CURRENT PROJECTS

This report is a summary of current projects for the months May, June and July 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_mining@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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MAJOR PROJECTS

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 Organization 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 has commenced self-heating research work in conjunction with Assoc. Prof. Kenneth Williams at the Centre for Bulk Solid and Particulate Technologies (CBSPT) and The University of Newcastle, with four test ovens in full time use to further understand the self-heating behaviour of coal cargoes.

The project has also commenced detailed corrosion studies in conjunction with Prof. Rolf Gubner and Dr. Katerina Lepkova at the Curtin Corrosion Engineering Industry Centre. The research work is focussed on developing a detailed understanding of the corrosion properties of bulk coal cargoes.

During September two information papers will be presented to the International Maritime Organization (IMO) by the Australian Maritime Safety Authority (AMSA) advising of the research program currently underway.

For further information on the project please contact project leader Ash Goodwin on 0419 794 837 or via email ash@goodwinportsolutions.com.

C20003
RISKGATE

University of Queensland
David Cliff

Value: $4,229,733
Report Expected: 25/09/2017
Industry Monitor/s: Occupational Health and Safety Task Group
ACARP Contact: Keith Smith

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.
Coalburst

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: 25/09/2017
Industry Monitor/s: Coalburst Task Group
ACARP Contact: Roger Wischusen

This project is a continuation of the scoping study that was completed in April 2016. 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 final report will be submitted by the end of August.

C26006
Coal Burst Monitoring Technology Using Microseismicity

CSIRO
Xun Luo

Value: $230,500
Report Expected: 25/09/2018
Industry Monitor/s: Coalburst 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 to make it available for coal burst research; and to perform preliminary data processing and evaluation.

In the first trial at Appin Mine, microseismic events associated with LW708 development and LW707 mining have been recorded. Many of the weak events recorded in the LW708 development are located in the fault areas. They may be used for assessing the change of stress conditions in the fault zones for coal burst prediction. Detailed data processing in in progress. Appin Mine has stopped mining and the microseismic monitoring system has not been in operation since May 5 because of the lack of a power supply.

Narrabri Mine is the second trial site for the project. The mine has recently experienced numerous ‘pressure bumps’, mostly in the gateroads near the major geological structures during longwall retreat. The design of the microseismic network for investigating the structure response in relation to pressure bumps is in progress.

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: Coalburst Task Group
ACARP Contact: Peter Bergin

Stress state and geotechnical conditions often change significantly near major geological structures (e.g. 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.

The project started in May. One of the key tasks within the project scope is to conduct 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. Appin Mine was initially selected to conduct this monitoring, and a preliminary monitoring design had been carried out for microseismic and stress monitoring at the location of the thrust fault which will be encountered during the roadway development of the Menangle Mains. However, due to the recent temporary closure of the mine, the planned monitoring at Appin Mine became uncertain, and an alternative mine site needs to be sought. After a site visit and preliminary investigation on the geotechnical and mining conditions, we have identified Narrabri Mine as an ideal alternative monitoring site for the project. Currently a detailed monitoring plan is being developed which will include microseismic, stress and displacement monitoring of an existing gateroad near a major dyke. The monitoring will focus on the roadway response during longwall retreat, and it will take place during October – December 2017.

Numerical modelling is being carried out to predict stress conditions near the thrust fault at Appin Mine. A large UDEC model has been set up, which includes the thrust fault and actual geological units at Appin Mine. The likely tectonic movement that generated the thrust fault in history is simulated by applying horizontal squeezing displacement on the model boundaries, and the stress redistribution in the vicinity of the thrust fault is investigated. Preliminary results indicate that high stress concentration exists in different zones near the faults. This could explain the observed deterioration of mining conditions. This work is ongoing and the next step of the investigation will focus on three-dimensional modelling using 3DEC.
C26060
Mechanics of Gas Related Coalbursts in Mining
SCT Operations
Winton Gale

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

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

The project was commenced in April. 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.

The project is financially on track and on schedule.

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 : Coalburst Task Group
ACARP Contact: Bevan Kathage

This project has achieved the measurement of Young’s moduli, Poisson’s ratios and Biot’s coefficients on nine triaxially loaded samples. These have shown that Young’s moduli are primarily dependent on the mean stress level within the coal with changes in stiffness up to an order of magnitude. The values of Poisson’s ratios are dependent on the mean stress but more on the shear stress and vary from almost zero to 0.4. Biot’s coefficients vary from 0 to 0.35. There is some degree of anisotropy in all parameters but this is less than in typical sandstones. The samples tested need to be examined to determine the influence of coal type on the mechanical behaviour.

A process for hydrostatic loading tests of coal fragments with fluid injection has been developed and the first test has been conducted and is apparently successful but not yet analysed. Hydrostatic tests cannot yield information on Poisson’s ratios.

Biot’s coefficient describes the poroelastic behaviour of the material. This leaves unanswered the effect of fluid pressure within small fractures, including cleats, within the coal. The prime need here is to know what fractures are open and affected by fluid pressure. The project is well ahead of plan and should be completed before the end of the year.

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

Value: $612,200
Report Expected: 25/03/2019
Industry Monitor/s : Coalburst 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.

A major portion of the project involves the application of an energy approach to the analysis of outburst and coal burst events. The energy approach requires an understanding of the stress distribution within the coal seam, the gas pressure, the elastic properties of the coal at changing conditions of confinement, the diffusion coefficient of the coal and the local structural regime. The latter is extremely important in understanding the mechanism of either of these events.

None of the above critical properties are routinely measured. Initial work has included agreement with participating operations, background data collection and examination of available outburst and coal burst documentation. The integration of exploration data has commenced using initial data sets from both Appin and Narrabri. The purpose of this is to understand the variation of major parameters on a site. Geophysical logs, acoustic scan data and full wave form sonic logs have been reviewed in the light of known measurements on a local scale. Samples of coal have been collected to measure strength, toughness, elastic properties, native sorption isotherms and structural fabric. Some of this work has been accomplished under the sister project C26061.

What is needed now is for mechanisms to be determined. Some substantial discussion must be held with the mines to discuss the failure mechanisms they have observed. In addition some testing will need to take place on site. This has not been budgeted into the research programme as it is really exploration work that the mines should conduct as part of their normal operations.

The project is substantially on schedule. It is intended to be a project involving the interaction of Sigra and the cooperating mines to arrive at the improved means of outburst an coalburst prediction. Sigra looks forward to more interaction.
C26066
Energy, Burst Mechanics Required for Coalbursts and Energy Release Mechanisms

University of New South Wales
Ismet Canbulat
Winton Gale

Value: $357,500
Report Expected: 25/05/2019
Industry Monitor(s): Coalburst 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 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;
- Preliminary analytical models have been developed to determine the strain and gas expansion energies in the rock masses;
- An international survey has been conducted in countries where the magnitudes of coal bursts have been measured and the amount of expelled coal and the severity of the events were recorded.

SCT Operations 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. The project is financially on track and is within the timeframe anticipated.

Environment - Subsidence and Mine Water

C20038
Standardised Subsidence Information Management System

NSW Department of Industry
Gang Li

Value: $655,000
Report Expected: 25/09/2017
Industry Monitor(s): Dan Payne, Phil Enright
ACARP Contact: Peter Bergin

The objective of the extension 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 parent project C20038. During the quarter the project team has been focusing on carrying out the work for Stage II of the project (please refer to the Gantt Chart).

We have completed the preliminary design of the query facilities for each of the project tasks (ie horizontal movements, maximum compressive strains, maximum tensile strains, maximum tilts and maximum subsidence). The results of our preliminary design were sent to the industry monitors for their comment.

We are currently focusing on:
- Finalising the design before the commencement of software development; and
- Identifying and rectifying data errors, outliers or anomalies to improve the quality of the product.

There are challenges in undertaking the project, especially in the area of recovering the missing mining information, such as face positions, longwall dimensions, cover depths, etc. As a result of the missing mining data, certain desired query outputs may not be possible to be completed within the project time frame. However, according to our latest review of the status of missing mining information in the database, the project team are reasonably confident that the above-listed project tasks can be delivered without delay.

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

This project seeks to optimise protocols for cultivation, preservation and planting of germplasm from a number of Persoonia species. Little is known regarding the ecology of this genus beyond common factors of rare species such as limited fruit set, poor seed germination and poor tolerance of transplantation. Many of these species are listed as threatened or endangered and also occur on mining leases in New South Wales, with several species the subject of mining consent conditions.
The development of recovery programs for these species urgently requires research into ecological and biological requirements for genetically robust ex situ recruitment. Persoonias are notoriously difficult to cultivate from seed making the optimisation of protocols for seed germination, tissue culturing and propagation a priority. They naturally occur in dynamic habitats that are prone to fire, yet there are clear interspecies differences in Persoonia life history responses to these disturbances. In response to fire for example, some species resprout while others are obligate-seeders, relying on seedbank generated recruitment to continue in the post-fire environment. The complex life histories of Persoonia species give clues to understanding their seed dormancy issues. Accordingly, our research into germination takes into account numerous variables in a multi-factorial experimental approach. Comparative studies between species are also useful in highlighting possible genus based dormancy patterns.

