coalfields. The project aims to obtain greater insights into goaf gas release rates from different coal seams at various distances behind the retreating longwall face. The project studies also aim to establish relationship between coal seam position and residual gas content, and develop gas emission rate profiles along the longwall panels. The project results also help in planning parameters necessary to assess gas emissions after sealing, in addition to production related gas management.

Extensive numerical modelling simulations have been carried out to investigate the effect of desorption time constant (Tau) and face retreat rate on gas emission profiles from various coal seams at different locations. Based on the results of these numerical modelling simulations and detailed field data analyses, the draft SGE model developed previously has been refined further, i.e. ‘Tau-vs-distance from the working seam’ function has also been incorporated into the SGE model. Additional post-mining goaf hole data obtained from the
Grosvenor field site has also been used to further calibrate the SGE model. In addition to the site geology, gas characteristics, geotechnical/caving characteristics, panel design parameters, the revised SGE model also takes into consideration of gas desorption rates from different coal seams and face retreat rate for calculating SGE at different production rates and for calculating SGE based on data from specific boreholes along the longwall panel.

C25066
Gas Management and Risk Mitigation Strategies for Longwalls

CSIRO
Rao Balusu

Value: $289,000
Report Expected: 25/01/2019
Industry Monitor/s: Bharath Belle, Jim Sandford, John Grieves

ACARP Contact: Bevan Kathage

The objective of this project is to develop optimum goaf gas management and risk mitigation strategies for highly gassy longwall mines to support achieving benchmark production rates. The work will involve field studies, modelling investigations, data analyses and demonstration of optimum gas management technologies and strategies at highly gassy mines, such as at Oaky North and Grosvenor mines. The project aims to obtain a fundamental understanding of the effect of U, Z and Y ventilation systems and various other parameters on effectiveness and performance of different types of surface and underground gas drainage technologies and designs. The project studies also provide greater insights into goaf gas migration patterns under different scenarios of main fans failure, large barometric pressure variations and major goaf falls, and an assessment of the risk of irrespirable atmosphere prevailing on the face through transient modelling analyses.

Detailed CFD models of the Oaky North and Grosvenor longwall faces have been developed and validated with field data from the mine sites. These validated base models were used for simulation of different goaf gas drainage strategies under various gas emission scenarios. Extensive CFD modelling studies have been carried out to investigate the effect of large roof falls in the goaf area and the consequent effect of sudden goaf gas displacement on gas concentration levels in the face area and in the tailgate return roadway. Transient CFD modelling simulations have been carried out to investigate the effect of large barometric pressure variations on tailgate gas concentration levels. The results of these studies would assist in optimisation of goaf gas drainage strategies and in development of appropriate risk mitigation strategies. CFD models of Grosvenor and Oaky North have also been used to obtain a fundamental understanding of gas concentration distribution patterns around the shearer area under different face gas emission scenarios and under different cutting heights/air velocity conditions. The effect of different gas control options on gas concentration profiles near the shearer has also been investigated.

C25072
New Approaches to Mine Gas Analysis and Ratios

Simtars

Fiona Clarkson

Value: $103,689
Report Expected: 25/12/2017
Industry Monitor/s: Bharath Belle, John Grieves

ACARP Contact: Peter Bergin

The aim of the project is to identify additional gases for the detection and monitoring of spontaneous combustion. This will be achieved through three objectives. The first objective is to conduct a survey of gases found in mine goafs, gas drainage samples, working areas and areas that include diesel vehicle traffic. The survey will establish which components of the BTEX, aldehyde and alkane low temperature fingerprint occur alongside the currently monitored mine gases. The second objective is to investigate sealed areas which are known to have had issues with coal heating and establish if ethylene is present. The third objective is to compare the fingerprint of these areas with that of the normal mine fingerprint and identify any differences in the two fingerprints.

The literature survey and review of relevant reports is in progress.

A wider series of longwalls and mining areas have been sampled to obtain information from older workings. The gases present are being compared with those identified from Stage 1 as occurring in particular environments.

Analysis and data collation has now been completed for all Queensland and New South Wales mines sampled to date for the project. The data obtained is now being benchmarked against the Stage 1 data and earlier projects including C10015 Detection of Heating of Coal at Low Temperature: Stages 1 and 2. Preparation of a report based on the available data is also in progress.

Sampling at the final Queensland mine has been delayed at the request of the mine due operational reasons. Discussions are to be held with the project monitors to discuss further options for completion of this project.

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

CSIRO
Qingdong Qu

Value: $153,075
Report Expected: 25/12/2018
Industry Monitor/s: Bharath Belle, Jim Sandford, Rae O'Brien

ACARP Contact: Bevan Kathage

The project objective is to characterise and predict floor seam gas emissions in longwall mining and identify optimal gas drainage strategies.

During the quarter the research team has looked into various field experiment and operation data associated with floor coal seams. These included pore pressure changes, post mining gas content, gas migration dynamics with tracer tests, gas drainage
design and implementation for floor coal seams, and gas emissions dynamics during mining. Significant insights into the responses of floor strata, groundwater, and gas were obtained, which has led to a proposal of three-zone conceptual model for floor strata-gas behaviours.

Literature reviews were completed and the results have contributed to a preliminary method of delineating the extent of the broken zone in the floor. Prediction of all other floor zones under Australian mining conditions will be conducted with numerical modelling studies, which has just been started and will be completed in the following six months. The numerical model, based on the longwall seven of Blakefield South mine, will characterise deformation, permeability changes, and gas desorption and release patterns of the floor coal seams.

C26055
Control and Management of Outburst Risk
University of Wollongong
Dennis Black
Najdat Aziz

Value: $100,000
Report Expected: 25/09/2018
Industry Monitor(s): David Webb
Russell Thomas
Sharif Burra
ACARP Contact: Peter Bergin

The main objectives of this project include:
- Investigate the use of gas desorption rate as a sound basis for determining outburst threshold limits for all Australian coal seam conditions;
- Update Bulli seam ‘benchmark’ using gas data provided by Bulli seam mines, and investigate the validity of DRI900 to determine outburst threshold limit for all Australian coal seam conditions;
- Compile a database record of Australian outburst events and analyse pre-incident conditions to identify common, significant factors that can be linked to outburst events. Outburst event data will also be used to update Ripu Lama’s outburst event graph; and
- Research the significance of other factors, such as gas pressure, gas gradient, water saturation, coal strength and stress, that may be relevant to identifying outburst risk zones, and implementing effective monitoring and controls to reduce outburst risk.

During the quarter, collection of gas data and analysis of gas desorption characteristics has continued. Gas data has been sourced from 17 mines and the gas database presently comprises 12,829 General test results, 700 Detailed-Level 1 gas test results and 152 Detailed Level two gas test results (table below). Collection of Detailed gas test data continues for use detailed gas emission analysis, including Bulli seam benchmark and relevance of DRI to outburst threshold determination.

<table>
<thead>
<tr>
<th>Mine No</th>
<th>Note</th>
<th>Core Viscosity Gas Data</th>
<th>Observation Gas Data</th>
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<tbody>
<tr>
<td>M1</td>
<td>NW</td>
<td>3.30I 181 11</td>
<td>General L1 L2 L3</td>
</tr>
<tr>
<td>M2</td>
<td>NW</td>
<td>6.66I 97 0</td>
<td>General L1 L2 L3</td>
</tr>
<tr>
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<td>NW</td>
<td>2.83I 153 17</td>
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</tr>
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<td>NW</td>
<td>2.81I 141 11</td>
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</tr>
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<td>M8</td>
<td>QD</td>
<td>6.3 120 120</td>
<td>General L1 L2 L3</td>
</tr>
</tbody>
</table>

Collection of historical outburst event data has now identified 871 reported outburst events in 22 Australian underground coal mines. Work is continuing to source additional detail for outbursts at several mines where inconsistent numbers have been previously reported.

Work is also progressing on collection and assessment of mining experience in areas where gas content was above ‘normal’ (circa 1994) outburst threshold levels. Results indicate that controlled mining (remote CM and shotfiring) was carried out, without outburst, in many areas where gas content remained above current ‘normal mining’ threshold levels (Graph below).

Coal samples are still being requested from site for use in coal strength and toughness testing. To date, coal samples have been received from six mines and Q3 crush time / particle size analysis testing has shown (a) few coals achieve >80% passing
212μm, regardless of crush time, and (b) increasing crush time causes agglomeration of coal particles in the ring mill leading to a net increase in particle size.

**C26058 Optimisation of the Coal Seam Gas Predrainage Process**

**Palaris Australia**

**Mark Blanch**

- **Value:** $293,220
- **Report Expected:** 25/09/2018
- **Industry Monitor/s:** David Webb, Russell Thomas, Sharif Burra
- **ACARP Contact:** Peter Bergin

This project will:

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

Work in this quarter included:

- A review of the current status of gas drainage practices including:
  - Site meetings were conducted at Moranbah North, North Goonyella, Carborough Downs and Oaky North Mines.
  - Data acquisition and assessment – mine planning, geology, gas reservoir, seam gas hazards and management practices.

Findings to date:

- The availability of measured permeability data at operating mines varies from none, up to as many as a dozen sites at an individual mine;
- Most permeability data tends to be acquired during the feasibility stages of a new mine or prior to mining in a new domain;
- Operating mines rarely take permeability measurements as part of their mining process;
- Gas predrainage planning at operating mines:
  - there is a tendency to use gas reservoir simulators during the early stages of gas drainage planning based on available reservoir data but not once a mine becomes operational;
  - generally mines use the “Offset Method” after the early drainage experience other than possibly when moving into a new mining domain,
  - the ‘Offset Method’ typically involves -
    - copying the predrainage design from the current panel to the next panel to be mined,
    - adjusting the boreholes spacing as a function of changes in gas drainage lead time, gas composition, gas content or around structure.
- the basis of adjustment include - from “gut feel”, empirical analysis and local rules of thumb - historical average gas flow rates, historical average gas content reductions;
- The gas drainage design process is set out in group standards for some mines, not well defined for others and absent at others; and
- At some mines the gas drainage and ventilation teams work closely together, at others there is an apparent disconnect.

Work planned for quarter four includes:

- Completion of the review of the current status of gas drainage practices:
  - site visit to Appin Mine,
  - data acquisition and assessment covering all mines supporting the project in the area of – mine planning, geology, gas reservoir, seam gas hazards and management practices,
  - completion of the literature review of coal mine gas management, gas pre and post drainage practices;
- Development of a permeability benchmark; and
- Identifying specific sites for stage two of the study at Appin and Moranbah North Mines.
The main objective of this project is to design, develop and operate RISKGATE www.riskgate.org, built to coal industry requirements; and populated with knowledge obtained from mining industry experts through a series of workshops. Broad participation from the mining industry has been the key factor underlying RISKGATE success.

The final work component of the current project is to prototype a topic – vehicle interactions, into the control effectiveness model, so that potential future revision and expansion of RISKGATE can be evaluated. Various templates have been received from industry monitors and the project team has synthesised these into a single prototype model. A mapping has been undertaken to take the current collision topic across to a vehicle interaction topic with control effectiveness and control erosion features. A wire frame model has been prepared based upon advice received so far. Based upon this with input from other ACARP vehicle interaction research a full prototype topic has been prepared for evaluation by the project monitor and the project team are awaiting his feedback before proceeding to the full prototype RISKGATE topic page.

Discussions are ongoing with a number of organisations about the potential application of the RISKGATE model to other areas of mining, beyond health and safety and beyond mining. Progress in these areas has been difficult.

Trial preparation work continues this quarter. Key highlights are:

- The upgraded modular manufacturing system continues to be tested at the Pinjarra Hills facility. Dummy products are being produced to evaluate operational parameters such as flow rates and pump speeds. The product gassing system will be installed in this unit in the coming weeks. Operating procedures and risk assessments for this unit have also been completed.

- A high level meeting was held with Solvay (Peroxide manufacturer) which has been supporting the project and agreed to provide all necessary raw materials for future trials. Solvay agreed to provide engineering services and conduct a safety audit of the modular manufacturing system. Certain modifications may be required after the completion of this audit and further testing will be conducted prior to shipment to Bald Hill Quarries (BHQ) for stage 1 blasting trials.

- A number of meetings have been held with BHQ in preparation for trials, an MOU is currently being drafted to facilitate the process and define the terms of a potential agreement towards technology implementation and future commercialisation.

- The team continued to liaise with the NSW regulator and is awaiting for a decision on the required licences to manufacture and trial the HP technology at BHQ.

The main objective of this project is to quantify the NOx fume evolution from hydrogen peroxide based hybrid mixtures involving ammonium nitrate, calcium nitrate and sodium nitrate. This will be achieved by designing and commissioning a blast chamber to detonate and measure the production of NOx and other gases from a selected range of HP hybrid formulations.

Key highlights are summarised below:

- Commissioning of the blast chamber has been completed and a number of tests have been conducted. Minor modifications and reinforcement of the blasting chamber access door had to be performed in order to ensure that gases were fully contained during the detonation testing process. The exhaust and gas monitoring system was thoroughly tested and is operating as planned. Wireless accelerometers installed in the chamber were also tested and functionality verified.

- The design of experiments has been checked and approved by the research team. Delays were experienced during the start of the testing program due to adverse weather conditions which prevented blasting from taking place.
The blast chamber testing program will continue until mid-November with data analysis starting soon after sufficient repetitions are obtained from all different hybrid formulations.

From mid-November to mid-December the team will be supporting external trials of the HP technology in Finland as part of a different project that complements the development of the HP technology. Blast chamber testing will resume after these trials with the final report expected to be completed at the end of January.

Environment

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

Edith Cowan University
Mark Lund

Value: $362,714
Report Expected: 25/11/2017
Industry Monitor/s: Colm Harkin, Scott Diggles
ACARP Contact: Keith Smith

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

- Determine the downstream effects of pit-lake decant, with a particular focus on environmental and amenity values;
- Determine the effects of inflow on environmental values and water quality within the pit lake, (essentially a field-scale demonstration of a key finding from C21038 that larger catchments should enhance pit lake water and environmental quality) -
  - understand the impact of variably saline river water on mixing within a moderately saline pit lake; and
- Develop a national standard protocol for seasonal river monitoring that could be applied by the coal industry to manage river flow-throughs (either accidental or planned), as a part of mine closure strategy.

The final report is being prepared, there have been delays, however it will be submitted prior to the end of 2017.

C23032
Real Time Mine Specific Upper Air Data For Use In The Management of Mine Noise, Dust, Blast Fume and Overpressure

Todoroski Air Sciences
Aleks Todoroski

Value: $165,160
Report Expected: 25/11/2017
Industry Monitor/s: Andrew Speechly, John Watson
ACARP Contact: Keith Smith

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

C23053
Study of Sustainability and Profitability of Grazing on Mine Rehabilitated Land in the Upper Hunter

NSW Department of Industry
Lester McCormick, Neil Griffiths

Value: $200,000
Report Expected: 25/11/2017
Industry Monitor/s: Bill Baxter, Nigel Charnock
ACARP Contact: Keith Smith

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

C24029
Development of a Toolbox for Fish Health Assessment in Aquatic Ecosystems Associated With Coal Industries

Central Queensland University
Nicole Flint, Sue Vink

Value: $97,740
Report Expected: 25/11/2017
Industry Monitor/s: Claire Cote
ACARP Contact: Keith Smith

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

C24030
Verification of the Vertical Distribution of Dust from Mining Activities

Advanced Environmental Dynamics
Darlene Heuff

Value: $361,140
Report Expected: 25/12/2017
Industry Monitor/s: John Watson, Kris Sheehan
ACARP Contact: Keith Smith

No report has been received.

C24033
Applying Risk Based Principles of Dispersive Mine Spoil Behaviour to Facilitate Development of Cost Effective Best Management Practices

Tree Crop Technologies (t/a Verterra)
Glenn Dale, Steven Raine

Value: $476,104
Report Expected: 25/11/2017
Industry Monitor/s: Craig Lockhart, Jason Fittler, Ross Gooley, Stuart Ritchie
ACARP Contact: Keith Smith

A draft report is with the industry monitor(s) for review.
C25031
Closure Criteria for River Diversions: An Alternative to Reference Sites

Edith Cowan University
Melanie Blanchette

Value: $232,293
Report Expected: 25/04/2018
Industry Monitor/s: John Watson
Michael Moore
ACARP Contact: Keith Smith

The use of reference sites for establishing closure criteria in areas disturbed by mining activities is accepted by regulators across Australia. Sites are considered rehabilitated when their condition (as measured by physical, biological or chemical criteria) approximates that of a natural co-occurring reference site. However, this approach often creates impossible or unrealistic targets for miners seeking to close rehabilitated lands. The broad objective of this research is to evaluate a new, more achievable approach to the closure of mine sites by comparing rehabilitated sites to the natural variability of the local environment, rather than specific reference sites. The outcome of this new approach to closure criteria will allow miners to create realistic and definable targets for relinquishing rehabilitation land, potentially simplifying closure and project approvals.

The broad aim of this research is to move from the use of reference sites in environmental assessment to a more pragmatic and robust methodology. We test this by designing realistic closure criteria based around the use of microbial communities as indicators of environmental condition. Specifically, we aim to:

- Test the validity of the approach by assessing rehabilitation sites in river diversions at Ulan and Ashton mines in the Hunter Valley;
- Compare the effectiveness of microbial communities as environmental assessment tools in relation to current monitoring programs undertaken by the companies;
- Extend and complement existing river diversion assessment tools; and
- Advance development of microbial community analysis as an environmental assessment tool through testing of underlying assumptions of space, time and scale.