Several articles are being prepared on seed biology of Persoonia for publication in international science/restoration journals as well as the final report on the first part of project C24013. Along with the information on management biology of Persoonia species generated by this project, a significant legacy of the project is the extensive seed and plant materials that is being used in the next phase of the project which concentrating on the issues involved in successfully re-establishing these species, particularly focusing on Persoonia hindii and P. hirsuta. In preparation for a planting of P. hindii in Autumn 2018, we are liaising with Western Sydney University and the Office of Environment and Heritage to quantify the genetic diversity among 15 populations on Newnes Plateau. Coupled with genetics, we are summarising the ecology of these sites using the spatial data provided by University of Queensland. Together, this will guide selection of potential recipient sites for the experimental trial planting in 2018.

Poor propagation success with P. hirsuta has meant that further propagative material is required to continue trials. P. hirsuta populations have been visited at Couridjah, Yanderra and Glenorie. A collection of 400 fruits was made from Glenorie. Cuttings will be collected from plants at all sites. Plants at all three sites are believed to be ‘intermediates’ between P. hirsuta subsp. hirsuta and P. hirsuta subsp. evoluta. The same ‘intermediate’ plants also occur Westcliff Colliery.

Persoonia are documented in the literature to require cross-pollination for larger fruit set. Given P. hirsuta and P. hindii often occur in small, fragmented populations or isolated individuals, it is possible that fruit set is pollinator-limited. Therefore, our experimental field-based work will examine pollinator limitation and its potential impact on natural recruitment across P. hirsuta and P. hindii populations during peak flowering in summer.

C25056
Change Detection in Complex Vegetation Communities

Biosis
Andrew Fletcher
Richard Mather
Sam Luccitte

Value: $274,700
Report Expected: 25/10/2018
Industry Monitor/s: Bernie Kirsch
Gary Brassington

ACARP Contact: Keith Smith

The project work has not commenced as yet. We are making final administrative and logistical preparations for commencement of the project which is planned for mid/late August. The project will start with the field capture of remote sensing and swamp vegetation data.

Exploration

C24016
Automatic Determination of Lithology Boundaries From Downhole Geophysical Logs

GeoCheck
Brett Larkin

Value: $76,000
Report Expected: 25/08/2017
Industry Monitor/s: Malcolm Ives
Patrick Tyrrell

ACARP Contact: Peter Bergin

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

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: 25/10/2017
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, sulphur and phosphorus 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-scanning 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, especially of claystone bands, 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.

A series of synthetic calibration standards has been prepared, based on intimate mixtures of low-ash coal with measured proportions of key mineral components. After a comprehensive check analysis program, it is planned to make these available to selected industry organisations, to assist with calibration of individual hand-held XRF units for coal applications. Papers outlining progress with the project were presented at the 40th Sydney Basin Symposium in the Hunter Valley (April 2017), and at the BBGG-ACARP Meeting in Mackay (July, 2017).

C24065
In Seam Wireless Drill Strong Communication System: Phase 2
University of Queensland
Eddie Prochon

Value: $330,000
Report Expected: 25/09/2017
Industry Monitor/s: Brad Elvy, Jim Sandford
ACARP Contact: Russell Howarth

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 design and manufacturing tasks have been completed. Static pressure testing and dynamic flow testing of the system (to simulate downhole operating conditions) has been completed for the fully assembled mechanical system.

Electrical and Electronics - All electrical design and manufacturing tasks were completed in early 2017. As of July, the software for the operating system and the Digital Signal Processing (DSP) code have been successfully implemented and function tested.

Intrinsic Safety Certification - The assessments for intrinsic safety certification was completed in December 2016. Inspection of the electronics assembly and witnessing of the encapsulation of the electronics was completed on 3rd August by a Simtars AS/NZS 60079 certifier at Mining3 premises. The draft intrinsic safety certificate for the BHA has been issued as of 9th August, and will be finalised within two working days of this date once Mining3 has completed cross-checking of all document references.

Field Deployment - Mining3 have locked in a deployment window of mid-to-late August with Tahmoor underground mine, during which the drilling department will undertaken drilling of cross-measure holes (600m – 700m). We are currently finalising operational procedures, and scheduling of a drill rig and drill rig operator.

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

Value: $178,000
Report Expected: 25/11/2017
Industry Monitor/s: Patrick Tyrrell, Paul O'Grady
ACARP Contact: Bevan Kathage

This is an extension project that builds on the successfully-completed project: C22016 ‘Enhancing fault detection by seismic diffraction imaging’. In C22016, algorithms were developed to extract diffractions from both 2D and 3D reflection seismic data. The extracted diffractions can then be used to identify small faults and dykes that are difficult to detect using conventional seismic reflection processing. However, diffraction extraction using these algorithms is only effective for seismic data from horizontal or sub-horizontal coal seams. The objective of this project is to evaluate the efficacy of the previously developed algorithms for improving the reliability of small fault detection, and develop new filtering techniques to extract the seismic diffraction signals from reflection seismic data with multiple coal seam and strata, dipping at different angles. The new technique will improve the efficiency and effectiveness of detecting the anomalies and discontinuities ahead of mining in a complex geological environment.

Following the recommendation by the industry monitors, in the past quarter, a structural geologist has been engaged to further evaluate the prototype algorithms developed in C22016 for the detection of small faults with the two Glencore 3D seismic datasets from several mined out longwall panels. At the final project review meeting held on 6 July during the BBGG-ACARP meeting in Mackay, it was concluded that diffraction imaging added confidence and precision to the interpretation of structures with > 2m throw, and lowered the detection limit of smaller faults. It was noted that the diffraction images contained information that with further algorithm enhancement should significantly improve the small fault interpretation.

The final report is now being prepared and it is expected that a draft of the final report will be submitted for review in October.
### Maintenance

#### C24007
**Longwall Hydraulic System Over Pressurisation Hazards Prevention**

**Asset Performance Improvements**
Henry Bartosiewicz

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The longwall system hydraulic pressure monitoring programs carried out at Mandalong and Newlands Northern Underground mine during previous project C17020 revealed the presence of anomalous and significant pressure transients in some hydraulic circuits of the Caterpillar shields. These extreme pressure transients can affect the safety, reliability and operational performance of the longwall system.

It is important to develop a good understanding of the conditions under which these over pressurisation events can occur in practice and to identify remedial actions in order to reduce these extreme loading conditions.

The objectives of this project include:

- Establish hydraulic pressure loading profiles (including sustained and transient pressures and their frequency) during operating cycles for different designs and various ages of longwall shields currently used in Australia (i.e. Joy, Caterpillar and Nepean/Inbye);
- Investigate the root causes of abnormal and unacceptable over-pressurization issues;
- Identify remedial actions to reduce extreme loading conditions (i.e. hose diameter and length changes, bend radius reductions, valve sequencing and relief capability, tuning of control systems, improved pressure sensing devices/strategies, contamination control etc). Where practical verify the effectiveness of proposed solutions in-situ or in the test rig; and
- Review the applicability of existing criteria and methodologies for general impulse and other types of prequalification tests specifications used in qualifying longwall hydraulic hoses and other system components.

The draft project report has been completed and sent to the industry monitors for their review.

#### C25054
**Distributed Acoustic Conveyor Monitoring - Phase 2**

**University of Queensland**
Fernando Vieira
Karsten Hoehn
Paul Wilson
Saiied Aminossadati

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The project will convert the basic principle of identifying malfunctioning idlers on underground conveyors in their early stages of failure, developed during Phase 1 (C24014), into a viable and commercialisation-ready technology.

Immediate focus was to trial the DAS technology on a conveyor at an operating underground mine. In September and October 2016, optical fibre was installed along the conveyor UC001 at the Anglo American Moranbah North coal mine.

An OptaSense DAS interrogator was used until the end of October 2016. It was replaced by a Future Fibre Technologies in November which was sporadically operational until April 2017. It then became out of service indefinitely owing to a longwall change and a lack of site support. Thus far, it has not been possible to retrieve this unit from Moranbah.

Since April two further interrogator models have been tested using a schedule of comparison tests. These were the new Future Fibre interrogator and one on loan from Fotech at their request.

The Mining3 test rig was moved to a new laboratory and re-commissioned. Using the new rig with worn rollers from QBH and running several trials on the QBH ship-loading conveyor, the team has now defined a table of words and terms to describe roller failures and has identified the failure progression pathways towards bearing collapse or seizure and all their corresponding frequency signature patterns. The table of the ‘wear vocabulary’ and the chart of failure modes is now in full use for diagnostic purposes.

The technical specification for an interrogator suitable for the conveyor monitoring role is now well established and has been communicated to the manufacturers who have loaned us units for test. All the interrogators tested have been scored against the specification and three are suitable for use but some technical improvements have been suggested.

There has been intense interest from mines, mining companies and two power stations in trialling the system, but another test site is yet to be found. The research team has requested assistance from the industry monitors to find a site to host the second trial. Two other tasks need to be completed:

- Making further progress on the wear pattern recognition software; and
- Developing a more suitable method of coupling the fibre to the conveyor frame.
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 in underground coal mines. This proof-of-concept study is based on the laboratory tests of photocatalytic oxidation of model DPM.

Over the last three months, the work has focused on modifying commercial titania photocatalysts to enhance the reaction rate of DPM photocatalytic oxidation. The photocatalytic test results show that the nanosized model DPM with a primary particle size of 25 nm can be efficiently destructed and fully oxidised into carbon dioxide using the modified titania photocatalyst. The reactor was illuminated by a 300 W Xe lamp and the humidity was varied to optimise the reaction rate of DPM oxidation. The reaction rate of DPM destruction obtained to date is over four times higher than the best result found this Feb. Photocatalytic tests with other modified titania photocatalysts are underway to understand the effect of photocatalyst characteristics on the DPM oxidation and attempt to further enhance the reaction rate.

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.

A specification for the modelling has been completed, and trial calculations are progressing (albeit possibly 2 – 3 weeks behind the planned schedule).

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 New South Wales Department of Industry.

The engineering approach to surface temperature control uses a mix of thermal insulation and water cooled features. Robust performance of DPF system under the lower duty cycle conditions that are typical in underground coal operations has required the use of specific DPF technology.
This quarter has seen further refinement to the design of the mechanical and thermal systems, with surface testing undertaken at Newstan mine for correlation purposes. Milestones include:

- Validation of thermal performance using engine dyno assessments;
- Validation of DPF soot tolerance and regeneration stability using a 100hr transient test cycle;
- Engineering of explosion and flame protection DPF and integrated instrument enclosure; and
- Electronic monitoring system refinement and vehicle integration.

In-house dyno testing of the wall-flow DPF will continue over the next quarter 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.
C22015
CM Self Guidance: System Hardening and Underground Deployment
CSIRO
David Reid
Mark Dunn

Value: $1,092,765
Report Expected: 25/09/2017
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 project C18023 for installation on a production roadway development CM; and
- Provide a convincing demonstration of the performance and practical advantages of this advanced navigation technology in this specific underground application to the stage where mining companies and 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.

Underground trials commenced producing data on 7th April. 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.

Underground testing and validation will continue through August, followed by the final project report. Great feedback is coming from the mine site.

Feedback from crews:
- The miner drivers have been checking the machine heading from the LASC CM screen as they set the MB650 up for an auto cut sequence and they believe this is a great feature and allows them to position the machine with greater accuracy compared to the existing laser line alignment alone;
- Some particularly interested miner drivers have been keeping the machine within the green lines as much as possible, having competitions between each other and other crews to see who can keep it in the green zone the most; and
- Instead of relying on surveyors/operators to update large numbers of eastings/northings etc, Ulan West suggest adding a new step as part of the existing sequence plan.

C24023
Gateroad Development Continuous Haulage System: Stage 3
Premron
Mick Whelan

Value: $1,960,000
Report Expected: 25/08/2017
Industry Monitor/s: Roadway Development Task Group
ACARP Contact: Roger Wischusen

This project is a continuation of previous projects C22009 and C23017. The project aims to develop an autonomous Continuous Haulage System for Mine Gate Road Development, utilising the Closed Conveyor System of the “Premron CHS”.

The project is based around the following key objectives:
- Manufacture and demonstrate a full scale, full length (180m), fully functional mine compliant Premron CHS installed above ground (in Gladstone) and mounted on a 260m mine monorail test rig, with two opposing 90° corners;
- Continuous batch feeding during tramming, as the Premron CHS negotiates the mine monorail track;
- Confirm braking system for both trolley and conveyor belt, utilising inline modular Exd rated Brakes fitted to drive units;
- Undertake further studies on the system’s performance;
- Complete mine systemisation studies.

The systemisation studies have provided Premron with a better understanding of mine site integration with the CHS and different mining operations. Several layout drawings have been completed for various mining operations, with in house studies undertaken to ensure compatibility.

Several design changes have occurred with the CHS tail end and a more detailed understanding of the head end design has been finalised.

Premron is negotiating with a host mine, with further systemisation being undertaken next quarter to allow completion of the build. Underground trials are likely to occur during the second half of 2018.

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

Progress to date includes:
- A review was carried out of the findings from the 500 bolt underground trial held 2016 using an airtrack bolting rig with the retro-fitted prototype to install vertical, inclined and horizontal bolts;
- Design of the production standard prototype chemical pumping and delivery system is complete;
- Procurement and manufacture of all components is complete;
- The host mine released and delivered the continuous miner for modifications to adapt the OKA technology late July;
- Assembly of the chemical injection modules will be complete on 11th August;
- The software control system (Pempek) won’t be complete until 18th August. At this time, the injection modules and control system will be installed on the miner materials pod;
- Testing and commissioning will follow.

C25061
Bolter Miner for Rapid Longwall Development: Phase A

Sandvik Mining and Construction Australia
Barry Wright
Winton Gale

Value: $92,000
Report Expected: 25/09/2017
Industry Monitor/s: Roadway Development Task Group
ACARP Contact: Roger Wischusen

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

C25064
Longwall Floor Coal Horizon Sensor

CSIRO
Jonathon Ralston

Value: $213,736
Report Expected: 25/09/2017
Industry Monitor/s: Paul Buddery, Rae O'Brien
ACARP Contact: Roger Wischusen

This 18 month project aims to develop a coal thickness sensing capability to support the delivery of automated horizon control systems for longwall or roadway development. The project’s 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.

The project has progressed to the next stage of development activity to identify key engineering and operational requirements associated with achieving a short term system evaluation on the longwall. This has involved working through a number of important practical challenges which include: identifying a suitable installation location (physical space, survivability, power and communications), provision of equipment enclosure (electrically transparent window, suitability approved for purpose), and resolving a meaningful operational configuration (ground contact, observable subsurface geology). Working closely with key Glencore automation personal at Ulan West, a workable approach has been identified to enable for a short-term on-machine evaluation stage. This is being actively developed and includes rehousing of embedded system components to provide a portable sensing system. Further practical arrangements with regards to operational risk assessment and system monitoring are also being progressed with the view to undertake the evaluation in September at Ulan West. Opportunities for additional validation surveys are also being pursued with Anglo (Moranbah North).

C25069
Optimising Electrical Protection System Strategies and Technologies

ResTech
Clint Bruin

Value: $174,350
Report Expected: 25/09/2017
Industry Monitor/s: Brad Lucke, Greg Briggs
ACARP Contact: Peter Bergin

The project’s key objective is to improve productivity by reducing equipment downtime due to nuisance tripping of electrical protection systems, while maintaining or improving existing levels of safety.

Following extensive literature reviews and simulation studies, the first four parts of the project are complete. The last part, which includes the final report, is nearly complete.

Part A: Examining the state of the art
Part B: Earth continuity protection related issues
Part C: Earth leakage protection related issues
Part D: Adaptive protection evaluation
Part E: Analyse, interpret, report and publish

Presentations were made at the Mine Electrical Safety Association Conference (MESC) in Brisbane, the Down to Earth Conference (DTEC) in the Hunter Valley, the Electrical Engineering Safety Seminar (EESS) in Sydney and MEMMES seminar, Maitland March 2017. We have also made a further presentation to New South Wales mines inspectors.

A Forum was held after EESS to provide more detailed information to industry and to also get feedback from industry. A total of 25 attended the Forum representing a cross section of the industry, including coal mines, suppliers and regulators. This provided valuable feedback which is being incorporated into the research.

System models have been developed that demonstrate the effect of changes in system parameters on the performance of earth leakage protection. The effect of cable resistance, capacitance and inductance determines the system response. As these parameters vary in proportion with cable length, the performance of earth leakage protection is directly related cable types and lengths. This simplifies the assessment of touch
potential and other adverse effects that lead to nuisance tripping.

The final report is nearly complete.

**C26049**

**Continuous Miner - Shuttle Car - Data Flow**

CSIRO

Mark Dunn

- **Value:** $100,000
- **Report Expected:** 25/11/2017
- **Industry Monitor/s:** Brad Lucke, Bruce Davies
  - **Roadway Development Task Group**

**ACARP Contact:** Roger Wischusen

This project will develop a systems-level architectural framework that will describe 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 project 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.

Successful delivery of the automation architecture reference document will:

- Provide a reference baseline to assess technology capabilities in current and future mining processes;
- Provide a set of key focus areas, similar to that identified by the LASC and RDTG committees;
- Foster a greater industry awareness and engagement for collaborative, mutually beneficial outcomes;
- Offer a roadmap of highly motivated R&D directions towards automation of roadway development tasks; and
- Provide industry with confidence for timelines regarding availability of emerging automation capabilities.

This project commenced with a review of similar roadmaps in other industries and technology areas. Engagement with key members of the mining industry will be undertaken in the next few months.

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**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 12 month project will develop a machine-based, bolt placement and roadway geometry profiling system based on laser scanning technology to provide a new information stream 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 static 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. Successive profiles will be registered and cascaded to form a longer roadway map. A key feature will be to determine useful ways to provide the information generated so that it can benefit end users.

This project commenced in June 2017 following project scope resolution with the Roadway Development Task Group. A preliminary, opportunistic evaluation of the laser hardware has been undertaken at Anglo American’s Moranbah North mine where a section of longwall bleeder road was scanned. The evaluation used a novel panoramic enclosure designed by CSIRO and powered by a mine-supplied IS UPS. The initial results have provide important ground truth information to establish baseline expectations with regards to coal reflectivity performance and will be used for comparison with future underground evaluations. Ongoing activity will focus on in-house system development and performance validation.

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**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:** 25/09/2017
- **Industry Monitor/s:** Paul Gill

**ACARP Contact:** Roger Wischusen

No report has been received.
C24010
Collision Awareness - Capability of Underground Mine Vehicle Proximity Detection Systems

Simtars
Andre De Kock

Value: $482,300
Report Expected: 25/09/2017
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.