Project update:
- Field work - All field work is complete;
- Laboratory work – Water quality analyses are complete. Pelagic and benthic river samples have been processed and delivered to the Australian Genome Research Facility for DNA extraction, sequencing and identification;
- Bioinformatics and statistics – In consultation with internal and external statisticians we have optimised statistical analyses for working with DNA data (project objectives 2 and 4). We have also secured access to the most up-to-date information on microbial ecology through the ECU library;
- Quarantine laboratory – We have secured funding from the ECU School of Science for the quarantine laboratory for another year, which allows us to store and process interstate soil samples;
- We will attend the Hunter Coal Environment Group meeting in Singleton, where Melanie will be presenting preliminary results.

C25039
Long Term Salt Generation from Coal Spoils

University of Queensland
Mansour Edraki
Neil McIntyre

Value: $239,150
Report Expected: 25/06/2018
Industry Monitor/s: Claire Cote
John Merritt
Scott Diggles
ACARP Contact: Keith Smith

The overall aim of the project is to develop a process for estimating long term salinity generation rates from different classes of mine spoil and spoil pile configurations that can be used in conjunction with water balance models to predict long-term final void salinity levels or the residual risk to receiving surface water or groundwater environments.

In this quarter, work has continued on the laboratory scale and medium scale (>1 tonne) leaching experiments at UQ St Lucia and Pinjarra Hills. An example plot of short-term water extract results shows the dominance of NaCl type salts and less significance of salts released by acid mine drainage processes in the samples collected at three mine sites.

Degradation of rock-like (IBC4-B8) and soil-like (IBC3-B9) spoils.

C26018
Managing Environmental Risks Effectively Post Rehabilitation for all Stakeholders

University of Queensland
Jonathan Fulcher

Value: $63,000
Report Expected: 25/03/2018
Industry Monitor/s: Bernie Kirsch
John Merritt
Patrick Tyrrell
Stuart Ritchie
ACARP Contact: Keith Smith

No report has been received.
C26019
Prediction of Long Term Erosion at Pit Walls
Henderson Geotech
Sue Henderson

Value: $90,000
Report Expected: 25/03/2018
Industry Monitor(s): Gavin Lowing, Jason Fittler, Ross Gooley
ACARP Contact: Keith Smith

The aim of the project is to provide a basis for estimating the effect of highwall and endwall erosion on the final void stability and footprint. Two lines of research are being followed: in the first, information and topographic survey has been received from several mines and the aim is to correlate extent of erosion measured from survey with various factors that might affect that extent. The length of the longest gully deeper than 0.3m has been adopted as the main measure for erosion. The reasons are that 0.3m is about the limit that can be easily interpreted from Lidar survey and that it is also the accepted maximum depth that farm equipment – in subsequent land use – can deal with.

To date, gully length has been measured for 22 pit walls. In the simplest analysis for about 2/3 of the pits maximum gully length was less than 40m but for the remaining pits lengths ranged up to 120m. Because some of the other information provided is incomplete, there are only about a dozen data records available yet for correlation and regression analyses. Preliminary analyses have been undertaken and while multiple linear regressions show promise at predicting maximum gully length, the statistical significance of regression coefficients is presently poor. Investigating factors individually, it appears that wall age may have a bi-modal effect, with about half of the results independent of age and half quite strongly correlated. More gully measurements will be made in the coming quarter to increase the data set for analysis.

In the second line of research, the Siberia Landform Evolution Model will be run for two pit walls to extrapolate erosion effects into the long term. The pits for this have been selected and topographic data is currently being interpreted for input to the model. Surveys eight years apart for one pit and nineteen years apart for the other will be used to calibrate the models that will then be run to simulate 100 years exposure.

C26024
Coal Mine Particulate Emission Factor Validation
Pacific Environment Operations
Judith Cox

Value: $133,794
Report Expected: 25/11/2017
Industry Monitor(s): Andrew Speechly, John Watson
ACARP Contact: Keith Smith

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

C26027
Eco Toxicological Approach to Validate the DGT technique to measure Bioavailable Metal Concentrations and Deriving Water Quality Trigger Values for the ANZECC Guidelines
University of Queensland
Sue Vink, Trang Huynh

Value: $170,500
Report Expected: 25/06/2018
Industry Monitor(s): Andrew Lau, Claire Cole, Scott Diggles
ACARP Contact: Keith Smith

The project aims to:
- Validate the DGT measurements as alternative mean to measure bioavailability metal concentrations through the aquatic-toxicity tests and DGT measurements;
- Compute and compare dissolved and DGT concentration EC10’s, LC50’s and species sensitivity distributions; and to
- Assess the potential for the DGT technique to address the test for bioavailable metal concentrations as required in the ANZECC decision tree.

The second quarter has seen substantial progress of Cu and Ni speciation modelling for test water for all scenarios. The detailed experimental program is established based on the literature review and toxicity data which identifies important factors to the success of the DGT-toxicity experiments. The laboratory experiment started in early September on Chlorella sp. It is expected that the result from Chlorella study will be available in January 2018. The test program for Ceriodaphia cf. dubia will start in December 2017. A comprehensive presentation on the progress of the project and preliminary results was given by project leader following by the discussion with industry monitor. Most of the work done over the last 5 months has been reviewed.

Geology

C24032
Supermodel 2015 - Fault Characterisation in Permian to Jurassic Coal Measures
University of Queensland
Joan Esterle, Renate Sliwa

Value: $316,730
Report Expected: 25/12/2017
Industry Monitor(s): Matt Grant, Richard Ruddock
ACARP Contact: Cam Davidson

This project is an extension to the current Supermodel 2012, and will focus on detailed characterisation of fault structures in the context of basin evolution, overprinting events, and present day stress regimes. This builds upon regional stratigraphic framework developed for the Rangal and the Moranbah coal measures and their equivalents in the Bowen and Galilee basins within which variability in coal geometry and interburden character is examined. This project takes this further, and
guidelines for estimating rock mass strength from laboratory properties

University of New South Wales

Ismet Canbulat
Joan Esterle

Value: $396,685
Report Expected: 25/03/2018
Industry Monitor/s: Dan Payne, Gavin Lowing, Gift Makusha
ACARP Contact: Cam Davidson

The main objective of this project is to develop a guideline for downgrading the laboratory properties to the field condition through combining the conventional rock mass classification systems and Synthetic Rock Mass numerical modelling technique.

The laboratory experiments on two different types of weak intact rocks (UCS<5MPa) including natural (limestone) and artificial have been completed at UNSW confirming the ascending and then descending behaviour of UCS data for weak intact rocks. This is the first finding in this regard for weak rocks as the earlier studies reported similar behaviour but for medium and strong rocks. The experimental program will be conducted on jointed artificial rock samples having different sizes and various non-persistent joint patterns for verification of the numerical models. Limit equilibrium analysis and finite element modelling have been identified to be the suitable tools for the analysis of the rock mass strength of failed cases. Five failed cases have been identified as suitable for back analyses and the preliminary models are being developed.

C25027
XCT Prediction of Breakage and Washability from Bore Cores

University of Queensland
Anh Nguyen

Value: $200,000
Report Expected: 25/11/2017
Industry Monitor/s: Patrick Tyrrell, Richard Ruddock, Shaun Booth, Stella Martinez
ACARP Contact: Cam Davidson

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

C25028
Coal Quality by Analysis of Scanned Images

University of Queensland
Emmy Manlapig

Value: $205,600
Report Expected: 25/12/2017
Industry Monitor/s: Justin Manalo, Mark Laycock, Noel Pranoto, Patrick Tyrrell, Richard Ruddock
ACARP Contact: Cam Davidson

Currently writing up the final report which should be with the Industry Monitors by Christmas.

C25035
Coal Subsurface Mapping for Open Cut Selective Mining

CSIRO
Andrew Strange

Value: $182,772
Report Expected: 25/12/2017
Industry Monitor/s: Brett Domrow, Margaret Stewart
ACARP Contact: Cam Davidson

The objective of this project is to develop a reliable seam sensing system to provide selective mining capabilities for open-cut coal mining. The system developed will measure the
thickness of the top layer of coal for an area such as a block then generate a digital surface that represents the lower boundary of the coal to be removed to assist the operator to selectively mine the resource.

Over the quarter, a final test of the system was completed on a local soccer field of size 100m x 60m. This area was chosen so that the survey time could be measured prior to going to a mine site. Whilst a standard open cut block is wider than this dimension, the number of scanned paths used in this survey matched the number of paths that will be completed during the mine site tests. The survey was completed in 20 minutes and it is expected this will be similar to the survey at an open cut site.

The sensing system was also successfully demonstrated to the industry monitors as part of the final presentation for the project. The project team is currently waiting for site availability to complete the final field trials of the system. The preparation of the final report has also commenced.

C25040
Shear Strength Characterisation of In Pit Mud to Ensure Low Wall Stability
University of Queensland
Adrian Smith
David Williams

Value: $210,000
Report Expected: 25/03/2018
Industry Monitor/s: Gavin Lowing
Leigh Bergin
Shaun Booth

ACARP Contact: Roger Wischusen

The overall objective of this project is to identify spoil and floor materials that do not require removal prior to spoiling because they do not substantially degrade on wetting-up, and hence are unlikely to promote low wall spoil pile geotechnical instability. The specific objectives of the project are to:

- Geologically identify and sample selected fresh and degraded spoil and floor materials to assess their potential for water-softening;
- Carry out appropriate in situ shear strength assessment of water-softened in-pit spoil and floor materials that can safely be accessed;
- Characterise physically and chemically in the laboratory the representative spoil materials sampled, including testing for slake durability;
- Carry out laboratory shear strength testing on fresh, moistened and water-softened specimens of the spoil and floor materials sampled.
- Relate the laboratory shear strength of the spoil and floor materials tested to their physical and chemical characteristics.
- Confirm the shear strengths determined through the back-analyses of low wall failures due to the water-softening at the base of low wall spoil piles.
- Develop field testing protocols for the identification of degradable spoil and floor materials, and to develop design guidelines for enhancing the geotechnical stability of low walls for both durable and water-softened spoil.
- Disseminate the results of the project to the industry via quarterly progress reports, six monthly review meetings, industry seminars, a final report, and conference and journal papers.

Since commencement, two mud sampling and testing campaigns have been completed. Representative samples from BMA’s Goonyella-Riverside, Peak Downs and Cavil Ridge mines have been subjected to physical and chemical characterisation testing, as well as geotechnical parameter testing including consolidation and direct shear testing.

Bulk samples of Category 1, 2 and 3 spoil and mud samples have all been subjected to numerous laboratory tests to characterise them in both their as-received state, and after degradation. Investigations are being made into the influences of prolonged saturation, wetting and drying cycles, and an altered slake durability test, on particle size and shear strength. Shear strength parameters have been applied in slope stability calculations using the program Slide 7. The results show the influence of weathering varies between samples and can have a significant effect on the particle size, and hence visual classification, of spoil Category. The variable degradation is being investigated against physical and chemical characteristics to identify potential indicators of the potential for breakdown.

Efforts are being made to research viable options for the in situ testing of mud deposits, including laser-induced breakdown spectrometry (LIBS), infrared spectroscopy, and a drone system. The aim is to identify a range of cost-effective methods to reliably categorise different spoil types and the mud derived from them. Rapid identification of spoil materials prone to breakdown could be used on site to compliment visual categorisation.

A sensitivity analysis of the BMA Spoil Category framework has been undertaken using Slide 7. Results show that incorrectly categorising a spoil material could overestimate slope stability. In most cases however, the results show that the framework is conservative and hence more precise classification of spoil and mud materials could result in improved spoil pile designs and large cost savings. This relationship will be further investigated using SoilVision Software to conduct three dimensional slope stability analyses. Adding a third dimension could result in improved back-calculated values of apparent cohesion and friction angle for both the spoil and mud.

Lastly, consolidation data from both standard oedometer and large slurry consolidometer testing will be used to estimate in situ pore water pressures and consolidated shear strengths of muds under imposed loading, further improving knowledge of the impact of spoiling over mud with respect to time. These data will be used in computer modelling to identify the changes in slope stability that can be expected as a low wall construction is advanced, including loading rate effects.

The project is currently on schedule, with promising results being produced. The laboratory testing is expected to conclude in January 2018, with the results being analysed and the draft report submitted in March 2018.
Drilling. The method uses a conventional borehole radar (BHR) waves for real-time prediction of coal top during blast hole. This project will use conductively-guided borehole radar (BHR) characterise coal seam structures in the open cut environment. Economically-sound techniques are available to map and stand-off distances is a serious issue to the Australian coal industry costing the equivalent of about one open cut mine for every 10 operating mines in coal lost. To date, no effective and economically-sound techniques are available to map and characterise coal seam structures in the open cut environment. This project will use conductively-guided borehole radar (BHR) waves for real-time prediction of coal top during blast hole drilling. The method uses a conventional borehole radar (BHR) with a dipole antenna, which can image sideways around the borehole, electrically coupled to a conductive wire or steel drill-rod to induce a guided wave along the axial drill-rod. The drill-rod ahead of the BHR becomes part of the radiating antenna.

The guided wave travels to the end of the drill-bit when some energy is reflected back and the remainder radiates from the drill bit. The radiated energy will be reflected by geological discontinuities such as the top of coal, and recorded by the BHR. This project will investigate the practicality of real-time prediction of coal top using this guided BHR wave imaging technique.

In the past quarter, the project team has been concentrating on numerical modelling to investigate the feasibility of top coal prediction using guided BHR waves. The modelling results suggest:

- A conventional BHR can be electrically coupled onto a conductive wire or steel drill rod to induce a guided wave along the axial drill rod;
- The drill rod ahead of the BHR becomes part of the forward-looking antenna;
- Forward-looking events are relatively weaker compared with the direct arrivals but can be enhanced by suppressing the direct arrivals and be used for estimation of the coal seam tops ahead of a drill-rod;
- The prediction accuracy is 1 – 9 cm, significantly better than the 30cm required;
- The forward-looking capability of the BHR is about 4–6 m based on the modelled data; and
- Conductivity of the overburden is the most important factor affecting our ability to see coal seam top ahead of the drill bit.

The numerical modelling confirms that guided BHR waves could be used for coal top prediction during blast-hole drilling providing the overburden is relatively resistive (the average resistivity should be higher than 80 ohm). The next phase of the project is to select a few mine sites to conduct field tests to verify the numerical results.

This project has the following objectives:

- A standard format for collection and use of data for drilling depth reconciliations;
- A free, public domain computer program to validate that a CoalLog data transfer format csv file complies to the CoalLog standard;
- A set of standard formats and field names for the transfer of coal analytical data;
- A set of graph pattern 'tiles' to facilitate implementation of the standard CoalLog lithotype patterns by geological software suppliers;
- A standard for the downhole geophysics metadata stored in the header of LAS files and possibly some standardization of downhole geophysical variable names;
- A set of recommended colours for plotting lithotypes; and
- A standard set of codes for -
  - survey company, geological logging organisation and geophysical logging company for borehole header data,
  - drilling company, rig type and hole size name (HQ, PQ, etc) for borehole drilling data.

A second round of meetings were held in Brisbane with major coal analytical laboratories and mining software suppliers to obtain feedback regarding the prototype for the coal analytical data transfer format. Their feedback has now been incorporated and meetings have been organized in Brisbane and Singleton in early November to explain the prototype to coal industry geologists.

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

- Reviewing suggested improvements to the already established CoalLog standard;
- The transfer of coal analytical data;
- Downhole geophysics metadata and geophysical variable names;
- Recommended colours for plotting lithotypes; and
- Codes for survey company, geological logging organisation and geophysical logging company, drilling company, rig type and hole size name (HQ, PQ, etc) for borehole drilling data.

If you can help please contact Brett Larkin, brett@geocheck.com.au.
Bowen Basin Coals

University of Queensland
Joan Esterle

Value: $141,050
Report Expected: 25/02/2019
Industry Monitor/s: Richard Ruddock
ACARP Contact: Keith Smith

This project aims to improve the predictability of in situ fluorine and phosphorus distributions within Bowen Basin coals. The approach is to map element variability within seams across various mine sites and then to develop a methodology to detect the domains and the geological controls. Elements of the project that are being investigated include primary deposition; subsequent burial and deformation; intrusive processes; or the influence from groundwater. Samples within and between seams in high and low domains under different settings will then be analysed to determine possible origins by geochemical (isotopic) means. This requires isolation of the primary fluorine bearing minerals, commonly apatite and fluorapatite, which occurs entrained within the cell lumens of semi fusinite. Less commonly, the fluorine bearing minerals can also occur within fractures or other macerals.

During the quarter the project team finalised agreements with the original participating companies and continued data and sample collection where it was outstanding. The project team also commenced secondary mineralogical data collection from public data sets across the Bowen Basin. This data is to be used to calculate mineral proportions from whole rock major element analyses using a least-squares method. The project team also refined the analytical methodologies in an attempt to mitigate any limiting factors for micro-analysis. Limitations such as the spot size used for chemical analysis, the ionisation potential of fluorine, the limit of detection of the analytical equipment or the disintegration of apatite under high-energy electron beams and the chemical anisotropy, have been reviewed and optimised. Analytical techniques to be employed now include integrating: scanning-electron microscopy, electron microprobe analysis, cathodoluminescence, infrared spectroscopy and laser-induced breakdown spectroscopy. Microanalysis using all of these techniques has commenced. Samples have been selected for trial in situ isotopic analysis using sensitive high mass-resolution ion microprobe.