The analysed results were sent to the three proximity detection suppliers participating in the project, for comment. Once their feedback has been received, it will be evaluated for inclusion and finalising the report.

C26047
Real Time Dust Monitor

University of New South Wales
Charles Hab
Duncan Chalmers

Value: $184,300
Report Expected: 25/03/2019
Industry Monitor/s: Bharath Belle, Brad Lucke, Jim Sandford, Peter Bergin
ACARP Contact: Bevan Kathage

At an initial meeting planning was undertaken for the first series of tests to be conducted. The silica, metal mine dust samples were also re-tested and the results confirmed the previous tests. This provided collaborative data that the new configuration was performing as expected.

Samples of New South Wales and Queensland coals were prepared and dosed with respirable silica. These samples were introduced into the test apparatus and the spectral responses were recorded. A suite of tests on the coal, and coal and silica were performed.

These tests showed good discrimination between the silica and the coal spectra. The indications from these tests suggest that the instrument can see and differentiate between coal dust and silica, with a response between 4-8 seconds. A confirmation series of tests will be run next week to replicate these results.

This project is on track and is generating good results.

C26048
Improving Respirable Coal Dust Exposure Monitoring and Control

University of Queensland
David Cliff
Mark Shepherd
Nikky La Branche

Value: $250,000
Report Expected: 25/05/2018
Industry Monitor/s: Bharath Belle, Peter Smith
ACARP Contact: Bevan Kathage

The project objective is to improve the industry capacity to prevent and manage respirable coal dust exposure of workers through:

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

Work to date has focussed 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;
- Staging industry seminars in Moranbah and Emerald to collect information on what industry is currently doing; and
- Initial trials of various real time dust monitoring devices prior to use in mines.

In the next quarter:

- The literature review will continue;
- Initial comparative trials of the real time monitors will be undertaken;
- Exposure data will be collected from DNRM and Coal Services to initiate analysis; and
- A workshop on respirable dust will be run at Ventilation Conference in Brisbane.
### Roadway Development

**C25003**  
Review of Roof Support Options for Next Generation Continuous Miners  

**SCT Operations**  
Winton Gale

| Value: | $43,000 |
| Report Expected: | 25/09/2017 |
| Industry Monitor/s: | Roadway Development Task Group |
| ACARP Contact: | Roger Wischusen |

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

**C25068**  
Automated Long Tendon Installation System  

**Conway Engineering**  
Des Conway

| Value: | $184,500 |
| Report Expected: | 25/09/2017 |
| Industry Monitor/s: | Roadway Development Task Group |
| ACARP Contact: | Roger Wischusen |

No report has been received.

### Strata Control and Windblasts

**C21013**  
Improving Cavity Prediction on Longwall Faces through a Combination of Reliable Convergence, Canopy Attitude and Leg Pressure Monitoring  

**Golder Associates**  
Bob Trueman

| Value: | $696,625 |
| Report Expected: | 25/08/2017 |
| Industry Monitor/s: | Dion Pastars Paul Buddery Peter Corbett |
| ACARP Contact: | Bevan Kathage |

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

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

**SCT Operations**  
Winton Gale

| Value: | $430,000 |
| Report Expected: | 25/08/2017 |
| Industry Monitor/s: | Brian McCowan Roger Byrnes |
| ACARP Contact: | Russell Howarth |

The aim of the project is to review the range of coal mine roof failure mechanisms and to monitor a number of key sites where a range of mechanisms are to be anticipated.

Work undertaken has been 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 draft report for the project is currently being written and is expected to be submitted in November for review.

**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: | Brian McCowan Jason Emery Roger Byrnes |
| ACARP Contact: | Peter Bergin |

The main objectives of this project are to:
- Evaluate the shear behavior 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
- 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.

Experimental work:
- Completed all experimental study on shear testing of the designated cables using the Megabolt Integrated Single Shear Testing Rig (MISSTR). The collected data is currently being processed and the modes of shearing analysed. Significant information obtained on the nature of various cable bolt failures and the influence of strand wire roughness as well as the applied axial pretension load;
The Megabolt rig has been transported to Megabolt office, Melbourne, as per Megabolt request and in compliance with the contractual agreement;

Commenced writing the end of project report on the experimental aspect of the study.

Numerical simulation:

Continue with the numerical simulation of the single shear study, this part of the study is scheduled for completion at the end of September 2017.

C24015
Convergence Based Roof Support Design
PDR Engineers
Terry Medhurst

Value: $245,800
Report Expected: 25/06/2018
Industry Monitor/s: Brian Vorster, Gavin Lowing, Paul Buddery, Roger Byrnes
ACARP Contact: Bevan Kathage

Current work on this project is an extension to the original work program 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. Data has been collected from Grassstree and a review of other available information is underway.

C24018
Cable Bolt Performance Under Axial Loading and Subject to Varying Geotechnical Conditions
University of New South Wales
Paul Hagan

Value: $117,823
Report Expected: 25/08/2017
Industry Monitor/s: Brian McCowan, Paul O'Grady, Peter Corbett
ACARP Contact: Peter Bergin

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

C24020
Assessment of Longwall Mining Induced Connective Fracturing of Overburden Strata
CSIRO
Deepak Adhikary

Value: $297,343
Report Expected: 25/09/2017
Industry Monitor/s: Dan Payne, Peter Corbett, Richard Porteous
ACARP Contact: Peter Bergin

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

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: Brian McCowan, Jason Emery, Paul Buddery, Roger Byrnes
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 instrumented bolts, shear strips and extensometers. The instrumentation is monitored throughout the change in stress distribution throughout the continuous miner advance or the retreating 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. Unfortunately this site is delayed until further notice due to unforeseen circumstances.
C25059
Intrinsically Safe, Integrated Wireless Communications Network with a Distributed Array of Geotechnical Sensors

SCT Operations
Stuart MacGregor

Value: $339,787
Report Expected: 25/02/2018
Industry Monitor/s: Brian Vorster, Peter Corbett
ACARP Contact: Peter Bergin

The objectives of this project are:
- Develop a wireless communications network to interface with existing mine communications networks that has IS certification ready for submission; and
- Develop a range of wireless capable geotechnical instruments including Tell Tales, Stress Cells, Instrumented Bolts, Shear Strips and Geophones to provide a distributed monitoring array for underground coal mines.

Work in the quarter has included the following major activities.

Field Trials of WiFi/Radio Mesh Communications
Proof of Concept trials of the radio mesh system for the networking of geotechnical instrumentation have been successfully completed and production trials are scheduled through August & September at two mine sites to test propagation and penetration of the radio signal underground.

A mesh radio interface has been designed for the Holville/SCT roofAlert digital extensometer and instrumented roof bolts and has been extensively tested on the new digital SCT/Holville MEMS based shear strip.

System design and integration of the communications and sensing boards has been completed. Figure 1 displays the RoofAlert Rock-IT interface and Figure 2 displays the RoofAlert SCT Instrumented Rock Bolt (IRB) interface.

A second version of the batteries pack required to power the digital instruments have been designed to incorporate improved sealing and connectors and are currently being assembled.

A new antenna housing is being designed in line with mentor comments to improve flexibility and impact resistance. A WIFI interface module to be used with the Holville digital geophone is undergoing testing on the workshop network.

C25060
Borehole Shear Monitoring Device for Routine Application in Roadways

SCT Operations
Stuart MacGregor

Value: $149,863
Report Expected: 25/09/2017
Industry Monitor/s: Brian McCowan, Brian Vorster, Peter Corbett, Roger Byrnes
ACARP Contact: Peter Bergin

This project will construct an in-place MEMS based shear indicator that can be installed in open holes and provide sufficient resolution to resolve discrete bedding plane shear and strata failure surfaces for the range of roadway conditions present in Australian underground coal mines.

Work in this quarter has focused on two main areas:
- Finalisation and refinement of shear strip design for production; and
- Hand Held Readout Unit.

Finalisation and refinement of shear strip design for production
Following the first successful trial of a 10 bay shear strip at Oaky Creek earlier this year, work has been completed on productionising the instrument and certification documents are nearly ready for submission. A second installation of the instrument – comprising two 4m long 8 bay units - has been built and will be installed during August in a New South Wales mine.

Overlapping work streams with associated ACARP project C25059 has enabled wireless communication integration with the MEMS shear strip. Figure 1 displays the bench testing unit.

Hand Held Readout Unit
The hand held terminal design is complete. The multi-purpose Hand Held terminal will include WIFI, and mesh radio communications for the collection of data as well as the Holville 2 and 4 wire protocols. IS certification documentation for the Hand Held Terminal is nearing completion. Figure 2 displays a proto-type of the Hand Held readout unit.
The shear strip and HHT terminal will be displayed at AIMEX in Sydney at the end of August as part of industry dissemination of the technology.

![Hand Held Readout Unit Proto-type.](image)

Figure 2 Hand Held Readout Unit Proto-type.

C25062
Roadway Stability Monitoring System
CSIRO
Chad Hargrave

Value: $189,435
Report Expected: 25/10/2017
Industry Monitor/s: Brian McCowan, 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;
- To trial this radar unit for small-change detection in a CSIRO custom-built test tunnel facility;
- Based on the results of these in-house trials, to carry out underground trials at a suitable mine site.

The goal of the project 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.

As reported for the previous quarter, radar power supply issues that tripped the IS UPS supply occurred during the April field trial at Moranbah North, and this prevented the radar from being tested underground. A review of the power supply requirements for the prototype unit was therefore undertaken, and a soft-start circuit was developed that resolved the problem. A brief site visit to Moranbah North was then carried out to ensure that the radar system would operate reliably with the IS UPS. This test was successful, and a return field trip was planned.

The return field trial was carried out at Moranbah North on 25 May. The radar was mounted in the bleeder road of a longwall, and a large number of scans were successfully acquired, including baseline data of the roadway and additional data after small changes were introduced into the roof and/or rib structures. The radar performed extremely reliably: the setup and acquisition process was straightforward and quick, which allowed the researchers to move the unit out of the way rapidly to allow roadway traffic to pass as required.

Processing of the field trial data has commenced, and initial results are very encouraging. The radar was able to detect small changes introduced into the scanned region, and the down-range performance was better than expected. Work in the coming quarter will focus on further detailed processing of these results 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

This project has just commenced. No work was undertaken this quarter.

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.

Literature review has been undertaken; completed all available stress measurement techniques and summarised pros and cons of each technique, particularly for the borehole breakout analysis to predict in situ orientations and magnitudes. Critical parameters influencing borehole breakout patterns have been reviewed, which are then further investigated through experimental and numerical analyses.

As planned, a laboratory study has been undertaken; to investigate the relationship between in situ stress magnitudes and borehole breakout dimensions, 16 true triaxial tests were carried out at CUMT in China using 20 MN Servo-controlled Triaxial Rock Testing Machine. Each individual test has been currently analysed in detail to filter valid and valuable experimental results.
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: Brian McCowan, 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.

Two underground mine visits were conducted:
- Blakefield South Mine in March 2017 - MG8 roadway and beltroad CTs 9, 13 and 16 were visited and water, coal and clay samples were collected. In addition, LW8 face TG8 corner, and TG8 roadway and barrier pillar were also visited. Required visual inspection was done. After the visit a meeting was conducted with the geotechnical engineer. Blakefield South mine provided geological, geotechnical and mine planning data. PhD student has currently been analysing this data.
- Springvale in June 2017 - LW421 beltroad around CTs 9 and 10 were visited to observe floor heave and the floor rock samples were collected. Kestrel and Grosvenor mines will be visited in December 2017.

The research team has been working on putting together an extensive literature review on floor stability problem including the coal mining, hard rock and civil engineering sectors. While the types of instability in relation to floor include not only floor heave but also floor bump, pillar failure, roof fall and subsidence, the emphasis is given to floor heave. A number of floor heave cases from coal mines in Australia, the US, the UK and China have been collected.

Based on the literature review, the followings will be the main focuses for this project:
- To understand the mechanism of buckling failure as the floor heave events in the roadways of the sponsor mines show buckling failures while the contributing factors have not been understood well;
- To understand floor heave at longwall face as few studies were conducted for the relevant mechanisms whilst the sponsor mines experienced major floor heave at longwall face.

In addition, monitoring techniques and technologies for floor were also reviewed and will be discussed with the industry monitors to assess whether the proposed techniques are applicable.

Furthermore, the classification matrix is being revised and data will be collected afterwards to identify the possible parameters for floor heave.

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: 25/08/2017
Industry Monitor/s: Brad Elvy, David Webb

ACARP Contact: Russell Howarth

The aim of the project is to study gas flows and pore pressure distribution below longwall panels with the view to improve the efficiency of gas drainage from coal seams below the goaf. The project comprises field measurement of gas flow and pressure in boreholes at Appin West, together with computer modelling of the fracture distribution and permeability of the ground between the Wongawilli seam and the Bulli seam.

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  
Frank Hungerford  
Ting Ren  

**Value:** $336,152  
**Report Expected:** 25/11/2017  
**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.

Work in the last quarter has focused on the following areas.

**Experimental and Numerical modelling studies on nitrogen flushing**  
Additional laboratory experiments of nitrogen flushing were conducted on coal samples from Metropolitan to provide better understanding of the flushing process. Numerical simulations were also conducted to further improve the reservoir model for nitrogen injection simulations.

**Post-flushing effect assessment at Metropolitan Colliery**  
Gas drainage engineers at Metropolitan Colliery advised that they are doing their best to core coal samples as proposed while they have to maintain effective drilling operations for their development and longwall panel. Site meeting and communications with the gas drainage engineer have been maintained with possible drilling completed before 20th July. The gas data from these coring samples will be included in the final report should they become available by the end of this project.

**Final report drafting**  
As the proposed nitrogen flushing trials at Appin Mine is unlikely to proceed due to operational issues on site, industry mentors have advised to wrap up this project in the recent project review meeting. We are now drafting the final project report which is expected to complete by the end of August.

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C24024  
**Drilling for Outburst Risk Determination**

**Sigra**  
Ian Gray

**Value:** $380,500  
**Report Expected:** 25/08/2017  
**Industry Monitor/s:** Andrew Lewis  
Bharath Belle  
Russell Thomas  
**ACARP Contact:** Bevan Kathage

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

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C25001  
**Ventilation and Gas Management - Underground Coal Mines: Stage 2**

**Bruce Robertson Sole Trader**  
Andy Self  
Bruce Robertson

**Value:** $270,000  
**Report Expected:** 25/10/2017  
**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 original project (review of existing ventilation and gas management practices in Australian underground coal mines) mainly preparation of guidelines and scoping reports.

The researchers are progressing with draft documentation of several components. The project is on track for completion in October.

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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.

Post-mining goaf holes data and other field data obtained from different mine sites has been analysed in detail to obtain a fundamental understanding of specific gas emission profiles from various coal seams under Australian mining conditions. SGE release profiles derived from post-mining goaf holes data show a significantly different pattern when compared with traditional SGE prediction models. Based on this data analyses, an alternative draft empirical model has been developed to
predict SGE profiles under different mining and geological conditions, and is presented at the ACARP project review meeting held in June 2017. The current draft SGE model takes into account of the site geology, gas, geotechnical and caving characteristics, and panel design parameters into consideration for calculating SGE predictions. Extensive numerical modelling simulations are being carried out to investigate the effect of desorption time and face retreat rate on SGE patterns from various coal seams at different locations. Based on the results of these extensive numerical modelling simulations and detailed field data analyses, the current draft SGE model will be refined further over the next few months.

C25066
Gas Management and Risk Mitigation Strategies for Longwalls
CSIRO
Rao Balusu

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 project 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 modelling investigations have been carried out to simulate different goaf gas drainage scenarios and to investigate the effect of various control strategies on gas concentration distribution patterns near the tailgate (TG) motor area under two different cutting heights and under different ventilation layouts. Preliminary simulations have been carried out with different face gas emission scenarios for detailed understanding of the gas concentration distribution patterns around the shearer. It is proposed to continue these simulations over the next few months to investigate the effect of face ventilation quantity and face airflow patterns on high gas concentration zones near the shearer area. CFD modelling simulations have also been carried out to investigate the effect of barometric pressure variations and goaf falls on tailgate gas and face gas distribution patterns. It is proposed to continue these studies over the next few months along with extensive parametric studies to assist in development of appropriate risk mitigation strategies. Results of all the above investigations have been presented at the ACARP project review meeting held in June 2017.

C25072
New Approaches to Mine Gas Analysis and Ratios
Simtars
Fiona Clarkson

Value: $103,689
Report Expected: 25/09/2017
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 are being sampled to obtain information from older workings. The gases present are being compared with those identified from Stage 1 as occurring in particular environments.

Sampling and analysis has now been completed for a Queensland mine sampled in May. Access to a second New South Wales mine was obtained and sampling was undertaken in June. The data from both mines is currently being collated. Sampling at the final Queensland mine has been delayed due to mine operational reasons. Discussions are underway to reschedule this work.

The results to date indicate that CO2 seam gas mines have a negligible alkane, aldehyde and BTEX profile whereas CH4 / C2H6 or CH4 / CO2 / C2H6 seam gas mines may have butanes, and pentanes present. This presence however may not be purely a function of the ethane content.

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

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The project commenced in June 2017. In the first two months of the project, the research team has focused on literature review and analysis of current data available. Search of all publications relevant to this project has been done and analysis is ongoing. Field data collection from Blakefield South mine LW7 snf LW8 was carried out once. Preliminary analysis has shown abrupt emission of floor seam gases into the ventilation return during longwall mining. Other available data from previous projects the research team had undertaken was gathered and ready for further analysis towards the project objective. The previous data available include tracer test, pore pressure changes, and post mining gas content measurement.

Coupled numerical modelling to investigate floor strata behaviours and gas emission patterns will be commenced in the following quarter. Visits to project sites for further data collection are also scheduled.

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.

Continuing to work with South32 Gas Lab to develop electronic logging of gas flow during Q3 testing to compile a fresh dataset for updating and analysis of the Bulli Seam Benchmark.

Continue to pursue site contacts from non-Bulli seam mines for the supply of gas data and coal samples for use in the research investigation and laboratory testing. In an endeavour to reduce the potential burden of time and cost on mine sites, the amount of information requested to be supplied for use in this project has been revised and condensed.

Laboratory testing of coal samples is continuing as coal samples are made available from mine sites. Coal samples from 5 mines have been tested to investigate the effect of crushing time on particle size distribution in Q3 testing. A Protodyakanov Drop Hammer has also been fabricated and is ready to conduct coal toughness testing.