Successful completion of this project is dependent on the data and samples being supplied by the supporting mine sites promptly.

The primary focus for November 2017 to January 2018 will be:
- Continue the isotope analysis;
- Finalise the collection of outstanding data and samples;
- Complete the bulk chemical data spatial analysis;
- Continue with microanalysis.

Based Mobile Laser Scanning

University of New South Wales
Simit Raval

Value: $96,068
Report Expected: 25/09/2018
Industry Monitor/s: Adrienna Robotham, Brian Vorster
ACARP Contact: Keith Smith

This project aims to evaluate a UAV-LiDAR system’s suitability for mapping structural characteristics of pit walls compared to Terrestrial Laser Scanning (TLS) and UAV Photogrammetry. In this 3rd quarter, a review meeting was conducted with Industry Monitors where the presentation and report on progress was well received. Followed by the review meeting, a rigorous data acquisition campaign was conducted on 20 Sept 2017 at the project site - Glendell Coal Mine.

UAV-LiDAR (Phoenix) system was flown aboard DJI Matrice 600 platform in multiple transects keeping approximately 35 m distance from the highwall generating a high-resolution point cloud data (See Figure). UAV-photogrammetry data were acquired using DJI Phantom 4 Pro for the same highwall with approximately 80% forward and side overlap. Terrestrial photogrammetry (TP) was also performed at the highwall using a high-resolution digital camera. Simultaneously, a high-resolution terrestrial laser scan (TLS) was conducted using Maptek I-Site 8820 scanner. Several ground control (GC) points were employed to assess the positional accuracy of the data acquired from the UAV. Accurate position of all the GCs as well as few distinguishable points on highwall was recorded using a survey grade total station. The UAV scans were also performed at another highwall located in an active mining area that has a recent slope failure.

At the end of the day, UAV was in air for a total of more than two hours capturing more than 17GB of LiDAR data plus 1,090 photos and 22 min of video footage. The data analysis will be complete during the next quarter.

C26030
Improved Structural Mapping of Pit Walls using UAV

High resolution UAV-LiDAR scan of the highwall

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

University of Queensland
Fernando Vieira

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

The main objective of this project is to develop a wireless sensor solution that will determine the groundwater pressure and flow throughout a spoil dump or tailings dam.

The three stages of this project are:
- Stage 1 looks at basic research, this stage is complete;
- Stage 2 concept development, is currently underway; and
- Stage 3 experimental proof of concept, this is planned to be run later in the year.

Current activities include:
- Research into magnetic based communication for through the earth data comms – currently researching flux gate magnetometers for receiving low power magnetic signals and frequency locking to lock onto a carrier wave that will be modulated onto the magnetic signal. This will form the physical layer of a communication protocol based upon magnetic induction and will be tested in parallel with a RF solution to determine the best method for optimal transmission range.
- Research into novel approaches for physical measurement sensors specifically for the project such as pressure sensors, moisture sensors and relative motion or displacement sensors. Currently researching alternative construction methods to extend the operational life of the sensors out to the ten year lifespan of a sensor. Looking at current developments in ceramic based sensors as being researched by UQ.
- Research into a conceptual solution for installation of sensors within existing spoil piles as well as developing spoil piles, this is looking at ways in which the sensors could be installed in the future.
- Research into a conceptual method of remotely or wirelessly charging sensors while they are embedded within the spoil pile. This is looking at current methods of wireless charging and theoretically applying this to the project to extend the battery life of the sensors and provide a charging mechanism.

Coal Mines

University of New South Wales
Ismet Canbulat

Value: $92,000
Report Expected: 25/03/2018
Industry Monitor/s: Adrienna Robotham, Brian Vorster, Gavin Lowing, Mike Martin
ACARP Contact: Roger Wischusen

The main objective of this project is to update geotechnical awareness and training video for open cut coal mines with the latest technology in animation and visualisation. A series of new modules related to geotechnical and operational risks will also be included in this updated version.

To date, two workshops with the industry monitors have been held. The industry monitors have decided to produce three different videos; one for operational personnel; one for supervisors and one for geologists. The scripts for those three videos have been completed with the feedback from the industry monitors. The suitable sites are currently being identified to start filming in November.

C26034
Storage and Time Effects on Coking Properties of Small Coal Samples

McMahon Coal Quality Resources
Chris McMahon

Value: $151,000
Report Expected: 25/03/2018
Industry Monitor/s: Angus McIntyre, Danique Bax, Patrick Tyrrell, Peter Chern, Richard Hingst, Richard Ruddock
ACARP Contact: Cam Davidson

The project objectives are to examine and quantify reduction in coking properties with time and conditions of storage on small samples that are commonly used in borecore and coal sampling generally.

Four potential coal sources covering a range of rank and coal quality have been made available with three being undertaken initially.

Confirmation of test methods by industry monitors was made with the methods document being circulated to the coal testing laboratories. Quotations for price for testing from three laboratories was sought and attained and the data collated, charted and recommendations made by MCQR for assignment of samples and laboratories. This was confirmed by industry monitors.

The first sample in the lab being tested for the client’s original purpose (that includes relevant test work for this project) has been signed over to the project (And a second separate project – notes following) and instructions issued to the lab for reserve
samples available (separate methods for each reserve available depending on mass available).

The laboratory is due to confirm methodology for samples and sample processing and testing. Additionally an ACARP proposal separate to this one requires some sample from the first sample and the lab is awaiting notification of requirements for that project also. Testing will commence likely in the next two weeks.

A second physical sample and a third borecore are due into the lab for testing within the next three months.

### Maintenance and Equipment

**C20030**  
**Powerlinkoz High Voltage Electrical Connection System (PLO)**

Connec  
John Keir

- **Value:** $450,000  
- **Report Expected:** 25/01/2018  
- **Industry Monitor/s:** Barrie Alley, David Lincoln, Tony Egan  
- **ACARP Contact:** Keith Smith

This project sets out to complete the development of a power cable connection system for underground and surface coal mines which offers significant operational benefits with reference in particular to AS/NZS1299, AS/NZS1300 and AS/NZS60079 series of standards. The research work associated with the project may also contribute to the development of these standards.

Manufacture and testing of the 3.3KV system has been completed. Field trials of the device have also been completed with over 10,000 hours of operation achieved. IECEx and ANZ certification have been awarded.

The 11kV system has been built and the certification process has commenced. Field trials of the device are also progressing with over 2,000 hours of operation achieved.

**C25034**  
**Mining Truck Tyre Integrity Monitoring**

CSIRO  
Garry Einicke

- **Value:** $162,965  
- **Report Expected:** 25/03/2018  
- **Industry Monitor/s:** Brian Mahar, Ivan Heron  
- **ACARP Contact:** Cam Davidson

‘Zipper’ failure is the name given to the rupture of a tyre wall due to rapid progressive rupture of cords within a tyre’s structural carcass or casing. This phenomenon has led to the explosive failure of tyres which has been responsible for injuries and fatalities at Australian coal mines as well as costs due to equipment downtime. In December 2014, Queensland’s Central Coroner recommended that mines introduce an annual process to ensure that tyres are operated within their design parameters and that every tyre undergoes integrity testing. This project is developing technology for checking the integrity of mining truck tyres. The objectives of the two-year project are:

- Develop a portable subsurface imaging system and software (using x-ray) for automatically diagnosing the structural integrity of mine truck tyres;
- Work with mine site personnel to develop practical and safe work procedures for using the developed portable system to assess whether mine truck tyres should/should not remain in service;
- Transfer the developed technology to a commercial collaborator who will then be equipped to provide either a tyre integrity diagnosis service or tyre integrity monitoring technology to mine sites.

The project team conducted a technology demonstration at the Blackwater Mine on 21 – 22 Sep 2017. The Blackwater Mine site Radiation safety officer (RSO) was provided with the risk assessment and a site radiation notice for the work. Sample sidewall locations of the following three truck tyres were examined:

- Bridgestone 11R22.5 (1.05 m OD);
- Michelin 24R35 (2.07 m OD);
- Bridgestone 59/80 R63 (4.1 m OD).

A portable gamma source (Iridium 192, 25 Curies) and a battery-powered x-ray detector panel were used to acquire x-ray images of the above tyre samples. The developed tyre integrity monitoring software was then used to check the integrity of the internal cords of the tyres. The software displays images in which the cords meeting user-specified criteria are automatically coloured green. Those cords failing to meet the user-specified criteria are automatically coloured red and correspond to tyre damage. It was confirmed by visual inspection that the developed analysis software was able to successfully detect undamaged and damaged steel cords.

The project team gratefully acknowledges the assistance of Ben Green (Blackwater Mine), Lachlan Thompson, Adam Turner-Jones and George Baloloy (ALS Global) during the mine demonstration.

**C25041**  
**Dynacut Fundamental Development and Scalability Testing**

University of Queensland  
Brad Neilson, Dihon Tadic, Joji Quidim, Steve Powell

- **Value:** $540,000  
- **Report Expected:** 25/12/2017  
- **Industry Monitor/s:** Ivan Heron, Kane Usher  
- **ACARP Contact:** Cam Davidson

This project follows directly on from project C24011, Quantifying development risks for a high capacity surface mining continuous cutting system in waste. There are two project elements: the first aims to quantify key performance and cost factors for DynaCut technology (an undercutting disc technology for mechanical cutting) in several overburden material domains with purpose-built cutters; the second aims to develop concepts for
new mining methods and approaches to exploit the benefits offered by high-capacity continuous cutting systems.

Testing of the DynaCut technology was performed in August and September at a sandstone quarry in South East Queensland, with multiple domains validated via core drilling and mechanical properties testing. Bench sections were excavated, with a working face of approximately 3m x 5m. The total cut volume approached 500m³. The machine demonstrated excellent performance (with cutting rates several times that achieved in previous hard rock trials) and cutter life was better than anticipated. Machine and performance data are now being collated and analysed to enable preparation of the final report.

The mine design component remains focused on preliminary economic evaluation and comparison of various mining concepts applied to typical deposit types and two specific case-study scenarios. This work is now also being finalised and collated.

C26020
Preventing Fatigue Cracking Via Proactive Surface Dressing

Bureau Veritas AIRS
Simon Krismer

Value: $126,940
Report Expected: 25/09/2018
Industry Monitor/s: Scott Studdert
ACARP Contact: Keith Smith

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

Initial phases of work for establishment of the project have been completed. A review of prior NDT reports to establish history of cracking and identification of target cracking locations has been completed for the 137 trucks across the two participant sites. This quarter, further experimental work has been undertaken to assess, quantify and compare various methods of surface removal for their effectiveness and ease of use, as well as to establish suitable procedures in order to control and quantify how much steel is removed by the application of the selected method(s) in situ. In particular, extensive trials have been carried out using various commercially available products in order to assess which of them are suitable for use in this project.

The participant mine sites have recently experienced a change in ownership, and the truck maintenance process is also being altered. These factors have resulted in delays to the implementation of the project field trials, and in the start of the data collection phase.

C26021
Verification of Interoperability - Collision Awareness and Avoidance Systems

CSIRO
Jeremy Thompson

Value: $105,844
Report Expected: 25/03/2018
Industry Monitor/s: Iain Curran, Matt Clements, Paul Forsaith, Tim Gray, Tony Egan
ACARP Contact: Cam Davidson

This project will develop an independent software verification tool to assess the compliance of proximity detection systems and vehicle control systems with an open industry communications protocol to address major gaps in systems interoperability.

The project will deliver a new software based verification tool to formally establish the level to which proximity detection and vehicle control systems comply with open industry interoperability communication protocols. This outcome provides both equipment manufacturers and mine-sites with a consistent and simple way to ensure that the design decisions made will meet expectations. A higher rate of take-up of proximity detection systems will directly improve the safety of open cut mining systems. This will have the following benefits:

- Provide vendor-neutral tools for compliance testing for hardware, software and communication platforms;
- Remove uncertainty around a given proximity detection system's interoperability performance; and
- Improve mine industry safety by supporting the take-up and integration of proximity detection systems.

Development of the initial release of the verification tool is almost complete. We have been in contact with several PDS OEMs to arrange for testing of the tool with their hardware. This testing is due to being as soon as the initial release is complete. This is scheduled for the end of the month.

C25032
Collaboration to Maximise the Benefits and Acceptance of Land Packages for Post Mining Leases

Central Queensland University
Jo-Anne Everingham, John Rolfe

Value: $239,215
Report Expected: 25/03/2018
Industry Monitor/s: John Merritt, Stuart Ritchie
ACARP Contact: Keith Smith

This project aims to test the use of a local expert/stakeholder panel to identify the conditions and suitable mix of agricultural uses and other functions for a mine lease to be completed, in order to gain acceptance by the agricultural sector and the local community. One focus of the project will be to establish a process where the key factors relevant to local communities and
the agricultural sector (the latter as the expected future user) can be identified and assessed.

This project involves four key aims:
- Identify the key factors that are likely to be relevant to future landholders, local communities, Aboriginal traditional owners and other stakeholders when negotiating closure of a mining operation;
- Model the economic returns and flows from transitioning mining leases to agricultural and other land functions;
- Test the use of different local expert/stakeholder panel models to select and negotiate preferred scenarios for mine closure and subsequent land use; and
- Use the findings to assist in the development of a process for negotiating mine closures that aligns with local community and stakeholder needs and acceptance.

The forth workshop was completed in Blackwater as planned on 10th August. This workshop had more focus on broader context issues around post-mining land conversion and the preferred design of a stakeholder working group, so that specific recommendations can be developed from the project results. It also involved some presentation of mapping results of the previous workshops back to participants.

The project team are now summarising the key results of the project into four reports, including:
- Report 2: An evidence based proposal for stakeholder engagement in planning post-mining land uses;
- Report 3: What landholders and stakeholders think about post-mining land uses – workshop outcomes + economics; and
- Report 4: Models for stakeholder engagement land use change decisions.

As well, the project team are organising a research forum in Emerald on 12th December 2017. The forum will provide an opportunity for industry, government and stakeholders to see some summary results of the project and discuss the issues.

Occupational Health and Equipment Safety

C25026
Reducing Risk Taking Among Australian Coal Miners

University of Newcastle
Anna Giacomini
Mark Rubin

Value: $302,235
Report Expected: 25/04/2019
Industry Monitor/s: Bharath Belle
Doug Kennedy
Patrick Tyrrell
Simon Coleman
ACARP Contact: Roger Wischusen

This project aims to investigate the causes of dangerous risk-taking behaviours in open cut and underground coal mining environments. It also aims to develop a practical intervention for coal miners in order to reduce dangerous risk taking and, consequently, accidents and injuries. The project will test the effectiveness of this risk taking intervention and provide a numerical tool that the industry can use to assess the sustained long term effectiveness of the intervention.

Most of the data collection for Survey 1 has been completed. However, we noted that miners from open cut mine sites were underrepresented in our sample. Following consultation with our Industry Monitors, and specific assistance from Doug Kennedy, an additional open cut mine has now been recruited for participation in the research. Liddell Coal Operations has committed to the project. We have established contact with the mine liaison and have commenced data collection at the mine for Survey 1.

We are continuing with recruitment of participants for Survey 2. To date, we have recruited 153 participants: 105 responses to the online survey and 48 paper responses. We are focusing recruitment on revisiting the mines that participated in Survey 1 as well as our online/social media broad recruitment campaign.

C25037
Health-e Mines: Virtual Health System to Improve Mental Health

University of Newcastle
Brian Kelly
Frances Kay-Lambkin
Ross Tynan

Value: $289,985
Report Expected: 25/04/2018
Industry Monitor/s: Occupational Health and Safety Task Group
Tony Egan
ACARP Contact: Roger Wischusen

This project has three key objectives. They are to:
- Develop an online portal ('Health-e Mines') through which Australian coal miners can access confidential, evidence-based online treatments for mental health, alcohol/other drug use, and physical health concerns;
- Evaluate the use of Health-e Mines and associated online treatment programs in pilot mine sites in New South Wales and Queensland in terms of feasibility, acceptability, reach, and effectiveness; and to
- Develop a clear plan for dissemination and sustainability of Health-e Mines beyond the current project.

We have now finalised development and refinement of the Health-e mines prototype.

In response to feedback from industry, we have included a number of new components to the website. Specifically, the website now has content to provide assistance to supervisors on how to manage staff who may be experiencing mental health related problems, including tips on signals to look out for, how to initiate a conversation, the role of the supervisor, and some information on legal responsibilities. We have also included content for people seeking information to support a colleague or a friend/family member, including tips on how to be provide support and to take action. Finally, we have established a partnership with MATES in mining, and have included information about how to connect with MATES, including access to telephone support tailored for those who work in the mining industry.
The Health-e mines website hosts a comprehensive array of evidence based advice, information and treatment programs. We have a number of mines that have already expressed interest in trialling Health-e mines at their site. If you are interested in finding out more information, or discussing how Health-e mines could be offered to staff at your site, please contact Ross Tynan, Ross.tynan@hnehealth.nsw.gov.au or 02 4924 6949.

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

University of Queensland
Robin Burgess-Limerick

Value: $298,704
Report Expected: 25/03/2019
Industry Monitor/s: Ellen Roots, Ross Di Corleto, Shane Apps, Troy O'Reilly
ACARP Contact: Keith Smith

The project objectives are to:

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

A prototype iOS application has been written by Bialkowski which forwards accelerometer data to a server via a wireless connection. If a connection is lost, the application stores and forwards subsequently when connection is restored. Hardware adapters have been procured to allow simultaneous power input and Ethernet output from an iphone mounted in a haul-truck seat. A visit was undertaken to Millennium mine in August, during which an iphone was successfully connected to a haul-truck in vehicle monitoring system, and accelerometer data from the iphone was received by the UQ server software.