Outburst event data for use in collating and analysing an Australian outburst event database has been provided by Metropolitan, North Goonyella and Tahmoor. Presently awaiting outburst data from South32 – Appin/Tower/Westcliff.

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; and
- 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.

The project will also establish a set of guidelines that will provide:
- A framework for gas predrainage design, management and validation; and
- A protocol for the acquisition, validation and application of key gas drainage and gas reservoir parameters.

Work in Quarter 2 has focused on:
- A literature search of coal mine gas management, gas pre and post drainage practices
- A review of the current status of gas drainage practices including:
  - site meetings were conducted at Metropolitan, Tahmoor, Narrabri, Blakefield South, Integra, Mandalong, Arrow Brisbane and Anglo Brisbane;
  - 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
- 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,
  - 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;
- At some mines the gas drainage and ventilation teams work closely together, at others there is an apparent disconnect.

Work planned for next quarter includes:
- Completion of the literature review of coal mine gas management, gas pre and post drainage practices;
- Continuation of the review of the current status of gas drainage practices including site visits at Grasstree, Carborough Downs, Grosvenor, Moranbah North, Broadmeadow, North Goonyella, Appin, Dendrobium and Wallarah 2;
- Data acquisition and assessment in the area of – mine planning, geology, gas reservoir, seam gas hazards and management practices;
- Initial development of a permeability benchmark; and
- Identifying specific sites for Stage 2 of the study at Appin and Moranbah North Mines.
OPEN CUT

Drilling and Blasting

C25005
Mine Based Trials of Alternative Explosive Formulations to Eliminate Nitrogen Oxide Emissions: Stage 3

University of Queensland
Italo Onederra
Miguel Araos

Value: $685,332
Report Expected: 25/09/2018
Industry Monitor/s: Chris Bartley, Ewan Mills, Travis Zolnikov, Vishwa Bhushan

ACARP Contact: Cam Davidson

The main objective of this project is to demonstrate that newly developed Hydrogen Peroxide based explosive products can be safely manufactured, handled, delivered and loaded at operational amounts (1-5 tonnes per trial). This will be achieved by conducting targeted controlled mine based trials.

Trial preparation work continues this quarter. Key highlights are summarised below:

- The research team was successful in obtaining Queensland state licenses to manufacture, store and test explosives in the Pinjarra Hills facility managed by University of Queensland and Mining3;
- An upgraded modular pilot plant to manufacture and deliver the HP blasting agent has been completed and is ready for testing at our Pinjarra Hills Facility. This unit is now capable of manufacturing quantities necessary to support mine based trials. The unit will soon be shipped to New South Wales for further testing in quarries operated by Bald Hill Quarries;
- Applications have been submitted to the New South Wales regulator to conduct tests as well as to certify both the manufacturing unit and the delivery system. The application has been submitted following Australian MPU code requirements;
- Stability/reactivity tests have also been conducted during this time as part of the due diligence and risk assessments prior to testing at Bald Hill Quarries in New South Wales and Meandu Mine; and
- Additional resources have been committed to the project and are supporting the efforts to commissioning trials at quarries in New South Wales and the scheduled final trials at Meandu Mine.

C26025
NOx Evolution - Hydrogen PH and Nitrate Explosives

University of Queensland
Italo Onederra
Miguel Araos

Value: $236,333
Report Expected: 25/03/2018
Industry Monitor/s: Chris Bartley, Ewan Mills, Travis Zolnikov, Vishwa Bhushan

ACARP Contact: Cam Davidson

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:

- The blasting chamber has been constructed and is now installed in our facilities following approval by University of Queensland. This chamber is currently being commissioned and instrumented with fast response pressure sensors, a fit for purpose gas monitoring system, high-G triaxial accelerometers, velocity of detonation measurement systems and a state of the art high speed video camera. All instrumentation is currently being tested and safe operating procedures are being finalised;
- Risk assessments associated with the operation of the chamber are also under revision and NOx evolution testing will begin soon after those have been finalised;
- New personnel are currently being trained on the safe operation of the chamber and all associated instrumentation;
- As with project C25005, the research team was successful in obtaining Queensland state licenses to manufacture, store and test explosives in the Pinjarra Hills facility managed by University of Queensland and Mining3. This was a necessary requirement to allow for manufacturing, storage and subsequent testing in the blasting chamber.

Environment

C20015
Sustainable Management of Plantations for Rehabilitation, Carbon and Wood Products

NSW Department of Industry
Ashley Webb
Georgina Kelly
Nick Cameron

Value: $187,068
Report Expected: 25/08/2017
Industry Monitor/s: Bill Baxter, John Hindmarsh

ACARP Contact: Keith Smith

A draft report is with the industry monitor(s) for review.
C23025  
Coal Pit Lake Closure by River Flow Through: Risks and Opportunities

Edith Cowan University  
Mark Lund

Value: $362,714  
Report Expected: 25/09/2017  
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) -
  o 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.

All data has been collected and is being analysed for inclusion in the final report that is due at the end of August.

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

Todoroski Air Sciences Pty Ltd  
Aleks Todoroski

Value: $165,160  
Report Expected: 25/08/2017  
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: 25/09/2017  
Industry Monitor/s: Bill Baxter, Nigel Charnock  
ACARP Contact: Keith Smith

The objective of this project is to answer the question “Can rehabilitated mine land sustainably support productive and profitable livestock grazing?”

The expected outcomes and benefits of the program are:
- A clear demonstration to stakeholders that land which has been rehabilitated can have value to the agricultural sector and wider community post-mining;
- Evidence of successful rehabilitation of grazing land to inform regulators and decision makers in New South Wales;
- Parameters for successful rehabilitation of grazing land to be used by mining operations to inform mining operation plan targets for similar rehabilitation in the region.

Progress this quarter:
- Final weighing of Group 2 steers at both sites in June 2017 showed advantage to steers grazing rehabilitated mine site pastures. Mt Arthur Rehab steers weighed 529kg/head with 6.2mm fat, analogue steers weighed 456kg/head with 3.6mm fat. HVO Rehab steers weighed 480kg/head with 4.3mm fat and analogue steers weighed 381kg/head with 2.4mm fat.
- Comparison of weight gain on a per hectare basis further illustrated the production advantage of rehabilitated pastures over the analogue comparison at these sites. The attached graph shows weight gain per hectare for both groups 1 and 2 steers. Note that HVO group 2 rehab had 50% higher stocking rate than other treatments.
- Blood testing showed that all steers at HVO and rehab steers at Mt Arthur were low in copper. No toxicity was found for elements tested.
- Community interest in the project was again strong with results discussed at the annual Hunter Mine Rehabilitation Conference and at displays presented by the Upper Hunter Mining Dialogue at Tocal Field Days.
- Media interest was strong, contributing to ABC TV Landline and Lateline programs, also network radio interviews local, regional and national press coverage.
C24029
Development of a Toolbox for Fish Health Assessment in Aquatic Ecosystems Associated With Coal Industries
Central Queensland University
Nicole Flint
Sue Vink

The objective is to develop practical indicators of fish health assessment applicable to waterway monitoring programs in coal mining regions. Since the project commenced, indicators of fish health have been developed and tested at six test locations of the Fitzroy Basin. The locations represented a range of Fitzroy Basin-relevant waterway types and land uses upstream and downstream of coal mine sites. Field sampling trips to the test sites were conducted in April 2015 (post-wet season), October 2015 (pre-wet season), April 2016 (post-wet season) and October 2016 (pre-wet season). Water quality, habitat condition and fish communities were sampled at each location using a multi-method approach. Data from the test locations were used to develop a series of regionally-relevant fish indicators.

From September to December 2016 an extensive field sampling regime was conducted, collecting data on water quality, habitat condition and fish communities at 20 priority sampling sites identified in a recent review for the Fitzroy Partnership for River Health (FPRH). Data from these sites, which were situated across all of the eleven river catchments of the 142,000 km² Fitzroy Basin, were used to test and validate the proposed fish indicators. A scoring system was then developed for the new Fish Health Index, providing a set of metrics associated with fish assemblages that can be used to indicate river health.

In April 2017 the Fitzroy Basin experienced heavy rainfall and severe flooding associated with ex-tropical cyclone Debbie. An extra sampling period was added to the project to collect post-event data and test the effects of flooding on fish indicators and the Fish Health Index, at selected sites during May 2017. To allow for the collection and analysis of additional data, the project end date was extended (with support from ACARP and ACARP and the project’s industry mentor). The research report for this project is now in the final stages of preparation.

C24030
Verification of the Vertical Distribution of Dust from Mining Activities
Advanced Environmental Dynamics
Darlene Heuff

The primary objective of this study is to give both the mining industry and regulators increased confidence in the results produced by dust dispersion models by validating and improving the methodology applied to open-cut mining operations. This objective will be achieved through the determination the best methodology for calculating dispersion based on the application of the micrometeorology (Option 1 and Option 2) and/or PG stability curve (Option 3) option within the regulatory approved dispersion model CALPUFF.

The research project is in its final stages with the field campaign completed. Results of the post-deployment calibration period suggest that the data sets will require review to remove a slight instrument bias in the dust sensor that was located at the 10m height.

Finalising the work is ongoing with the draft report is due for completion by the end of August.

C24031
Cost Efficient, Empirically Based Framework Using Integrated Datasets to Demonstrate Rehabilitation Quality
University of Queensland
Peter Erskine

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

C24033
Applying Risk Based Principles of Dispersive Mine Spoil Behaviour to Facilitate Development of Cost Effective Best Management Practices
Tree Crop Technologies
Glenn Dale
Steven Raine

It is estimated that the current instantaneous liability for rehabilitating dispersive spoil dumps is $2 to $3 billion for the Bowen Basin alone and significantly more nationally. The project objective is to develop a framework to support practical, cost-effective management of dispersive spoil.

The project has delivered a comprehensive program leading to significantly improved capability to manage and cost-effectively rehabilitate sodic-dispersive spoil. The project has delivered:

- An industry survey of current approaches to sodic spoil rehabilitation;
- A comprehensive assessment, analysis and synthesis of sodic sites and prior trials throughout the Bowen Basin;
- The establishment and assessment of trials at sites across the Bowen Basin: German Creek East; Moranbah North; Lake Lindsay;
• Ongoing assessment of routine rehabilitation works at Coppabella, plus a pre-existing trial at Lake Lindsay;
• Development of a Bayesian model to estimate the erosion likelihood of rehabilitated dispersive spoil sites, plus user manual to guide selection of modelling scenarios;
• Documentation of best practice guidelines for dispersive spoil management; and
• Communication of project results via a web tool to present the model as a decision support system for use by non-technical specialists. The web tool comprises three modules: a spoil nutrition calculator; a slope performance model; and a rehabilitation cost calculator. The associated web site also provides a repository of project reports.

The field trials will provide a valuable resource beyond the scope of the current project for ongoing evaluation of slope performance under different treatments. This will support a cycle of continuous improvement to further improve parameterisation of the model and update best management procedures. The project outcomes have complementary benefits to the Natural Resource Management sector.

Successfully rehabilitated dispersive spoil site, Moranbah North. Average ESP at this site was 24%, ranging up to 57%.

C24036
Incorporating Salinity into the Source Catchments Model for the Fitzroy Basin

BMT WBM
Damion Cavanagh
Nathan Johnston
Tony Weber

Value: $304,000
Report Expected: 25/09/2017
Industry Monitor/s: John Merritt
Scott Diggles
Steve Downes

ACARP Contact: Keith Smith

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

C24038
Quantifying Coal Dust in Urban Samples

CSIRO
David Wainright
Graham O’Brian

Value: $176,765
Report Expected: 25/08/2017
Industry Monitor/s: Bernie Kirsch
Stuart Ritchie
Tim Manton

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: 25/03/2018
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 (e.g., river diversions) 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 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 produced by ACARP; and
• Advance development of microbial community analysis as an environmental assessment tool through testing of underlying assumptions of space, time and scale.

Field work - All field work is now complete.
Laboratory work – DNA extraction of river samples will commence shortly at Edith Cowan University for sequencing at the Australian Genome Research Facility. This activity will produce a list of taxa per sample (and genetic distances among samples) to fulfill project objectives. Sediment analyses at Edith Cowan University School of Science Analytical Chemistry Laboratory will commence shortly. Water quality analyses are complete.

Biophysical data (May-December 2016) – main messages:
- Artifi cially increasing base flow stability and reducing flow variability (i.e., drying periods) combined with increased light due to canopy loss likely promotes excessive growth of certain aquatic macrophyte species (reeds);
- Increased reed cover was measured throughout the study areas, although particularly within the diversions, downstream of diversions, and where flows had been altered by anthropogenic activities;
- Subtle changes in the natural flow regime by artifi cial diversions - undetectable by gauging stations -have an ecological effect;
- Reeds were outcompeting trailing bank vegetation in the diversion and altering benthic structure by forming layers of silt over gravel and cobble;
- Reed growth has resulted in sites becoming shallower; pools that serve as dry-season refugia for aquatic taxa are at risk of disappearing;
- The strongest relationships between sites and water quality variables occurred in May, when sites were shallower and less hydrologically connected. This is a classic phenomenon in Australian rivers, where sites evolve into unique ‘mesocosms’ along a drying river.

Melanie and Mark presented biophysical data from project C25031 at the IMWA conference in Finland in June 2017.

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 Cole
John Merritt
Scott Diggles

ACARP Contact: Keith Smith

The overall aim of the research 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 fi nal void salinity levels or the residual risk to receiving surface water or groundwater environments.

In this quarter, work has continued on characterization of spoil samples from a wide range of lithologies collected from German Creek and Rangal formations. The mid-scale mesocosms have been set up and leaching experiments are underway on > 1 tonne soil-like and a rock-like spoil samples under saturated, wet-dry, and natural conditions.

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

We are substantially into the writing-up stage for this project. We have largely completed the research, and are now confirming the footnoting and bibliography as well as reworking drafts to improve expression, clarity and what further research might be useful to consider.

There are hearings in the Senate currently taking place about EPBC Act rehabilitation implications, and these are being monitored to ensure the project is as up to date as it can be.

A presentation has been completed for the Planning Institute of Australia conference in September, which we will shortly be sending to the Committee prior to providing the draft of the final report.
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. In the first stage, the extent of erosion behind existing pit walls is being measured from imagery and survey for correlation with possible contributing factors such as age of wall, wall slope and depth of Tertiary. The Siberia Landform Evolution Model will then be run for at least two selected walls to extrapolate erosion effects into the long term.

Seven mine sites have provided at least some data; four other mines have confirmed that they will supply data but have not yet done so. Survey measurements have been tabulated for three pits at one mine. It appears that about thirty database records will be extractable from information already provided. Once this is done, simple statistical analyses will be used to look for the key drivers of erosion impact.

During the next quarter, two or more pits where there is a history of survey data and erosion progression will be selected for landform evolution modelling. Erosion to date will be used to calibrate each model, which will be run to simulate 100 years exposure to predict how erosion would continue if each wall was exposed long term. It is anticipated that results of the study will be presented as predictive graphs and/or a decision table.

C26024
Coal Mine Particulate Emission Factor Validation

Pacific Environment Operations
Judith Cox

Value: $133,794
Report Expected: 25/09/2017
Industry Monitor/s: Andrew Speechly, John Watson

ACARP Contact: Keith Smith

The main objective of the project is to update the Upper Hunter Air Quality Particle Model with the Australia specific emission factors, material properties and control factors.

The intended outcome of the project is to provide a robust demonstration that the particulate emission factors developed through previous ACARP funding can be used to improve atmospheric dispersion modelling performance against actual observations. This will provide further evidence that the particulate emission factors are applicable to the Australian mining industry, and should be adopted as industry-standard. In this quarter we have continued with the updating of the emission inventories and preliminary dispersion modelling. It is hoped that a draft report will be issued by the end of August 2017.

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: 25/04/2018
Industry Monitor/s: Andrew Lau, Claire Cote, Scott Diggles

ACARP Contact: Keith Smith

As the Diffusion Gradients in Thin Film technique (DGT) uses a hydrogel layer to mimic biological membrane uptake metals in water, it has been suggested that DGT would provide a measure of the bioavailable fraction of metals, which is more likely to represent the toxic fraction for biota. In addition, dissolved organic carbon (DOC) has ability to decrease metal bioavailability in water and consequently reduce toxicity. This study aims to confirm the metal concentration measured by DGT is the bioavailable concentration using an eco-toxicological approach. A laboratory study is conducted using a series of microcosm toxicity assay with four levels of DOC (0, 5, 10 and 20 mg/L), two metals (Cu and Ni) and 3 local test species including Ceriodaphnia cf. dubia (a temperate zooplankton), Chlorella sp (Green alga) and Melanotaenia splendida (a fish found in north-eastern and central Australia). The test organisms serve as bioassays, sensu stricto, for bioavailable metal and then cross check with metal concentrations measured by DGT (Figure 1). The findings from this research will form the basis for the development of more realistic tools to monitor and assess environmental risks.

As planned, literature review has been undertaken; rationale on test species selection; and toxicity data on Cu and Ni of selected test species are completed. In the second quarter, laboratory studies will start (mid-August). A detailed experimental program has been established based on the literature review and toxicity data which identifies important factors to the success of the DGT-toxicity experimental program. This includes suitable test organisms, metal concentration ranges of the tests and DOC levels.
Geology

C24032
Supermodel 2015 - Fault Characterisation in Permian to Jurassic Coal Measures

University of Queensland
Joan Esterle
Renate Sliwa

Value: $316,730
Report Expected: 25/09/2017
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. The proposed project takes this further, and contributes a systematic examination in the Bowen, Surat and outlying Triassic basins.

During the quarter:
- A presentation was made to the BBGG-ACARP bi-annual meeting, which illustrated the map product (a 2017 update to the 2008 Sliwa et al Solid Geology map of the Bowen Basin) and basic report structure and findings of the project;
- The report is about 75% complete and the authors are chasing a few remaining data contributors for specific seismic lines;
- The report and map will need final clearance from the contributors, once the map is complete.

C25025
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 the 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.

At UQ, the testing and de-bugging of the Bonded Particle Model code is continuing to ensure that it is capable of re-producing published micro-properties. A supplementary test code is being developed to calibrate direct shear micro-properties with physical macro-properties. These two codes will ultimately be combined to generate calibrated Synthetic Rock Mass models.

Field data, including highwall images, collected for this project, are being viewed to develop discrete fracture network models (DFN) for comparison between different pits, and as input to modelling. Also, UCS tests on non-standard size samples of coal having low quality mechanical properties have been completed. Overall, the results are promising. Further steps include comparison with previous Short Impact Load Cell (SILC) test and conduction of numerical simulation.