Five replacement truck seat cushions have been modified by Seat Shop Australia to allow the iphones and associated adapters and cabling to be installed in haul truck seats. Three iphones are currently installed in haul-trucks at Millennium mine, and accelerometer data is being received by the UQ server software. However, regular breaks in transmission are occurring, the causes of these service disruptions are being investigated.

C26028
Proximity Detection System Performance Testing Framework

University of Queensland
Joji Quidim, Susan Grandone

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

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

Due to a change of industry monitors, a workshop was held on 26th July with existing and new project monitors to discuss and reorient the project’s objectives. Slight adjustments have been made to the project plan to reflect the results of this discussion. The latest updated plan has been circulated as Revision 1.8.

The project team is currently in the middle of completing work units 3 – 5 according to the latest approved plan and progress is on schedule. Two workshops (18th September and 25th October) have been held with project team members, industry monitors, and selected industry participants in attendance. The next workshop is expected to be in either December 2017 or January 2018.

Overburden Removal

C24037
Automated Bulk Dozer Push: Reducing the Cost of Overburden Removal

University of Queensland
Ross McAre

Value: $341,400
Report Expected: 25/11/2017
Industry Monitor/s: Andrew Denman, Hans Hayes, Shaun Booth, Tony Egan
ACARP Contact: Cam Davidson

A draft report is with the industry monitor(s) for review.
C25038
Dragline Excavation Sequencing: Phase 2

University of Queensland
Andrew Jessett
Ross McAree

Value: $112,900
Report Expected: 25/04/2018
Industry Monitor/s: Andrew Denman
Win Klass
ACARP Contact: Cam Davidson

This project aims to develop and test an operator assist that computes excavation sequences for a dragline and provides excavation guidance to the operator. An excavation sequence is the set of locations the dragline should position itself at, the material it should remove at each position, and the locations it should spoil that material to. The technology being developed is targeting more consistent production, faster lineal advances rates down the strip, and continuous assurance that future material movement tasks remain feasible.

The methodology for sequencing is to enumerate combinations of excavation tasks subject to constraints on the set of available decisions, and to search for the task sequence that gives the best performance in terms of progress to plan and productivity. These sequences are presented to the operator, giving guidance on where to position, where to dig from, and where to spoil. Implementation of the Generation 1 system is to be trialed at Caval Ridge, with the aim to evaluate the benefits of the technology.

The project work across the last quarter was to progress the implementation such that the sequencing system can be run live on DRE35 at Caval Ridge. Specific activities included:

- A workshop at Caval Ridge to distill the 'rules of thumb' as use cases for excavation scenarios typical for current DRE35 operation;
- Applying the excavation use cases as a template for constructing the decision tree used to explore excavation sequence variants;
- Implementation of a cost model that uses drive characteristics and machine/terrain interaction to compute cycle times; Implementing visualization interfaces to present excavation tasks (walk sequence and material movement) and to track progress against the task; and
- Formulating the use case for live operation of the decision tree framework that computes excavation sequences, including recalculation as operation progresses against the prescribed task.

The project plans to be testing the sequencing system live on DRE35 by the end November.
COAL PREPARATION

Major Projects

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

University of Newcastle
Kevin Galvin

Value: $1,318,748
Report Expected: 25/12/2017
Industry Monitor/s: Kevin Rowe
ACARP Contact: Nerrida Scott

This project will move an innovative process improvement from the laboratory and pilot scale to a trial in an operating plant at full-scale. The project has a committed host site, with strong engineering and scientific support from contributors.

A larger size feed, up to 4mm, will be directed to the Reflux classifier, thereby reducing the load to the dense medium cyclones. This will in turn increase the capacity of the slimes screen which has been the limiting factor in the capacity of coal preparation plants. The work has the potential to increase plant throughput for a given Capex, and may even deliver higher yield.

In a second project, C20052, the facility will be used to undertake a full-scale trial of cascading Reflux Classifiers, involving gravity separation and then desliming of the final overflow product. The goal is to provide alternative methods for processing fine coal, extending the recovery to lower particle sizes via the controlled desliming of the clean coal product.

From a research perspective, this construction project is a major undertaking, involving four organizations and other consultants. The final construction phase for the first research project, C19001, was completed in November 2015. The project work was then undertaken through 2016, and the draft final report lodged in January 2017.

In preparation for Project 2, C20052, a modified circuit was required. The modifications commenced in the second half of 2016 and were largely completed by the end of November 2016. Thus commissioning of the new circuit was undertaken by December, followed by initial experimentation. The need for a number of circuit adjustments was identified and some changes were made to improve the operability. The need for these adjustments reflects the substantially lower processing rates for the much finer feed. The -1 mm feed is sourced from a -16 mm feed, hence it is still necessary to convey particles up to 16 mm in size onto the large screen. The diameter of the pipe on the main pump inlet side is too great, hence there is a tendency for the feed to segregate and cause a blockage. This pipe was replaced allowing the work to resume.

The facility works very well, generating high quality gravity separation and desliming as noted in the quarterly report on Project 2, C20052.

The final stage of this project will follow the completion of Project 2 much later in the year, and will involve the dismantling of the facility, retrieval of the proprietary equipment, and disposal of the remaining material.

Dewatering

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

University of Queensland
Yongjun Peng

Value: $213,600
Report Expected: 25/11/2017
Industry Monitor/s: Alvaro Diaz Lema
ACARP Contact: Nerrida Scott

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

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

QCC Resources
Andrew Swanson
Bob Drummond

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

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

C25010
Optimising the Performance of Solid Bowl Centrifuge for Tailing Dewatering

University of Newcastle
Rohan Stanger

Value: $125,560
Report Expected: 25/12/2017
Industry Monitor/s: Ryan Flanagan
Tom Wilson
ACARP Contact: Nerrida Scott

This project is based on providing analytical insight into the performance of a solid bowl centrifuge for coal tailings dewatering. Currently the project has characterised one suite of feed/cake/effluent from a single seam and used the material to develop a laboratory centrifuge test that could be used on other potential tailings types. The samples were tested for laser particle sizing, XRD and SEM-EDS to understand the particle and mineral characteristics. Overall, the project has been delayed by the availability of samples from the mine site during 2017 but is now close to completion. Final analyses to be completed involves the Laboratory Centrifuge tests and some centrate samples for XRD. These centrate samples were not part of the work schedule but are considered worth doing to provide insight into exactly what isn’t removed from the pilot and commercial scale Solid Bowl Centrifuges.
The objectives of this project are to:

- Achieve ~94% solid recovery for tailings.
- Dilute tailings thickener underflow with 45% solids to around 14% solids.

The results showed an ~3% increase in moisture of the filter cake in comparison with no chemical treatment. Pilot-scale trials on flotation concentrate (with 10% solids) and tailings (with 3% solids) were completed. The results showed that mixture of flocculent/cationic surfactant can increase capturing ultrafine solid particles while there was around 3% increase in moisture of the filter cake in comparison with no chemical treatment. Pilot-scale trials on tailings thickener underflow with high solid concentration were also accomplished. The tailings thickener underflow with 45% solids was diluted to around 14% solids. The results showed 33% moisture with 92% solid recovery without any chemical treatment.

Furthermore, comprehensive laboratory-scale experiments unveiled that mixture of flocculent/cationic surfactant can increase capturing ultrafine particles to obtain high quality of effluent water. The sequence of the addition of chemicals also play critical role in capturing ultrafine particles. On the other hand, adding flocculant first, then the anionic surfactant can breakdown the flocculated particles and result in lower moisture. However, the quality of effluent water cannot be very high.

The objectives of the project are to:

- Apply the high-g centrifugation effect on dewatering fine coals and tailings;
- Evaluate the Somerset dewatering technology at pilot scale and in continuous mode;
- Optimise the fine coal dewatering by using the concepts of split dewatering and combined centrifugal and chemical-enhanced de-wetting forces; and
- Compare pilot-scale findings to full-scale results.

Progress during this quarter

Pilot-scale studies on flotation concentrate (with 10% solids) and tailings (with 3% solids) were completed. The results showed ~25% moisture, ~95% solid recovery for concentrate and ~30%, ~94% solid recovery for tailings. Using flocculant or cationic surfactant increased capturing ultrafine solid particles but there was around 3% increase in moisture of the filter cake in comparison with no chemical treatment. Pilot-scale trials on tailings thickener underflow with high solid concentration were also accomplished. The tailings thickener underflow with 45% solids was diluted to around 14% solids. The results showed 33% moisture with 92% solid recovery without any chemical treatment.

In the last quarter, 12 more flocculants from three different chemical suppliers were evaluated using the bench-top centrifugal dewatering test unit. Three of these newly tested flocculants gave higher solids recoveries than the flocculant being used at the site while keeping the product moisture almost the same.

A series of centrifugal sedimentation tests were carried out aiming to understand the operation of the industrial SBC bowl section. The effects of flocculant dosage and feed particle size distribution on the dewatering performance were examined.

The construction of the continuous pilot-scale SBC test unit is completed by the overseas manufacturer. It is expected to be installed at The University of Queensland next quarter.

The objectives of the project are to:

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

Progress during this quarter

The samples from a BMA mine in the Bowen Basin were received and prepared for the project. Two different ranks of samples were obtained from coal flotation circuits of different CHPPs for size distribution and physicochemical characterisation. Sample A showed a wide range of particles size distribution and majority of the particles size were around 90 microns. Sample A was split into -50 and +50 microns.
fractions for zeta potential studies and ash analyses. The results revealed that -50 microns fraction contained more negative surface charge in comparison with +50 microns fraction that means there were more oxygenated groups on the finer fraction. The Washburn technique was used to measure the coal hydrophobicity. The hydrophobicity studies showed strongly hydrophobic surface of sample A with contact angle of 88 degrees. The float-sink analysis on sample A was done to obtain vitrinite-rich and inertinite rich samples. The samples were sent to CSIRO to start Coal Grain Analysis (CGA). Initial XCT images on vitrinite-rich and inertinite-rich samples also revealed promising results regarding distinguishing of vitrinite and inertinite-rich particles by XCT.

Environmental Improvement

C25006
Test Procedures to Achieve More Cost Effective Minimisation of Coal Dust Emission During Rail Transport

Introspec Marketing Services
John Planner

Value: $50,000
Report Expected: 25/12/2017
Industry Monitor/s : John Watson
Stuart Ritchie
ACARP Contact: Nerrida Scott

This project will recommend modified coal surface treatment for mine to port rail transport to achieve significant annual cost savings by largely eliminating the use of chemical surface veneer treatment, and replacement by water spray. The project objectives include achievement of the following outcomes:

- Effective minimisation of coal surface dust emission during rail transport to meet reasonable Community expectations and to provide a simple and authentic explanation of the procedure;
- Effective minimisation of coal surface dust emission during rail transport to meet reasonable Regulatory expectations;
- Scientifically based demonstration of ability to meet Regulator expectations in Queensland and New South Wales, based on extensive research conducted over the past two years on causes and management of coal dust emission during rail transport;
- An alternative more relevant wind tunnel simulated operational test procedure to the current “one size fits all” overly severe procedure, developed in 2008 for timely introduction of chemical surface veneer;
- A simulated operational test procedure with coal surface wind speed more appropriate to normal maximum wind speed data for each CQCN rail system;
- A test procedure with coal sample moisture content determined by ‘as loaded’ moisture content, adjusted 6.3mm sample top size, for each coal product;
- Validation of operational simulation wind tunnel results by field trials on CQCN rail systems through continuous trackside opacity measurement;
- Opportunity for Coal Producers to meet reasonable Community and Regulatory expectations with cost effective coal surface treatment.

The draft report will be issued in December.

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

CSIRO
Graham O'Brien
Michael Campbell

Value: $175,622
Report Expected: 25/05/2018
Industry Monitor/s : John Watson
Kevin Rowe
Stuart Ritchie
ACARP Contact: Nerrida Scott

The objectives for this project are to:

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

The sampling program which is being conducted in the Newcastle area is progressing satisfactorily. Commencing July 2017, two TSP samples and a PM10 have been collected at the same location on two different sampling days each month. Two date eight sets of samples have been collected.

The volume of air, and the mass of particulates deposited on each filter was measured, which enabled particulate density to be expressed as µg/m³. Metrological information (wind direction and wind speed) is also collected for each sampling date.

Work has commenced on analysing these samples to determine the proportion of water soluble particulates for the TSP and PM10 samples. The filter papers are being divided into four equal segments and two different analysts at the Steel River Testing laboratory and one analyst at the CSIRO laboratory are each analysing a separate segment. The remaining quarter is kept as a reserve sample at the CSIRO laboratory.

The mass percent of water soluble particulates present in the July 2017 samples are shown in Table 1. These results for these two sets of samples not only show quite good agreement between the different analysts, but also different proportions of water soluble particulates in the TSP and PM10 samples collected on the two different sampling dates.

<table>
<thead>
<tr>
<th>Sample Collection Date</th>
<th>Sample type</th>
<th>Steel River Testing Analyst 1</th>
<th>Steel River Testing Analyst 2</th>
<th>Steel River Testing Analyst 3</th>
<th>CSIRO Analyst 1</th>
</tr>
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<tbody>
<tr>
<td>13-Jul-17</td>
<td>TSP</td>
<td>83.9</td>
<td>42.7</td>
<td>40.8</td>
<td>37.7</td>
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<tr>
<td>23-Jul-17</td>
<td>PM10</td>
<td>86.8</td>
<td>40.7</td>
<td>37.7</td>
<td>37.7</td>
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<tr>
<td>13-Jul-17</td>
<td>TSP</td>
<td>50.7</td>
<td>41.5</td>
<td>39.1</td>
<td>37.7</td>
</tr>
<tr>
<td>19-Jul-17</td>
<td>TSP</td>
<td>9.6</td>
<td>11.4</td>
<td>12.2</td>
<td>12.2</td>
</tr>
<tr>
<td>19-Jul-17</td>
<td>PM10</td>
<td>77.3</td>
<td>20.5</td>
<td>22.5</td>
<td>22.5</td>
</tr>
<tr>
<td>15-Jul-17</td>
<td>TSP</td>
<td>8.9</td>
<td>16.6</td>
<td>11.2</td>
<td>11.2</td>
</tr>
</tbody>
</table>

Table 1: Mass percent of water soluble particulates in the TSP and PM10 samples collected at the Newcastle sampling site.
Next quarter:
- Continue collecting TSP and PM10 samples at the Newcastle site;
- Continue to determine the proportion of water soluble particulates in the samples;
- Investigate correlations between metrological conditions (wind direction and wind speed) and the total amount of dust and the ratio of solubles and insolubles collected with the TSP and PM10 samples;
- Commence CGA analysis on selected samples; and
- Source dust samples from Wollongong and Brisbane and from a Hunter Valley open cut mine.

### Fine Coal

**C20052**
Full Scale Gravity-Desliming Using Cascading Reflux Classifiers

University of Newcastle
Kevin Galvin

| Value:          | $215,480 |
| Report Expected: | 25/01/2018 |
| Industry Monitor/s: | Kevin Rowe, Tom Wilson |
| ACARP Contact:  | Nerrida Scott |

The objective of this project is to investigate the performance of cascading Reflux Classifiers (RC2020) in the gravity separation and desliming of fine coal at full-scale. This project is an extension of the former project C18037, the aim being to assess the scale-up. While there is existing industrial knowledge concerning the gravity separation of fine coal in a Reflux Classifier there is no previous industrial investigation of the RC2020 desliming process at full-scale or of the synergy achieved using the cascading arrangement. There is always uncertainty associated with the question of scale-up given the potential for non-uniform separation to occur in large scale devices.

A cascading sequence of two full-scale Reflux Classifiers will be used to generate a clean coal product from a feed within the size range 2.0 to 0.0 mm. The objective is to use gravity separation to produce a clean coal product down to a particle size of about 0.038 mm or higher, and to deslime the product with minimal coal loss. Modifications to the testing facility to support this ACARP project, C20052, were completed and commissioned in December allowing some initial experiments to be done. A number of other circuit adjustments was then undertaken and completed.

Samples from over 20 runs have now been collected, covering a range of circuit feed rates (eg 52, 100, 162 m3/h in the RC1400 gravity unit). The effects of varying fluidisation rate (4.9, 6.0, 8.0 m3/h) in the deslime unit were also examined, achieving classification in line with expectations. Set points of 1060, 1080, and 1110 kg/m3 were used to examine the effect of different bed heights.

The plant work was suspended while samples were processed and analysed. A review of the work to date showed that the circuit was able to successfully produce clean coal product over a broad range of conditions, at feed rates of 52 to 162 m3/h (18 to 53 t/h solids), feed ashes of 30 to 52 wt.%, achieving product ashes of 3.4 to 9.3 wt.%, and combustible recoveries of 40 to 86 wt.%. The work also demonstrated the consequences of operating the first stage gravity separator at too-high a set point. This condition causes mineral matter to report to the desliming unit, resulting in the mineral matter forming a lower bed in the desliming unit, and forcing the coal to overflow. The work has identified a robust design that permits a low set point separation. The reject would then be sent to a second gravity stage from which a deslimed thermal product would be produced. A coking coal product would emerge from the first-stage gravity product following desliming. New work is being conducted to examine this option. The project is due to be completed in the next quarter.

### C23036
New Approach to Coarse Coal Flotation

University of Newcastle
Kevin Galvin

| Value:          | $141,457 |
| Report Expected: | 25/12/2017 |
| Industry Monitor/s : | Kevin Rowe, Tom Wilson |
| ACARP Contact:  | Roger Wischusen |

The objective of this new study is to investigate the performance of the Reflux Flotation Cell at a laboratory scale in coarse particle flotation up to 2mm. The fundamental knowledge produced by this study will be used to support a larger, pilot scale, study, and in turn a full scale trial. This project addresses a long standing problem in flotation, extending the size range to coarser particles. Success in this project will lead directly to pilot and full scale investigations of coarse coal flotation. The plan is not to replace gravity separation of the coarser size particles, but to bridge the gap between the different circuits. This project will provide an understanding of the coarse particle flotation mechanism, and the precise conditions required to succeed.

More recent experiments have been conducted using particles in the range 1.4 to 2.0 mm, at an average of 1.7 mm. Under these dilute tracer particle conditions the recovery has dropped to 50% over a wide range of the gas flux. This finding is consistent with achieving a buoyancy limitation. For a fixed bubble size, larger particles will have a smaller specific surface area (area per unit volume), and hence the bubbles that pack across the surface of the particle deliver less buoyancy compared to the increase in the buoyant particle weight. Unfortunately examination of the effects of the bias flux provided no additional insight here.

Following on from the success achieved in floating coarser particles at tracer level concentrations, we conducted actual separations using cyclone overflow covering the size range from 0 to 2 mm. The initial work was conducted at very low pulp densities of order 1 wt%. Very high recoveries were achieved across the size range 0 to 1 mm, with gradual drop off to 2 mm, with significant recovery at 2 mm. The findings were compared with the yield at a sink-float density of 1.6, thus using the ideal bench mark. The gas flux was maintained at relatively low levels in line with the tracer work.

The work conducted at 5% solids showed an increased drop off in recovery as the particle size range increased when no wash water was added, and for a low wash water addition corresponding to a neutral bias. However, when a much higher
waste water rate was used, the coarse particle recovery increased to high levels across the full size range. This finding was surprising given that additional wash water often results in a loss in recovery due to disturbance of the froth. We suspect the frother in the waste water stabilized the recovery.

A new program of work was conducted using 0-2 mm feed at 5% solids, using different bias fluxes, and gas fluxes. The experimental findings are clear. At a gas flux of 0.5 cm/s or lower the flotation is very efficient at recovering particles across the full size range. However, as the gas flux increases there is a strong collapse in recovery at the coarser sizes.

Experiments were undertaken to determine the performance using the low gas flux at a feed pulp density of 15% solids over the size range from 0-2 mm. This was the feed to the cyclones. We only have the data on the finer -0.125 mm portion, however, the observation made during the experiments is that the recovery of the coarse particles across the full size range was high. The project work has been completed, and the final draft report will be submitted later this year.

**C23045**

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

University of Newcastle  
Kevin Galvin

- **Value:** $294,820  
- **Report Expected:** 25/07/2019  
- **Industry Monitor/s:** Clinton Vanderkruk, Kevin Rowe, Penny Walker

**ACARP Contact:** Nerrida Scott

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

Preparations are underway for a full-scale trial. A number of laboratory experiments have been conducted in order to inform the project on what is possible. These experiments involve a two-stage system, each with a 0.1mx0.1m cross-section, and vessel 2.0 m high. The initial experiments were focused on two-stage operation under conditions below the target processing rate. The feed rate used was equivalent to 1400 m³/h through a 2.0 m diameter unit, limited only by the available pumping equipment. The residence time in the first Reflux Flotation Cell was only 15 seconds. The feed had an ash of 59.7%. Overall, the 1st stage combustible recovery was 60.8%, and the rougher product ash 46.4%. The 2nd stage product had an ash of 15.8%, significantly higher than achieved in our earlier experiments. However, the second stage tailings ash was 83%, indicating that a higher wash water rate could have been used, hence much lower product ash should be possible. The overall two-stage recovery was 51.7%, very consistent with the tree flotation curve. Additional work indicated the overall recovery could have been increased to 64%.

**C24042**

**Pilot Scale Study of Fast Flotation**

University of Newcastle  
Kevin Galvin

- **Value:** $95,180  
- **Report Expected:** 25/10/2017  
- **Industry Monitor/s:** Kevin Rowe, Nerrida Scott

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

**C24043**

**Simultaneous Gravity Separation and Desliming of Fine Coal - A Novel Concept**

University of Newcastle  
Kevin Galvin

- **Value:** $141,380  
- **Report Expected:** 25/10/2017  
- **Industry Monitor/s:** Alvaro Díaz Lema, Tom Wilson

**ACARP Contact:** Nerrida Scott

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

**C24045**

**Adaptation of Coal Grain Analysis to Improve Yield Estimation**

QCC Resources  
Andrew Swanson, Bruce Atkinson

- **Value:** $120,456  
- **Report Expected:** 11/25/2017  
- **Industry Monitor/s:** Dion Lucke, Naomi Pritchard

**ACARP Contact:** Nerrida Scott

Accurate prediction of flotation yield is difficult. Modelling of density separation processes is reasonably straightforward, however existing methods of modelling of flotation yield are poor.
This project offers further development of an already commercially available analytical tool (Coal Grain Analysis – CGA) that is likely to be able to solve the issue and provide a more accurate basis for modelling flotation yield. The information will be generated in a form that will enable direct utilisation in the likes of LIMN process models.

This project involved sampling of four separate CPP flotation circuits with CGA determined on each of fresh feed, concentrate and tailings streams. The CGA data have allowed flotation response of each grain type to be evaluated.

The preliminary data demonstrate correlations between steady-state flotation rate constant and particle size for each of vitrinite and inertinite. Interestingly, vitrinite rate constant increases with increasing particle size, while inertinite rate constant decreases with increasing particle size. A preliminary project report, covering the scope of C24045, will be issued by December.

C24049
Performance Enhanced Diesel Collector for Coal Flotation
CSIRO
Shenggen Hu

In laboratory tests, it has been found that a performance-enhanced diesel collector can achieve increased collecting abilities than diesel alone. The objectives of this project are to carry out preparation plant based assessment/demonstrations of the performance-enhanced diesel collector for:
- Increasing the recovery of both coarse and fine coal particles; and/or
- Reducing the consumption of diesel oil while maintaining good flotation performance;
- Improving collector addition methods with enhanced dispersion of collector.

Plant-based trials were carried out at a CHPP site in February to investigate the effectiveness of 2 reagents (PES 80 and PEK 12) for enhancing collector performance. Results from the plant-based trials indicated that the performance-enhanced reagent (PES 80) can increase the collecting ability of diesel. The combustibles recovery obtained with this performance-enhanced diesel collector can be up to 5% higher than that with the same dosage of normal diesel collector if the intensity of mixing is sufficiently high. The performance-enhanced diesel collector does not cause negative impact on the dewatering of flotation concentrate.

Additional plant-based trials were conducted in June at another CHPP having a coal which is difficult to be floated. The combustibles recovery obtained with the performance-enhanced diesel collector in the primary Jameson cell can be up to 2 to 6% higher than that with the same dosage of normal diesel collector. The combustibles recovery in the second mechanical cell was also considered to be significantly increased as the slurry level in the sump of flotation concentrate was significantly higher than normal during the addition of the performance-enhanced diesel collector. The moisture content of the filtration cake for the performance-enhanced diesel collector was found to be the same as those for normal diesel collector.

Analysis of all samples were completed and the final report is being prepared.

C25008
3D Flotation of Fine Coal
University of Newcastle
Kevin Galvin

Value: $185,260
Report Expected: 25/11/2017
Industry Monitor/s: Ryan Flanagan, Tom Wilson
ACARP Contact: Nerrida Scott

Conventional 2D Flotation involves the agglomeration of fine particles to the surface of rising air bubbles. Residence times have not changed significantly in the past 100 years. This new project is concerned with 3D Flotation in which the fines are attached to a novel binder. The coal particles then become embedded within the 3D matrix of the binder, producing a very low density product that floats to the surface. The final product can also be washed over a screen.

The objective of this study is to establish 2m3/h and 20m3/h laboratory pilot scale facilities for demonstrating the novel 3D Flotation Technology. This system will allow assessment of separation performance across a range of coals, while providing further validation of the system scale-up, and assessment of economic potential.

This is the second report since the exchange of the contracts. We have already achieved successful beneficiation through a semi-continuous approach, forming agglomerates via a high shear nozzle, capturing the agglomerated suspension, followed by dewatering. The key challenge now is to make the system fully continuous. The original experiments conducted demonstrated difficulty with achieving continuous dewatering of the agglomerates via a dewatering screen. While initial separation is achieved, extended operation leads to a decline in the separation, most probably due to the deformability of the agglomerates and their potential to blind the screen.

We have established that these agglomerates are buoyant hence they tend to rise naturally relative to the water. We previously constructed a system to promote the buoyant separation of the agglomerates to achieve continuous steady state separation. We have since commenced work to trial the new Reflux Flotation Cell, and have found it necessary to build an understanding on how best to use the system. At this stage we have only conducted about six experiments. We have achieved one very satisfactory run where we achieved complete recovery of the agglomerates in the overflow. However, we need to promote stronger washing of the overflow product, insuring we do not lose agglomerates to the underflow.

New experiments were therefore conducted to examine the role of the bias flux and wash water flux on product yield and ash content. The initial fluidization wash water rate was 1 L/min, leading to acceptable yield but unsatisfactory washing. Since then we have used a washing rate of 3 L/min, running the system at increasing overflow rates and hence bias fluxes, achieving eventually achieving full yield. Certainly the higher
wash water rate leads to more effective cleaning of the product, but also the need for a higher overflow rate. The analysis needs to be conducted in multiple ways, firstly using a screen to separate the entrained liquid from the product, then filtering to remove some of the entrained product, and finally collecting all material. More experiments are planned, varying the gas rate and wash water rate, and introducing some frother to influence the bubble size. We will also look at a simple open tank with a two-stage approach.

C25009
Rapid Extraction of Frothers from Process Water

University of Newcastle
Jamie Dickinson

Value: $122,965
Report Expected: 25/01/2018
Industry Monitor/s: Alvaro Diaz Lema, Kevin Rowe
ACARP Contact: Nerrida Scott

The objective of this project is to investigate the rapid extraction of residual frother, such as MIBC, from process water using a novel flotation device, Reflux Flotation Cell (RFC), to achieve up to an order of magnitude increase in the throughput rate over conventional flotation systems. Success in this project would allow flotation circuits to operate at optimal frother concentration, while ensuring efficient plant operation.

Recirculating process water containing even modest levels of flotation frother can cause significant problems in CHPP operations, such as inefficient operation of DMCs, thickeners, sumps and pumps. Without the availability of inline measurement of frother concentration, operators tend to compensate for an over-frothed plant by reducing the rate of frother addition to the flotation circuit at the expense of flotation performance, and hence fine coal yield. Frother adsorbed at a bubble surface is recoverable using flotation. However, extremely low feed throughput rates are necessary using conventional flotation systems to ensure a reasonable recovery and upgrade, making the capital expenditure for frother recovery unviable in a CHPP operation due to the high volumetric feed rate to be processed.

Experiments involving the RFC have demonstrated a significant throughput advantage achieved by using the inclined channels to enhance the bubble-liquid segregation rate. Drift flux theory has indicated that for a given recovery and upgrade, the feed flux through the RFC is maximised for a mean bubble size in the order of 100 µm. Recent experiments have demonstrated maintained recoveries and upgrades using bubbles of this order in size, for feed flux to gas flux ratios ranging approximately 1 to 10. Experiments examining frother extraction from process water containing gangue and coal particles are underway.

C25013
Evaluation of Residual Frother Minimisation Strategies

CSIRO
Philip Ofori

Value: $167,714
Report Expected: 25/02/2018
Industry Monitor/s: Justin O’Neill
ACARP Contact: Nerrida Scott

The objectives of this project are to:

- Quantify the effectiveness of methodologies to mitigate excess frothing in coal preparation plants; and to
- Further develop a frother detector that can be used to determine frother distribution in process and recycle streams.

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

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

Frother partitioning experiments have been performed in a batch flotation system to study the kinetics of residual frother removal with and without solids present. Two-stage flotation tests have been performed to examine the impact of solids and coal types on frother partitioning and the effectiveness of second-stage flotation in reducing residual frother.

Experiments are being conducted in a pilot scale air stripping column to determine the effectiveness of this process in the removal of frother from aqueous streams. These experiments will be completed in the next quarter. A plant audit will also be conducted to determine residual frother levels in selected streams for comparison with the pilot scale data.
C25014
Plant Scale Testing of Safe Aerosol Frother Addition to Reduce Residual Frother and Reagent Costs

CSIRO
Philip Ofori

Value: $165,582
Report Expected: 25/12/2017
Industry Monitor/s : Alvaro Diaz Lema
Justin O’Neill
ACARP Contact: Nerrida Scott

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

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

The complete aerosol generation system was assembled and tested in our pilot plant and minor modifications required were implemented before for site installation and commissioning. Detailed CHPP-based experimental plan was also developed. Plant installation, commissioning and major experimental campaign has been completed. Data analysis has been completed. The analysis has identified some gaps in the data so a follow-up site experimental campaign is being organised to resolve the issues.

In the next quarter the second site experimental campaign will be implemented once suitable times have been worked out with site personnel. This will be followed by sample and data analyses and report preparation.

C25020
Flotation Tailings Online Measurement

A & B Mylec
Alan Bennetts
Todd McDonald

Value: $45,200
Report Expected: 25/10/2017
Industry Monitor/s : Alvaro Diaz Lema
Naomi Pritchard
ACARP Contact: Nerrida Scott

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

C26001
Impact of Sub Optimal Operation: Stage 2

CSIRO

Value: $41,500
Report Expected: 25/03/2018
Industry Monitor/s : Ryan Flanagan
ACARP Contact: Nerrida Scott

The objective of the parent project C24039 ‘Impact of Sub-Optimal Operation’ was the quantification of the effects of sub-optimal operation in a coal preparation plant. Methodology for a consistent approach to the analysis of the issues involved was developed by employing the concepts from ‘The Intelligent Plant’ project. This was tested with 19 case studies which covered a number of activities in the plant operation, and in all cases a successful description of the situation was obtained in a consistent manner. Methodology for this project required the entry into ‘The Intelligent Plant’ diagnostic system via a different starting point to that used in the original system. Given the successful outcome of the original project, it was recommended that a second phase project be carried out with the objective to modify the existing ‘Intelligent Plant Diagnostic’ System to access not only from a Symptom/Measurement entry, but also via a Sub-Optimal Operation (Health Issue) option.

Currently reviewing the first draft of the inverted Health Issue (HI/Sub-Optimal Process)/Symptom (Measurement) matrix. The new inverted matrix now allows for a ‘fuzzy’ approach in order to filter the information which will keep the system relatively simple.
<table>
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<tr>
<th>Project Code</th>
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<td>C24050</td>
<td>Options for the Addition and Control of Non Magnetic Material in Correct Medium</td>
<td>CSIRO</td>
<td>$205,490</td>
<td>25/12/2017</td>
<td>Clinton Vanderkruk, Justin O'Neill</td>
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<td>C24051</td>
<td>Effect of Particle Crowding at the Vortex Finder and Spigot on Cyclone Operation</td>
<td>CSIRO</td>
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<td>C25015</td>
<td>Pilot Plant Scale Testing of Modified Downcomer in Jameson Cell</td>
<td>CSIRO</td>
<td>$184,149</td>
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<td>C25016</td>
<td>G Force Reduction and Failure Monitoring of Multi Sloped Screens</td>
<td>CSIRO</td>
<td>$190,282</td>
<td>25/12/2017</td>
<td>Clinton Vanderkruk</td>
<td>Nerrida Scott</td>
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</tbody>
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The objective of this project is to investigate various options for the addition or maintaining/controlling the level of non-magnetic material in the correct medium following a period where the concentration of non-magnetics in the medium is low, e.g., after a shutdown or outage. The most prospective of these options and any operating procedures will be tested at a plant.

Remaining test at low density is still to be completed waiting on the plant to be processing the right type of coal to complete the test work. A final report is currently being prepared.

This project aims to quantify the changes in DMC operational conditions on particle crowding of the vortex finder and spigot. The major outcomes of this project would be an improved understanding of the influence of particle crowding and medium stability on DMC cleaning capability. The understanding is based on well-defined experiments, and the availability of improved quantitative relationships allows for better management strategies for DMC operation.

Report writing in progress for this project has begun. Processing of the last two experiments has been completed and the analysis has been undertaken. The latest experiments, one on crowding the VF and the second crowding the Spigot were at high concentrations of crowding material and resulted in considerable crowding particularly at the Spigot.

The objective of this project is to carry out large pilot scale investigations of the modified downcomer at a mine site for a comprehensive assessment of improved combustibles recovery and scalability, via:
- Designing and constructing a pilot scale test rig;
- Comparing the performance of the modified downcomer with that for the unmodified downcomer in terms of the combustibles recovery and product ash value under normal plant feed conditions and assess the scalability of the modifications; and
- Carrying out residence time distribution tests to determine the effectiveness of modified downcomer in improving cell hydrodynamic behaviours.

The pilot scale test rig is being developed by modifying a 500L Jameson cell from Glencore Technology with mass flowmeter and RTD test facilities. Two mine sites were visited to collect information for planning field trials. One site was found not suitable for this project due to the slow dissolution of Nalflote 9840 which is used as frother at this site. Approval for site access has been obtained from one preferred mine site. Detailed measures are being prepared for the safe operation of pilot-scale test rig. Based on staff availability and CHPP maintenance schedule, the plant-based test is planned to start in later November.

This project has two objectives, designed to address the priorities of optimising maintenance practices and equipment designs to deliver improved process efficiency at lower cost. It will provide a detailed proof of concept on desliming and drain and rinse screens by:
- Determining the effect of further reducing the screen g force on desliming and drain and rinse screens on screening efficiency;
- Monitoring a screen continuously for failure indicators using the system developed to show that the system is viable for use as a long-term indicator of imminent screen failures. (The output from the monitoring system will be published to a secure web interface so that plant operators and metallurgists can observe the motion of the screens, displacement, stroke and failure indicators in near real time).
Weights were removed from the exciters of the desliming screen and the drain and rinse screen dropping the g force on the desliming from 3.5 g at the front springs and 4.5 g on the rear springs to 2.8 g at the front springs and 3.8 g at the rear springs a reduction in g force of 0.7 g. The drain and rinse screen was reduced a further 0.8.

Samples were taken before and after the change for both screens and are currently being analysed.

Monitoring at the site has been continuing since the installation in August 2016. All sensors still operating and monitored from QCAT. No unusual deviations from the normal operation have been noted. The sensors are very sensitive to loading conditions on the screen and the histogram of the operation show that there are two main operating feed rates onto the desliming screen, as shown below. Monitoring is expected to continue for another few month the or until a sensors fails at which time they will be removed or replaced depending on the applicability of this to the monitoring project which will also take place at this site.

![Histogram of Displacements](image)

### Process Control

#### C22033
**Advanced Control and Optimisation of DMC Operation**

**CSIRO**

Shenggen Hu

- **Value:** $246,685
- **Report Expected:** 25/01/2018
- **Industry Monitor/s:** Rahul Patel
- **ACARP Contact:** Roger Wischusen

The objective of this project is to develop, implement and demonstrate an advanced control system that optimizes DMC operating conditions under which a target product ash and/or a given incremental ash can be achieved.

Plant-based trials for six different seams have been carried out to compare the predicted product ash values with those from coal analysis. The largest difference between predicted and analysed ash value was 1.5%. The average error of six cases was less than 1%.

An approach for on-line estimating the relationship between instantaneous ash value and density has been developed and validated using data from six different coal seams. The relationship has two parameters. One parameter is determined from the observation that for a given coal mine instantaneous ash values of all seams at density of 1.61 are close to each other. Another parameter can be related to the washability curve which can be online estimated from measured DMC product yield and medium densities in feed, overflow and underflow streams.

Due to file damages caused by computer virus, a significant amount of time was spent to redo data analysis and software for the sensitivity analysis of errors. The sensitivity analysis of errors in ash-density curve and washability curve was carried out based on baseline values from plant-based trials for six different seams. ± 1% (absolute error) ash change at RD=1.27 in ash-density curves will cause ± 0.8% change in the predicted product ash over the possible range of cut-point. ±5% error (absolute error) in the ash value at the density of 1.65RD can cause about ±0.22% error (absolute error) in the predicted DMC product ash value at the DMC cut-point of 1.36RD and this error is ±0.69% at the cut-point of 1.50RD and linearly increases with an increase in the DMC cut-pint.

The final report is being prepared.

#### C25011
**Effect of Flotation Water Chemistry on Coal Chemistry, Fluidity and Coke Quality**

University of New South Wales

Noel Lambert

Seher Ata

- **Value:** $150,000
- **Report Expected:** 25/12/2017
- **Industry Monitor/s:** Rebecca Fleming
- **ACARP Contact:** Nerrida Scott

The final report is being prepared and continuing work being undertaken under project C26013.

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

University of New South Wales

Noel Lambert

Seher Ata

- **Value:** $169,000
- **Report Expected:** 25/11/2018
- **Industry Monitor/s:** Rebecca Fleming
- **ACARP Contact:** Nerrida Scott

The aim of this project is to expand on project C25011 that was initiated at the beginning of 2016. In stage 1, the effect of inorganic electrolytes on coal fluidity was investigated since the use of recycled water, high in salts, was found to cause a reduction in the thermoplastic properties of coals. This stage of the project aims to explore in more details the effect of water quality on coal thermoplastic properties in a flotation operation.

The project leaders have met with the mining operation(s) involved in the project to discuss the samples, including coal, water, and reagents, needed for the project. Some of the samples have recently been received. Preliminary flotation experiments are underway.
General

C25007
Derrick Stack Sizer In Plant Evaluation

WPE Process Equipment
Brian Packer
Darren Mathewson

Value: $150,800
Report Expected: 25/11/2017
Industry Monitor/s: Naomi Pritchard, Rebecca Fleming
ACARP Contact: Nerrida Scott

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

C25019
Adaptation of Coal Grain Analysis to Improve Yield Estimation

QCC Resources
Bruce Atkinson

Value: $165,584
Report Expected: 25/09/2018
Industry Monitor/s: Dion Lucke
ACARP Contact: Nerrida Scott

Accurate prediction of flotation yield is difficult. Modelling of density separation processes is reasonably straightforward, however existing methods of modelling of flotation yield are poor.

This project offers further development of an already commercially available analytical tool (Coal Grain Analysis – CGA) that is likely to be able to solve the issue and provide a more accurate basis for modelling flotation yield. The information will be generated in a form that will enable direct utilisation in the likes of LIMN process models.

Two sites have been sampled for the project. Four further sites will be sampled.

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

University of Newcastle
Dusan Ilic

Value: $80,000
Report Expected: 25/02/2018
Industry Monitor/s: Kevin Rowe
ACARP Contact: Nerrida Scott

This project will investigate the validity of AS4156.6, the Australian Standard on the determination of dust extinction moisture (DEM) and dustiness for coal. This project is a second part of the investigation (first part completed in 2015, C23039), with focus on coal sample preparation and reducing error. Coal full size (F/S) air drying (A/D) duration (prior to screening to -6.3mm size fraction for the test) and sample preparation including moisture adjustment is being investigated.

Progress:
- All coals have been homogenised in the as supplied state;
- Coal A and Coal C have been tested extensively for air-drying duration and moisture content modification scheme;
- A three day air-drying duration has been investigated for Coal A and Coal C (at three different sets of conditions/moisture content reduction/addition schemes). After 3 days of air-drying (in the full size fraction) Coal A dust number is around 10 (wet) and Coal C has a dust number between 100 and 1000 (dry). Therefore Coal A sub-samples were dried (two different schemes) and Coal C sub-samples were increased in moisture (two different schemes);
- Coal A is a hard coking coal and Coal C a lower ranked thermal coal. Coal A DEM was observed to be in the range of 5.3-6.1% and Coal C DEM 10.7-11.2%;
- From testing completed thus far, two possible sources of variation have been identified – 1) representative sampling of the sub-test sample for moisture content determination (pre-check moisture analysis) and 2) fluctuation of dust collector bag weight with room conditions (within the range specified by AS4156.6). Reducing this variation will be the focus of further testing of Coal A and Coal C;
- Regarding the testing scheduled for Coal A and Coal C, the progress currently stands 50%. Following completion of Coal A and Coal C, the remaining coals will be tested at one air-drying duration and one moisture content modification scheme with a defined updated procedure aiming to reduce variation.

Observations/comments:
- A number of steps in the current method AS4156.6 are open to interpretation which can lead to inconsistency/variation. Rewording will be required;
- Moisture content analysis and sample size used in the method is being investigated going forward. It is likely that the sample size (-6.3mm size fraction) will be increased to increase the fidelity (reduce moisture content variation) of the test. The use of a reference bag is being investigated to decrease effect of paper bag variation.

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

University of Queensland
Yongjun Peng

Value: $116,600
Report Expected: 25/04/2018
Industry Monitor/s: Alvaro Diaz Lema, Justin O’Neill
ACARP Contact: Nerrida Scott

This project is a continuation of project C23039 through plant tests and technology transfer. The project objectives are to:
- Implement the oxidation measurement tools in coal preparation plants and train plant engineers how to use these tools;
- Measure the degree of coal oxidation at different feeds and stockpiles on sites, correlate the oxidation with coal flotation performance;
- Develop an oxidation database to guide the plants to manage oxidised coals through blending and adjusting operation conditions; and
Trial the new reagents identified for floating oxidised coals from the previous project C23039 in the plant to improve the flotation of oxidised coals.

Two oxidation measurement tools, alkaline extraction-UV/Vis and dissolved oxygen demand test, have been successfully implemented in two coal preparation plants processing oxidized coals. The site engineers have been trained to use these tools as a routine measurement to monitor the degree of coal oxidation of the flotation feed and the plant feed.

The degree of coal oxidation in flotation feed has been measured on a large number of samples during several plant surveys from August to October, 2017. Coal surface oxidation was correlated with plant flotation performance. The results showed a general trend that flotation combustible recovery decreased sharply with the increase of the degree of coal oxidation, and a critical oxidation degree was identified, below which the flotation recovery became nearly zero, for each plant. These results will help these plants to predict their plant flotation performances based on the measurement of the degree of coal surface oxidation.

During the plant surveys, coal samples with different degrees of oxidation were collected and will be used for the lab tests to identify the best reagent system to improve the flotation. The identified reagent system will be trialled in the plant.

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

CSIRO
Mike O’Brien

Value: $140,025
Report Expected: 25/07/2018
Industry Monitor/s: Clinton Vanderkruk, Rod Fox
ACARP Contact: Nerrida Scott

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

Pilot banana screen has been set up and tests conducted to ensure it is operational. Coal has been collected and the test work will begin in November.

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

The objects of this project are as follows:

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

Construction of density meters is underway and the system has been tested with excellent results that match the splot Ron for low impedance measurements however at high impedance values there is a considerable variation which has been attributed to the length of the leads. This is being overcome by the installation of a signal driver circuit which will negate the effect of long cable leads.

For the mass/motion analysers work is underway construction a system which will drive the accelerometers and wireless communication between the sensor and a WiFi or Bluetooth receiver. The receiver can then relay the results via the internet to the control room or back to CSIRO for analysis. These systems will be rolled to the plants later this year.
C26012
Improved Flotation Recovery Via Controlling Froth Behaviour - Stage 2

University of Queensland
Liguang Wang

Value: $100,000
Report Expected: 25/02/2019
Industry Monitor/s: Naomi Pritchard, Rebecca Fleming
ACARP Contact: Nerrida Scott

The objectives of this project are to:
- Demonstrate and evaluate a real-time froth control system for maximising and maintaining the separation efficiency of coal flotation;
- Demonstrate and evaluate a simple and fast tool for measuring the concentration of frother in flotation cells and water circuits at accuracy of 0.9 ppm or better.

We commenced the construction of the froth control system in August. Modification of the froth monitoring sensor is underway, with the software being updated for data acquisition over extended period of time.

We have planned to test the froth control system on a pilot-scale flotation cell at University of Queensland before taking it to the site.

We did some preparatory work for measuring the concentrations of frother in a coal flotation plant. Onsite work will be planned in the following quarter.

C26014
Low Cost Online Measurement of Particle Size and Density for Diagnostics Across the Fine Coal Circuit

University of Newcastle
Peter Stepien, Rohan Stanger

Value: $119,633
Report Expected: 25/07/2018
Industry Monitor/s: Alvaro Diaz Lema, Rebecca Fleming
ACARP Contact: Nerrida Scott

This project is based on developing an image based tool for capturing particle size/shape and location characteristics as they are directed around a radial pathway. The particles migration distance to the outer edge and its size will be used to determine overall density, and hence provide a means of capturing online ‘washability’ data. The start was delayed until September and has now begun in earnest. A prototype has been designed and built and will be commissioned over the next 1-2 months. The intention is to construct a working “batch” prototype (possibly two) in this project, with a continuous model planned for the next funding round. Current testing has involved assessment of lower cost imaging tools which suggest that detection limits of 10µm and 5-30 frames per second are possible. The next step after commissioning will involve testing particles of controlled size and density as a means of calibration.

C26016
Benefits of Online Thickener Underflow Rheology Measurements

Clean Process Technologies
Noel Lambert

Value: $251,000
Report Expected: 25/03/2018
Industry Monitor/s: Naomi Pritchard, Ryan Flanagan
ACARP Contact: Nerrida Scott

The aim of this project is to find how useful are the rheology measurements generated by the Thickener Underflow Monitor (TUM). The TUM was developed by Clean Process Technologies (CPT) in project C24048.

The TUM is currently able to generate information regarding the rheology of coal thickener underflow (as well as solids concentration m/m and v/v, slurry density and particle density), but the usefulness of this information is not well understood.

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

Progress during this quarter
Have been in contact with site staff to arrange deployment onto the Bulga CHPP. Safety inductions and medicals need to be performed by CPT staff when available to be able to progress to onsite work. Limited resources of personnel at CPT in the short term have made this not possible yet.

It is targeted to have the TUM onsite in the 4th quarter of 2017, with the trial to be ran and completed by the 4th quarter. This will enable the test program to be completed by end of 2017.

During completion of laboratory test work from the Bulga site, it was realised that some additional measurements are required in relation to viscosity that were previously not allowed for. Although our current laboratory devices measure over a moderate range, this range was not low enough to be useful for calculating yield stress values, which are important when dealing with CHPP tailings, dewatering operations and tailings dams.

We have been in contact with a supplier and have purchased a new laboratory rheometer which will cover the entire range of shear stresses necessary for this work to be completed and are awaiting delivery. These values can then be analysed and compared to outputs from the TUM. We are also aware that a larger shear stress range may be required for the actual TUM measurement, but we will analyse results and consider this for future work for this project.
TECHNICAL MARKET SUPPORT

Major Project

C27001
Maritime Regulation Project: Self Heating and Corrosivity Test Evaluation

Goodwin Port Solutions
Ash Goodwin

Value: $1,197,363
Report Expected: 25/09/2019
Industry Monitor/s: Maritime Regulation Task Group
ACARP Contact: Anne Mabardi

In 2015 the International Maritime Solid Bulk Cargoes Code (IMSBC Code) was amended (via amendment 03-15) to incorporate mandatory requirements for shippers to test for hazard characteristics for coal cargoes using specific approved methods. This amendment came into mandatory effect from 1 January 2017.

Specifically, the Hazard section of the IMSBC Code Schedule for coal notes that when carried on board a vessel “may create flammable atmospheres, may heat spontaneously, may deplete oxygen concentration (and) may corrode metal structures.” The Characteristics table in this schedule also categorises coal cargoes as a ‘Material Hazardous only in Bulk’ (MHB) type cargo.

In 2016, testing of coal samples identified issues with accuracy and consistency of hazard classifications when coal was tested using the IMSBC Code tests to assess for potential corrosion and self-heating hazards. The results of the test work were presented to the Australian Maritime Safety Authority in December 2016, which led to AMSA issuing:

• Exemption certificate (EX5450) allowing shippers of IRON ORE, IRON ORE FINES, BAUXITE and COAL to use an alternative method for evaluation of the MHB corrosive properties of these materials. The alternative method is by use of the standard DIN 50929-3 Corrosion of metals; probability of corrosion of metallic materials when subject to corrosion from the outside; buried and underwater pipelines and structural components as detailed in the exemption; and
• Certificate of approval (AP5416) allowing shippers to categorise COAL, meeting certain criteria which would otherwise characterise the coal as a dangerous good, to be declared MHB (SH) on the condition that extra precautions are taken.


The certificates provide an interim pathway for coal shippers to declare corrosion and self-heating properties of coal cargoes, however further research is necessary to identify test methods that accurately categorise these properties for coal.

The project includes research to investigate issues identified in relation to the accuracy, repeatability and reliability of the modified C.1 corrosion test when applied to coal cargoes, and provides Australian coal producers with a centralised means of participating in the International Maritime Organisation led investigation into a modified/alternative test for corrosivity as applied to solid bulk cargoes.

The project also includes research to review the N.4 self-heating test prescribed for use in the IMSBC Code in order to identify a modified or alternative testing method to accurately establish the self-heating potential for coal cargoes.

The proposed timetable will enable alternative and/or modified test methods to be considered by the International Maritime Organisation in time for incorporation within the 05/19 amendment of the IMSBC code which, if adopted will result in the alternative methods being available to shippers in a voluntary form from 1 January 2020, followed by mandatory implementation from 1 January 2021.

The project is conducting self-heating research work led by Ken Williams at the Centre for Bulk Solid and Particulate Technologies (CBSPT) and University of Newcastle, with four test ovens in full time use to further understand the self-heating behaviour of coal cargoes. The outcomes of the self-heating work will be reported on in the first half of 2018.

The project has also commenced detailed corrosion studies led by Katerina Lepkova at the Curtin Corrosion Engineering Industry Centre. The research work is focussed on developing a detailed understanding of the C.1 corrosion test technique prescribed for us on bulk coal cargoes. The project is also providing input into a coordinated international group of industry participants via the Minerals Council of Australia.

In September 2017 two papers were presented to the International Maritime Organisation (IMO) by the Australian Maritime Safety Authority (AMSA) advising of the research program currently underway. The papers are available upon request:

• CCC 4/5/3 – Self-heating and information relating to the Australian industry self-heating coal research project; and
• CCC 4/5/11 – Test methods to determine corrosivity of solid bulk cargoes.

For further information on the project please contact Ash Goodwin via email ash@goodwinportsolutions.com.

Metallurgical Coal
C23049
Coke Analogue to Examine the Effect of Mineralogy on Coke Reactivity: Part 3

University of Wollongong
Brian Monaghan

Value: $469,208
Report Expected: 25/12/2017
Industry Monitor/s: Kim Hockings, Oliver Scholes, Tim Manton

ACARP Contact: Dave Osborne

The aim of this project is to understand the impact of mineralogy on the reactivity of metallurgical coke using a coke analogue material in a pseudo CRI test. Specifically, for Part III.

Key outcomes of the project will be:
- Development of a validated index used in predicting coke reactivity from its mineralogy; and
- A brief review of CRI and MBI academic literature.

Key outputs of the project:
- Literature review of MBI/CRI equations (complete);
- Model of the coke analogue reactivity (report section in draft: being finalised);
- Experimental analogue work for model validation and data (finalised);
- Sole oven pilot cokes to test the effects of Fe and Ca on reactivity (finalised);
- The work is complete and the modelling report section has been updated and is being finalised.
The sole oven work was presented at the workshop of Australian coal research on metallurgical coal at UNSW in July. There were some delays in the washing of the coals for the sole oven pilot cokes that have delayed the final report.

C24054
In-situ Study of the Plastic Layer Formation in Coking Coals using a Lab Scale Test Furnace

University of Newcastle
Jianglong Yu, Merrick Mahoney

Value: $213,530
Report Expected: 25/04/2018
Industry Monitor/s: Oliver Scholes, Sean Flanagan, Shaun Booth

ACARP Contact: Dave Osborne

The objective of this project is to understand the formation of a plastic layer and its influence on coke oven operation and the coke quality. A 4kg lab-scale double-heated-wall coke oven has been built at NIER of UoN which has the capacity of simulating the heat transfer of large scale coke ovens and allows in-situ measurements and direct sampling of the plastic layer during coking process. The project has been extended to do some preliminary investigations on coal blending and coke oven validation.

Using the UoN lab-scale 4kg coke oven, good quality coke samples have been produced at a heating rate of 10°C/min. The temperature profile and Internal Gas Pressure were measured in-situ at five positions in the coal bed inside the reactor and plastic layer samples were obtained during heating. The plastic layer samples from single coals have been systematically analysed using various advanced analytical techniques, including TGA-FTIR, ART-FTIR, and Synchrotron, etc. The results have formed an interim report that has been submitted to ACARP early the year. The coke oven rig has been recently modified to allow the operator to load the coke reactor into the coke oven preheated to 850°C in order to simulate the heating conditions of large-scale coke ovens. CSR/CRI tests have been carried out through CSIRO/SGS on coke samples made form single coals and blends to validate the UoN coke oven. Coking experiments have been carried out on a number of coals and coal blends with plastic layers sampled. Synchrotron micro-CT tests will be done in early November.

C24057
Estimating the Fusible Content of Individual Coal Grains and its Application in Cokemaking

CSIRO
David Jenkins, Karryn Warren, Merrick Mahoney

Value: $230,026
Report Expected: 25/12/2017
Industry Monitor/s: Kim Hockings, Nick Andriopoulos, Oliver Scholes

ACARP Contact: Dave Osborne

The objectives of this project are to use three recently developed analytical techniques to obtain new insights into the link between the size distribution of the fusible and infusible macerals and minerals and resultant coke structure and strength. This has applications in optimising the preparation of coal for coking and in obtaining the highest strength coke from coals. The techniques to be used are enhanced Coal Grain Analysis (CGA), the analysis of 3D microstructure of coke from Computed Tomography (CT) scanning and the analysis of fracture surfaces using fractographic techniques.

Progress to date:
- All of the analyses are complete and preparation of the draft report is underway;
- The extension project to analyse a further two coals grind series has also commenced.

In the next quarter we plan submit the draft report.

C25042
Mechanistic Model for the Understanding of the Sole Heated Oven
This project is aimed at using the previously developed dilatometer and sole heated oven models to build a detailed mechanistic model of plastic layer behaviour in a coke oven and to use it to predict aspects of coke microstructure that can be related to coke properties.

The full CFD model has now been prepared that incorporates the previous models and has been tested against experimental data. The model is now ready to test the next data sets when they arrive this month. The submission of the draft report is expected to be at the end of February 2018.

C25045
In-Situ High Temperature Strength of Low CSR Cokes

University of New South Wales
Pramod Koshy

Value: $104,000
Report Expected: 25/04/2018
Industry Monitor/s : Kim Hockings
Nick Andriopoulos
ACARP Contact: Dave Osborne

This project is a joint collaboration between UNSW Australia and ANSTO. This is an extension of the Stage I project which investigated the effect of high temperatures on the mechanical properties of high-CSR cokes. The objectives of the current project are to:

- Assess the validity of the high-temperature testing methods and to determine and predict the creep deformation in low-CSR cokes;
- Determine the in-situ creep compressive behaviour at high temperatures for cokes of low CSR values; and to
- Clarify the association of the coke CSR values (for high and low CSR cokes) with the actual modification of coke strength at high temperatures and to develop correlations with the parent coal attributes.

In the present project, two low-CSR coke samples were provided. From these cokes, cylindrical samples (~21 mm height, ~19 mm diameter) were cored out. These samples were then end-polished and then heat treated at 1100°C for 5 h in argon to remove any volatiles. Samples with consistent bulk densities and defect-free surfaces (16 for each low-CSR coke) were selected for the high-temperature mechanical tests at ANSTO. Room temperature mechanical strength data showed that both the low-CSR cokes had average strengths in the range 14-16 MPa.

Constant stress tests were done for both low-CSR cokes using the facilities at ANSTO. These revealed that the onset deformation temperatures were slightly lower for the low-CSR cokes in comparison to the high CSR ones; moreover, the slope of the deformation curve was less steep for these low CSR cokes. High-temperature mechanical testing of these cokes revealed that the compressive strengths at 1400°C (figure shown below) were similar to those displayed by the high CSR coke. Further testing is underway to determine the repeatability of the strength values at different temperatures.

C25046
Using High Range Mass Spectrometry to Study the Link between Coal Structure, Coke Strength and Thermoplastic Chemistry in Blends

University of Newcastle
Rohan Stanger

Value: $104,240
Report Expected: 25/12/2017
Industry Monitor/s : Kim Hockings
Nick Andriopoulos
ACARP Contact: Dave Osborne

This project was based on characterising the molecular character of coking coals as they transition into the plastic layer and then into semi coke. The technique used is Laser Desorption & Ionisation time of flight mass spectrometry (LDI-TOF-MS) which is capable of semi-quantifying the molecular weight distribution to ~7000 Da in size. Currently four coals have been evaluated with a 5th coal undergoing final analysis. The semi-cokes were produced isothermally at the critical fluid temperatures (softening, max fluidity and resolidification) with LDI-TOF-MS analysis being conducted on the solid semi-cokes and selected solvent extracts. A further series of tests were conducted using a more experimental heating system to produce dimensionally heated samples for LDI-TOF imaging across the coal-plastic layer-semi-coke- coke continuum. The current results have shown that molecular changes occur within the solvent extracts such that a minimum amount of ‘light’ molecules (<500 Da) are needed to solubilise the heavier components (500-3000 Da). The solid state analysis has shown that peak molecular weight in the raw coal is related to coal rank, while peak intensity of the semi-cokes is related to coal fluidity. The last part of this project involves dimensional heating of a coal blend of low and high fluidity to differentiate molecular activity. A draft report is expected to be submitted in November.

C25048
Automated Optical Image Analysis of Coke Texture and Structure and their Connection with Coke Porosity, Reactivity, Strength and Parent Coal Blend
CSIRO
Eugene Donskoi

Value: $149,913
Report Expected: 25/12/2018
Industry Monitor/s: Oliver Scholes, Sean Flanagan
ACARP Contact: Dave Osborne

The main objectives of this project are to:
- Further develop structural coke characterisation which will include the identification of different types of IMDC and RMDC;
- Develop novel automated image analysis methods for coke texture characterisation; and
- Determine the most important parameters characterizing coke structure and texture and achieve a more integrated understanding of relationships between the different characteristics of coke and the parent coal blend through examining relationships between coke micro/nano-porosity, different IMDC and RMDC structures, coke textural characteristics, reactivity and strength, and characteristics of initial coal blend.

The progress to date:
- Task 1: Coke selection, data collection and polished blocks preparation.
- Task 2: Development of Software for controlling the Motorized Rotating Polarizer, collecting images and producing and analysing Maximum/Minimum reflectance and Bireflectance maps.
- Task 3: Porosity measurements and proper data processing have been completed and corresponding analysis performed.

The fourth stage of the project, 'image collection', has been delayed. The initial concept was that each MosaiX image corresponding to a certain polarizer angle is collected independently. As a result significant errors were observed during the calculation of bireflectance and Max-reflectance (see Figure 1) for large MosaiX images caused by both imprecise positioning of the moving stage between taking images and image shifting during stitching. In order to address these issues, we had to change the concept to the technique when the polarizer rotates for each elementary image rather than once per MosaiX acquisition. After collection of all elementary images at all angles, they were combined into MosaiX images corresponding to certain angles. Subsequently, the MosaiX bireflectance and Ro-Max images were calculated. After the technique was developed and tested it was found out that the MosaiX images artefacts produced by shifts were significantly reduced but still present. We had therefore to develop the third approach where all bireflectance-related images are initially calculated for each set of elementary images, and only after that the resulting elementary bireflectance images are combined into MosaiX bireflectance images.

![Figure 1 Bireflectance images collected on Mineral4/Recognition4: a) Part of a large MosaiX image after calculation from all MosaiX images corresponding to different angles. Bright porosity edges can be seen (artificial bireflectance) obtained due to the interference of porosity area and coke area as a result of the shifts present in MosaiX images corresponding to different polarizing angles; b) bireflectance image obtained from elementary images without MosaiX.](image)

C25049
Fusibility of Coal Blends and Behaviours of Minerals in Coking

CSIRO
Merrick Mahoney, Priyanthi Hapugoda

Value: $193,020
Report Expected: 25/04/2018
Industry Monitor/s: Kim Hockings, Stephen Brant
ACARP Contact: Dave Osborne

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

Progress to date:
- All the coking of coal lumps were completed by the collaborator Newcastle University (Task 2 and 3) and coking images from Pearson’s were already received and characterisation in progress;
- CGA analysis of coke oven feed size fractions for each of the 6 single coals and 3 blends; All size fractions (+2mm, -2+1mm, -1+0.5mm and -0.5mm) of coke oven feed (24) and 3 blends (12 samples) imaged and processed using CGA;
- Modification of CGA software to characterise coal blends for Task 6;
- SEM assessment of coal and coke halves are going on for Task 7.

In the next quarter:
- MTA analysis of the cokes produced for these 9 samples (collaborators, Newcastle Uni);
The objectives of this project are to:

- Use the characterised images (Task 3) from the matched coal and coke halves to determine the fusible reflectance range for each coal (Task 4) will be completed;
- Image Processing with fusible inertinite thresholds will be completed and retrieve final data from all size fractions for each of the 6 single coals and 3 blends;
- Establish work for SEM assessment of coal and coke halves to provide detail on mineral size and chemical transformation during coking (Task 7), Ongoing; and
- Start writing the final report.

C25051
Links Between Microstructure Development in Softening Coal and the Characteristics Controlling Coke Quality

University of Newcastle
Merrick Mahoney
Richard Sakurovs
Value: $139,715
Report Expected: 25/12/2017
Industry Monitor/s : Nick Andriopoulos
Oliver Scholes
ACARP Contact: Dave Osborne

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

- Further develop understanding of the relationships between key microstructural features of coke and coke failure mechanisms and strength indices;
- Understand the development of key microstructure features by identifying key processes in the plastic layer contributing to the development of coke microstructure; and to
- Develop some understanding of how different inertinite types can influence structure development by modifying processes in the plastic layer.

CT images were collected for the samples at the Australian Synchrotron. Analysis of the images is near complete with interpretation of the results underway. Report writing has commenced, with submission of the report to be January 2018.

C25052
Concentrating Coke Oven Sized Inertinite Particles: Behaviour in Targeted Coking Blends

University of Newcastle
Wei Xie
Value: $91,690
Report Expected: 25/01/2018
Industry Monitor/s : Shaun Booth
Tim Manton
ACARP Contact: Dave Osborne

The objectives of this project are to:

- Concentrate coke oven sized inertinite particles that contain various semi-inert contents;
- Study the influence of these coke oven sized inertinite particles on coking behaviour of another “standardised” coal measure; and
- Establish relationships between the concentrated inertinite particles reflectogram and the measured physical and chemical changes of the targeted coking blends, to provide support for predicting coke strength.

To achieve these objectives, the project combines CATA for swelling, permeability, DETA for volatiles evolution and Pearson Coal Petrography for coke fusibility analysis. The coke oven size inertinite particles (1.6-2.0 mm) have been obtained by using an upgraded Reflux Classifier.

This project was initially delayed about six months because one of our colleagues had used the reflux classifier for concentrating small size macerals (~40 µm) for their ACARP projects. In the last quarterly report, we mentioned that we were expecting to complete all experimental tests in the coming quarter and submit the draft report by December this year. Now we are about two weeks behind the working programme because of my overseas travel for an International conference, we will finish all DETA and CATA tests in our lab by the middle of November. The large coke samples from the Sole Heated Oven should be prepared by the end of November from another lab in NIER building. We then are able to send the samples out to Canada for macrotexture analysis. We are expecting to get this done before Christmas. We are hoping to submit the draft report by January next year, which is about one month delayed with the working program.

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

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

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

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

The coals and cokes for this study have been obtained and prepared for neutron scattering analyses and reactivity tests. The reactivity tests of cokes with CO2 are underway as well as the neutron scattering analyses of the unreacted and reacted cokes to investigate nanoporosity. The preliminary results
indicate that closed porosity down to 10nm opens gradually during gasification.

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

CSIRO
Karryn Warren
Merrick Mahoney

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

The objectives of this project are to:

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

The techniques to be used are enhanced Coal Grain Analysis (CGA), the analysis of 3D microstructure of coke from Computed Tomography (CT) scanning and the analysis of fracture surfaces using fractographic techniques.

Progress to date:
- CGA is underway for Coal D and the coke samples have been obtained from reserves ready to prepare for Fractography and 3D CT imaging.

Next quarter:
- We will finish the CGA of the coals. A proposal for access to the Australian Synchrotron medical imaging beam line (for 3D CT image collection) will be submitted if able or CT images will be collected using a desktop CT device.

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

University of New South Wales
Yansong Shen

Value: $100,000
Report Expected: 25/04/2018
Industry Monitor/s: Chris Urzaa
Morgan Blake
Stephen Brant
ACARP Contact: Dave Osborne

This project aims to evaluate the performance of Australian black coals in the operation of pulverized coal injection (PCI) in the raceway of ironmaking blast furnace (BF) under industry-scale BF conditions, rather than lab- or pilot-scale conditions. In particular, the project will assess the suitability of two types of calculations of coal combustion efficiency (termed burnout) under real BF conditions for a range of Australian black coals i.e. burnout calculation over the entire raceway surface vs. burnout calculation along the tuyere centreline only.

During the past three months:
- Model improvement: Significant effort has been made to improve the PCI model by including more details. In this quarter, we further refined a CFD-DEM model to simulate the raceway shape and size, and in the meantime, we developed a Euler-Euler model to simulate the raceway shape and size, considering the CFD-DEM approach is expensive in computational cost and thus sometimes it is not feasible for large-scale industry simulations.
- Some coal data has been received from Peabody and CSIRO in August.
- Typical results: They have been used in PCI simulations by the modified PCI model. New simulations are running. The results with confident convergence should be available by the end of Nov. Two types of calculations of coal combustion efficiency (termed burnout) under real BF conditions are conducted for a range of Australian black coals i.e. burnout calculation over the entire raceway surface vs. burnout calculation along the tuyere centreline only.
- Yansong attended a review meeting in September, and reported the recent progress.

C26042
Coal Swelling in PCI Lance Conditions

University of Newcastle
Liza Elliot

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

Swelling of coals in the tuyere lance during pulverised coal injection is expected to occur rapidly and is associated with the sudden exposure to heat emanating from the tuyere / raceway and the heated gas in the blowpipe. This swelling potentially risks the formation of blockages in the PCI lance which could result in a reduction or loss of PCI rate to the furnace. Lance blockage risk increases with increasing PCI rate. Therefore, as blast furnace operators attempt to increase productivity by increasing PCI rates, they will become more concerned with ensuring the selected coals used in PCI do not block the lances of their furnace(s). The proposed project aims to investigate the swelling performance of coals in PCI before combustion and determine key parameters for judging the likely swelling of coals within the lance before entering the blowpipe. The results will be compared with crucible swell numbers which are determined at significantly different conditions to those inside the lance to better determine whether the swelling of coals within the lance can be attributed to the natural coking properties of the coal as measured by CSN, or if CSN is unsuitable for predicting the behaviour observed.

Heat transfer calculations indicate the temperature of the carrier gas within the lance does not attain the temperatures necessary for devolatilisation and the resulting swelling behaviour to occur. However, the lance wall is well above devolatilisation temperatures, suggesting a mechanism where the coal particles
settled or travel on the tube wall, heating by conduction and swelling during devolatilisation may be occurring.

Initial trials of the experimental apparatus found that the off gas was too hot. This caused difficulty in collecting the coal sample once it had passed through the furnace. A quench gas and cooling circuit has been added. Operability of the cyclone for collecting the sample at these new conditions is being assessed.

C26043
Characterising the Degradation of Cokes made from Australian Coals and Subjected to Simulated Blast Furnace Operating Conditions

University of New South Wales
Paul Zulli
Xing Xing

Value: $167,640
Report Expected: 25/02/2018
Industry Monitor/s: Stephen Brant, Tim Manton

The main objective of the project is to develop the understanding of degradation of metallurgical cokes under simulated BF ironmaking conditions (measured gas and thermal profiles within the furnace). This project will provide both a fundamental and applied means to assess coke performance, related to inherent coal and coal blend properties.

Progress to date (against Milestones M1-M9, see below):
- M1 - M4 were completed in the period from February to May;
- M5 - M6 were completed in the period from June to September;
- M7 - Tensile strength, I-drum tumbling strength, crystallinity, microstrength and porosity of two cokes gasified and annealed under the more aggressive conditions have been determined using tensile testing, I-drum tumbling testing, XRD, ultra-micro indentation and image analysis;
- M8 - The final report is under the preparation.

The gasification under higher CO2 concentrations promoted the solution loss reaction. The addition of H2 into gasification atmosphere only slightly increased coke gasification.

When H2 is added to the gas mixture, the following reactions take place:

\[ CO_{2(g)} + H_{2(g)} = CO_{(g)} + H_{2O(g)} \]  \( (1) \)

\[ C_{(s)} + H_{2O(g)} = CO_{(g)} + H_{2(g)} \]  \( (2) \)

Addition of H2 to the CO2-CO gas mixture increases CO to CO2 ratio; however, coke gasification by H2O formed by reaction (1) is faster in comparison with gasification by CO2, what explains the increasing gasification rate with addition of H2. Hydrogen also directly reacts with coke forming CH4; however, the degree of this reaction at high temperatures is quite low.

I-drum tumbling test and tensile test determined the degradation of coke periphery and core, respectively. The tumbling strength of both high reactive coke (Coke D) and low reactive coke (Coke H) decreased upon gasification in BF-like conditions; however, the degradation of tensile strength upon gasification only observed for Coke D. This indicates that the degradation of cokes with high reactivity (Coke D) under BF-like gasification conditions, took place through the entire coke lump; however, the degradation of coke with lower reactivity (Coke H) was more severe at the periphery than in the core. After the subsequent annealing up to 2000 °C, the degradation of coke periphery and core occurred in the same manner for both cokes. Analysis of porosity development of cokes confirmed degradation upon gasification and annealing observed in testing of coke strength.

Under the BF-like gasification conditions, the strength degradation of Coke D was more significant than that of Coke H in both periphery and core; however, with further annealing up to 2000°C, the strength of Coke D degraded less than Coke H. This indicates that the effect of the high temperature annealing on coke degradation is significant, so an assessment of coke quality and performance in the BF should be evaluated under high temperature (2000°C).

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M1 - Collection and characterisation of coal and coke samples including feed coke, parent coals
M2 - Initial workshop
M3 - Coke gasification
M4 - Coke annealing
M5 - Interim workshop
M6 - Characterisation of cokes treated under the simulated BF conditions
M7 - Characterisation of cokes treated under more aggressive gas conditions
M8 - Preparation of final report and publications
M9 - Final workshop

The characterisation of the coke treated under the more aggressive conditions will be completed in November (M6). Two selected cokes (Coke D and Coke N) will be subjected to Pearson Bireflectance analysis to determine the change in microtexture upon gasification and annealing. The final report will be drafted in November (M8).

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

University of Queensland
Karen Steel
Wei Xie

Value: $149,750
Report Expected: 25/04/2018
Industry Monitor/s: Ashley Conroy, Nick Andriopoulos, Oliver Scholes

ACARP Contact: Dave Osborne

This project is a follow on from project C24055 of the same name. In project C24055 we observed interactions occurring and proposed that inertinite plays an important role in volatile release behaviour, and consequently liquid phase behaviour,
which has a variety of impacts on behaviour in the coke oven. In this project we are attempting to confirm our hypotheses. In particular, we are doing ‘cross-fertilisation’ studies where we mix the inertinite from one coal with the vitrinite from another. To produce maceral concentrates we are attempting to handpick macerals from large chunks. We are using the same analytical techniques of rheometry, DETA and TGA, however, the TGA analysis will be conducted on larger sample sizes to allow better mass transfer to occur within the sample.

We have developed a procedure for producing maceral concentrates which involves hand-picking in an N2 filled glovebox (with 0.0% O2). Petrographic analysis on Coal #1 and Coal #2 indicate 86.8% and 90.6% vitrinite, respectively, in the vitrinite-rich concentrates, and 78.4% and 86.6% inertinite, respectively, in the inertinite-rich concentrates. We are extremely pleased with this high degree of separation. The samples will be forwarded to ALS to conduct coal grain analysis to obtain further information on the petrographics. We have also forwarded the samples to Richard Sakurovs for him to carry out small angle neutron scattering to examine the pore characteristics. Rheometry and DETA test work on Coal #1 indicated a loss of liquid material when the inertinite was blended with the vitrinite and also a retention of volatile matter. At this stage it is proposed that volatile matter becomes trapped/adsorbed onto the pore structure of the inertinite. The integral of the DETA curves also suggested a retention of carbon. Rheometry test work on Coal #2 also indicated a loss of liquid material. Interestingly, we achieved identical viscoelastic measurements when the vitrinite from Coal #1 was blended with the inertinite from either Coal #1 or Coal #2. We also achieved identical results when the vitrinite from Coal #2 was blended with the inertinite from either Coal #1 or Coal #2. This suggests that the inertinite in each of the coals interacts with vitrinite in a similar way.

We are currently producing maceral concentrates from Coal #3 and will be completing the rheometry and DETA test work before continuing with the cross-fertilisation studies. Following this we will move towards hypothesis building/testing with regards to the interactions occurring. We will also complete high mass TGA studies to support the DETA results.

**C26045**

Mineralogy Effects on the 3D Porosity of Coke

*University of Wollongong*

Brian Monaghan  
Richard Sakurovs

| Value: $189,140 |  
| Report Expected: 25/04/2018 |  
| Industry Monitor/s: Kim Hockings, Oliver Scholes, Tim Manton |  
| ACARP Contact: Dave Osborne |

The specific focus of the proposed work will be to utilise the coke analogue in combination with 3D microCT analysis to evaluate not only the effects of mineralogy on reactivity but specifically how the minerals are effecting porosity development with time and temperature.

Key outcomes of the project will be:

- A brief review of 3D measurement and characterization techniques applied to coke; and
- A validated and extensive 3D data set of coke reactivity data with time and temperature that can be used to inform extant CSR/CI data and its application.

Dr Dong’s focus is on the 3D modelling. He is progressing developing a methodology for 3D analysis:

- Written a draft paper based on synchrotron data. The mentors will receive in the coming weeks for review. This work was presented at the Workshop of Australian Coal Research on Metallurgical Coal at UNSW on 28/7/2017.
- CSIRO has almost completed all the first series of micro CT measurement. We are currently awaiting data. At this point things going to plan.

A complete review of 3D measurement submitted to ACARP and the Industry Monitors in October.

Jayasekara has completed all experimental work for the initial coke analogues. Progress on the 2D characterization (SEM, XRD, porosity and reactivity) of the analogues is complete.

**C26046**

Relevance of Maceral Concentrates to Whole Coal Coking Predictions

*University of Newcastle*

Wei Xie

| Value: $69,500 |  
| Report Expected: 25/05/2018 |  
| Industry Monitor/s: Graeme Harris, Kim Hockings, Oliver Scholes |  
| ACARP Contact: Dave Osborne |

The first goal of this project is to clarify how to concentrate maceral components from coke oven feed particles combining the reflux classifier and Coal Grain Analysis. The second goal is to examine what maceral concentrates represent in whole coal and the extent of the concentrates and the blends modify industrial fluidity of whole coal. The third goal is to establish the relevance of coal maceral concentrates on whole coal coking prediction. To achieve these goals, this project uses Coal Grain Analysis (CGA) for analysing coal maceral populations and compositions of whole coal, Reflux Classifier feed and products; Reflux Classifier for concentrating coal maceral concentrates; and Gieseler plastometer for evaluating the fluidity of the concentrated maceral particles containing heterogeneous vitrinite and inertinite and particles of similar maceral compositions, produced from a blend of vitrinite and inertinite dominant particles.

In the last quarterly report, we mentioned that we were expecting to receive 3 coals with varying ranks, 1.0, 1.3 and 1.5% reflectance from the ACARP coal bank. However, we were suggested that the ACARP coal bank could only provide us with a small amount of small coal particles. Because we need a big amount of large coal particles to achieve our goals, we have to request these coals from coal suppliers. To date, we received the first coal on October 10. We are preparing this coal sample for the CGA test. Over the next quarter, we are expecting to complete the CGA test, the reflux classifier separation and the fluidity analysis for the first coal.
**General**

**C25044**

Trace Elements in Coal: Status of Test Methods in use and Applicability to Industry Needs

QCC Resources
Ian Anderberg

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<td>Graeme Harris, Greg Wickman, Kahlee Saunders, Kay Palmer, Kristene Rhodes, Oliver Scholes</td>
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ACARP Contact: Dave Osborne

The current work is an extension and has two key objectives:
- Provide confidence in the level of precision and accuracy for analysis of As, Cd, F, Hg and Se performed by Australian coal testing laboratories; and
- Evaluate the potential for bias on fluorine for a wider range of Chinese coal reference materials.

All reference materials have been obtained and unknown Australian coal samples prepared. Six laboratories are participating in the interlaboratory test program. This has involved the issue of blind coal reference materials and unknown samples generated from Australian coals to the participants. The first of the three rounds of testing was started in August and is now complete. The second round of testing will start in November with the final round planned for January.

**C25047**

International Carbonisation and Coke Testing Round Robin

ALS Coal
Adrian Reifenstein

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ACARP Contact: Dave Osborne

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

**C25050**

Overview of ACARP and NERDDC Outcomes

CSIRO
Richard Sakurovs

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ACARP Contact: Dave Osborne

The main objective of this work is to present an overview and synthesis of the main findings generated by ACARP and NERDDC activities to make them more accessible to the coal industry and researchers entering the coal and coke research areas.

The individual summaries and assessments of the 120 reports are largely complete. Report preparation and identification of research gaps will start before the end of the year. The expected date for submission of the draft report is April 2018.

**C25053**

Coal Sample Bank

CSIRO
Keith Vining, Lukas Koval

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<td>Graeme Harris, Kim Hockings, Technical Market Support Committee</td>
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ACARP Contact: Dave Osborne

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

This project started in March 2017. To date, 17 coal samples were delivered and stored at -18°C and their details updated to the database. Out of 17 stored coals 13 were fully analysed and analysis results provided by the provider. Special request for three coal samples to support the research project C26046 was send to the selected providers, however only one was provided up to date.

An additional three samples were added to the database. In addition first coke sample will be also provided by the same producer.

**C26003**

Management of SA and ISO Coal Technical Committees Work Programs

Carbon Connections
Barry Isherwood

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ACARP Contact: Dave Osborne

This project is a continuation of ACARP support for the management of and input into both Australian and ISO Coal Sampling, Preparation and Analysis Standards.

The ISO TC27 Solid Mineral Fuels, was held in Brisbane in October and a full report is currently being written.
C26037
Australian Participation in Development of ISO Methods for Sampling, Analysis and Coal Preparation and National Technical Committee Support: 2017/2018

Standards Australia
Ahshanur Rashid

Value: $117,500
Report Expected: 25/01/2018
Industry Monitor(s): Kevin Rowe, Kim Hockings, Rebecca Fleming

ACARP Contact: Dave Osborne

ACARP supports Australian representation on key International Standard Organization (ISO) committees of relevance to coal exports and to the Standards Australia National Mirror Committee MN-001. This investment enables Australia to influence and shape the international development of methods for sampling, analysis and coal preparation standards. This current support is for the following:

Support for Australian Mirror Committee - Schedule of meetings:

- MN-001 (Coal and Coke)—Mirror Committee for ISO/TC27, chaired by Barry Isherwood
  - Next meeting 2018 (date and venue TBA)
- MN-001-01 (Coal analysis) — Mirror Committee for ISO/TC27/SC3 and SC5, chaired by Barry Isherwood
  - Last meeting: 27th July 2017, BHP Office, Brisbane
  - Next meeting: 16th November 2017, Newcastle
  - Meeting objective: Review ISO/TC27/SC5 & SC3 documents including systematic reviews and finalise Australian mirror Committee position on ISO ballot (and comments).
- MN-001-02 (Coal Preparation) —Mirror Committee for ISO/TC27/SC1 and SC4, chaired by Dave Osborne
  - Last meeting: 10th August 2017, NIER, Newcastle.
  - Next meeting: 30th November 2017, CSIRO QCAT.
- MN-001-05 (Coal Mining and Geology), chaired by Walter Pickel
  - No meeting planned; Subcommittee has no work program.
- MN-001-06 (Determination of Gas Content), chaired by Jim Sandford
  - No meeting planned; Subcommittee has no work program since publication of AS 3980-2016.

- Organised and ran the ISO/TC 27 Meeting 15-20 October 2017 at the Stanford Plaza, Brisbane:
  - Invitation forwarded to ISO/TC27 for 2017 plenary meeting;
  - SA created a website for ISO TC 27 meeting. ISO/TC27 Secretariats (and delegates) will be using this in preparation of the meeting documents:
  - SA Events Team and SA Project Manager supported ISO/TC27, SC Secretariats and MN-001 Committee to make the meeting successful.
The current project work is Phase-IV and is concerned with the development and demonstration of the Stone Dust Looping (SDL) process for abatement of the ventilation air methane (VAM). Previous phases of this project are designated as Phase-I to III and they primarily focused on prototype development and pilot-scale demonstration of the SDL process without the option for regeneration of stone dust particles. The vision in Phase-IV is to furnish the SDL process with the necessary means for in-situ regeneration of these particles. This is driven by the fact that additional heat is released when the CO2 formed by the oxidation of VAM reacts with the calcium oxide particles undergoing the in-situ regeneration. This in turn, enables the SDL process to reach the state of auto-thermal operation (i.e. self-sustaining) at methane concentrations as low as 0.2 Vol% and temperatures well below the auto-ignition temperature of methane (about 450°C). This phase aims at pilot-scale demonstration of the above configuration as well as determining its scaling principles and techno-economic merits.

It is a two year project with the primary aims of:
- Design, construction, commissioning and field trials of a 200 m³/hr (~56 L/s) twin-reactor SDL unit fitted with a manifold gas switching (MGS);
- Derivation of the scale-up rules for the twin-reactor in the MGS configuration;
- A detailed techno-economic assessment of the twin-reactor in the MGS configuration.

The focus of the first year of the project is on objective (i). The design of the SDL unit is ongoing. Budget estimates for fabrication have been received and the design reviewed and updated based on feedback from fabricators. The tender process for fabrication has commenced. The following progress has been achieved against the relevant milestone tasks.

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C24061
Proof of Concept Photocatalytic Destruction of Methane for Coal Mining Fugitive Emissions Abatement
CSIRO
Yonggang Jin

Value: $179,120
Report Expected: 25/12/2017
Industry Monitor/s: Ben Klaassen, Jim Sandford
ACARP Contact: Roger Wischusen

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

C26004
CFD Modelling of Reverse Thermal Oxidisers for VAM Abatement: Phase 1
University of Newcastle
Behdad Moghtaderi

Value: $154,320
Report Expected: 25/12/2017
Industry Monitor/s: Donna Dryden, Jim Sandford
ACARP Contact: Roger Wischusen

This project is part of a larger multi-phase program of study aimed at Computational Fluid Dynamics (CFD) modelling of Ventilation Air Methane (VAM) abatement systems. The study consists of two phases with Phase-I focusing on CFD modelling of ceramic-brick RTO devices and Phase-II dealing with fixed-beds.

During this quarter the CFD modelling work for the reverse thermal oxidisers for VAM abatement has continued its progress towards achieving key targets. The project is on time and budget. Of particular importance is that the base CFD model has now been completed and validated against two comprehensive sets of experimental data for homogeneous gas explosion in a detonation tube with no flame arrester designated as Test-7 and Test-13. The simulations were carried out using ANSYS Fluent 18.1 CFD package. The model equations were discretised in space and time following the control volume approach and utilizing a transient pressure based solver. The flow domain was represented with a quad mesh and second order numerical schemes were used in the simulation. The Flame Generated Manifold (FGM) combustion model was chosen because it uses...
detailed chemistry and provides significant advantages over other models which use empirical relations and require calibration for different operating conditions.

As observed in the experiments, the set of conditions for both Test-7 and Test-13 led to deflagrations and not detonations. Grid independence studies were carried out after carefully choosing appropriate turbulence and reaction models. A grid-refinement study showed that an adequate resolution of the flow field had been achieved. Initial turbulence level was found to have a major role in predicting the onset of pressure rise in overpressure prediction. The explosion process is very fast so to resolve flow and reaction timescales for accurate prediction of reaction progress and pressure wave, a CFL number below 0.1 was used. From this study, it is noted that it is important to choose appropriate initial turbulence and time-step values for other operating conditions. The onset of pressure rise and overall overpressure prediction has been predicted closely in this study for Test-7 and Test-13.

It can be concluded from this validation exercise that the developed methodology can be used to simulate explosion in detonation tubes for this and other operating conditions. The model is readily extendible to other geometries and situations. As a result, the team is currently running some experiments in the detonation tube with ceramic bricks to collect data on flame arrester properties of checker bricks in regenerative thermal oxidisers. The data will be used in the next quarter against the predictions of the CFD model to assess the effectiveness of the ceramic bricks in preventing pressure and flame front propagation.