SCT in conjunction with UNSW has developed a first draft review of the currently used downgrading methods that can be distributed for comments by Geotechnical Engineers in the industry. Improvements to the draft is continuing.

Extensive experimental study has been commenced at UNSW on two different types of intact rocks including natural (limestone) and artificial. The tests on small to medium size samples have been completed and the experiments will be performing on larger samples. Also, some jointed artificial rock samples have been made at different sizes and various non-persistent joint patterns to be tested and later used for verification of the numerical models.

C25027
XCT Prediction of Breakage and Washability from Bore Cores

University of Queensland
Anh Nguyen

Value: $200,000
Report Expected: 25/09/2017
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: 25/09/2017
Industry Monitor/s: Justin Manalo, Mark Laycock, Noel Pranoto, Patrick Tyrrell, Richard Ruddock
ACARP Contact: Cam Davidson

During the quarter the final project report has been written. It will be submitted for review very soon.
### C25035
**Coal Subsurface Mapping for Open Cut Selective Mining**

**CSIRO**  
Andrew Strange  

- **Value:** $182,772  
- **Report Expected:** 25/09/2017  
- **Industry Monitor/s:** Brett Domrow, Margaret Stewart  
- **ACARP Contact:** Cam Davidson

The objective for 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.

The developments over the past quarter are as follows:
- The data acquisition and logging software for the system was tested and some issues were identified. These issues were resolved and the software was refined to increase reliability of operation in the field. Specifically, the software will successfully continue to operate when there is a communications interruption between the sensor sled and operators laptop.
- A new robotic vehicle was acquired which is significantly more powerful for towing. The suspension and increased motor torque provides the capacity to overcome traction issues experienced in previous surveys. The vehicle can be driven faster which will eventually decrease the overall survey time. A new towing mechanism was added and trialled at CSIRO with the result being an increased tow pivot angle to 90 degrees which decreases the turning circle size at the end of each single survey path.
- An end to end test of the system has been conducted at CSIRO both in the lab and outdoors. These tests were successful.

As a result of the progress this quarter, the team is now contacting industry to determine locations to conduct final mine site tests to validate the system developed. The project team will also contact the industry monitors to gauge interest in a local field demonstration and prepare the final report.

Picture below shows an image of the new robotic vehicle and the sensing system.

### 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; and to
- Disseminate the results of the project to the industry through quarterly progress reports to ACARP, approximately six-monthly review meetings coordinated by ACARP, industry seminars, a timely final report, and conference and journal papers.

Since project commencement, the first mud sampling and testing campaign has been completed. Representative samples from BMA’s Goonyella-Riverside, Peak Downs and Cavil Ridge mines have been subjected to physical and chemical characterisation, and shear strength testing.

The bulk samples of Category 1, 2 and 3 spoil and mud types from Cavil Ridge and Goonyella Mines, were subjected to a range of laboratory classification and geotechnical parameter testing, and investigations into the rate of degradation of spoil and mud subjected to prolonged exposure to water, and to repeated wetting and drying cycles. The results show significant and rapid degradation of spoil of all categories, which impacts their particle size distribution, shear strength, compressibility and permeability.
Efforts continue to be made to research viable options for the in situ testing of mud deposits, including laser-induced breakdown spectrometry, infrared spectroscopy, and a drone system. The aim is to develop a range of cost-effective means of more reliably categorising different spoil types and the mud derived from them, and of cost-effectively and safely investigating the geotechnical parameters of mud to enable an assessment of whether or not it can be spoilt on. Rapid identification of spoil materials prone to break down could be used on site to compliment visual categorisation.

Slope stability analyses of case studies are being undertaken using Slide 7, and complemented using the full mining suite provided by SoilVision Systems, which provides the ability to analyse slope stability in three dimensions. A probabilistic approach is being applied to better represent the sensitivity of the slope stability calculations to the selection of spoil and mud geotechnical parameters.

C26022
Real Time Prediction of Coal Top Through Guided Borehole Radar Wave Imaging for Open Cut Blasthole Drilling

CSIRO
Bonzhuong Zhou

Value: $210,985
Report Expected: 25/11/2018
Industry Monitor/s: David Drakeley, Troy O'Reilly

ACARP Contact: Bevan Kathage

Damage to the tops of coal seams caused by incorrect blast stand-off distances is a serious issue to the Australian coal industry. 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 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.

The first task recommended is to setup the criteria for site selection and parameters for successful trials. Industry feedback has been sought from the project support companies Idemitsu and BHP. Based on the feedback and comments from these companies, the project team have suggested the parameters for success of trials and criteria for trial site selection to be used by the project, which have been accepted by the industry monitors.

Geophysical logging data especially resistivity logs has been sought from potential test sites offered by the supporting companies. Idemitsu has provided this project with the geophysical logs from Boggabri Mine. Numerical modelling investigation is in progress based on these geophysical logs, which could help us to better understand the characteristics of EM wave propagation at this mine site.

C26023
Borehole Data Standard

GeoCheck
Brett Larkin

Value: $87,500
Report Expected: 25/01/2019
Industry Monitor/s: Angus McIntyre, Danique Bax, Malcolm Ives, Patrick Tyrrell

ACARP Contact: Roger Wischusen

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 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 graphic 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;
- A standard set of codes for:
  - Drilling Company, Rig Type and Hole Size Name (HQ, PQ, etc) for borehole Drilling data.

The project started during this quarter. A prototype format and field names for the transfer of coal analytical data has been produced. Meetings were held in Brisbane with major coal analytical laboratories and mining software suppliers to provide them with copies of the prototype and explain it to them. It is intended that further meetings will be held with them in the next month to obtain their feedback.

Volunteers from industry are sought to assist on committees to review prototype standards for:
- The transfer of coal analytical data.
- Downhole geophysics metadata and geophysical variable names.
- Recommended colours for plotting lithotypes.
- Codes for: Survey Company, Geological Logging Organisation and Geophysical Logging Company, Drilling Company, Rig Type and Hole Size Name (HQ, PQ, etc).

If you can help please contact the project leader at brett@geocheck.com.au.
The aim of this project is 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 minesites, to detect domains and geological controls (primary deposition, subsequent burial and deformation, intrusion or 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 mineral, commonly apatite and fluorapatite, commonly entrained within the cell lumens of semifusinite, but also occurring (less commonly) in fractures or other macerals.

The team welcomed a new member, Alex Duxbury, a UQ Honours student. Alex’s project will focus on the ‘tuff’ model as a potential source of phosphorus and fluorine within the basin. Additionally, the team has conducted site visits as the project is still currently in a data collection phase. Interpretation of data already supplied from some of the sites has been undertaken and used to assist current sampling strategies.

Attempts to conduct isotopic analysis on Company A samples have been unsuccessful due to unforeseen circumstances. However, the team has undertaken preliminary analysis of coalblocks using cathodoluminescence and Raman Spectroscopy. Cathodoluminescence was useful in identifying fluorapatite within the coal samples and will be investigated further as an indicator of fluid source. However, during Raman Spectroscopy, the fluorapatite fluoresced, saturating the detector. It is therefore unlikely that this technique will be suitable for this study.

The team has further refined some of the processing and analytical methodologies to reduce sample preparation time and optimise the analysis undertaken (ie quantitative versus qualitative). However, through reading previous research and discussions with experts it appears that the limiting factors for any micro-analytical techniques that we hope to use is either the spot size, limit of detection, ability to achieve a pure concentrate and/or the ionizing potential of fluorine. Having said this, the additional techniques that may be suitable include: X-ray Photoelectron Spectroscopy and Laser-Induced Breakdown Spectroscopy and we intend to test the suitability of these techniques moving forward.

Successful completion of this project is dependent on the data and samples being supplied by the supporting mine sites in a timely manner.

The primary focus for August to October will be:
- Start the isotope analysis for company A;
- Finalise the collection of outstanding data and samples;
- Continue with data and spatial analysis; and
- Continue with microanalysis.

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**C26030**

**Improved Structural Mapping of Pit Walls using UAV Based Mobile Laser Scanning**

*University of New South Wales*

*Simit Raval*

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<thead>
<tr>
<th>Flight No.</th>
<th>Distance from Highwall (m)</th>
<th>Number of transects</th>
<th>Surface point density (points/m²)</th>
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A flying speed of 5 m/s was able to capture 230 pts/m² at 35 m from the highwall with 1-pass transect whereas 2 m/s speed has generated 600 pts/m² under the same conditions.

Surface coverage with the UAV-LiDAR system was significantly higher in comparison to the terrestrial laser scanner (TLS) system (Maptek I-Site 8820) due to orientation and occlusions biases. The area of about 14.2 m x 210 m on top of the middle bench plus a length of about 76 m on the front face of the highwall remained unscanned with TLS (refer the Figure ). length was not captured in the TLS scan of the middle-bench on the highwall as well a considerable section on the front-face of the highwall (76.8 m) remained un-scanned with the TLS system.
Figure Overlay of UAV-LiDAR and TLS scan for analysis of the highwall coverage.

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.

This project commenced in February and will progress in three stages. Stage 1 looks at basic research and this stage is now complete. Stage 2 concept development is currently underway. With a third stage 3 Experimental proof of concept planned to be run later in the year.

During stage 1 the project team investigated the main components that would make up an autonomous ground monitoring solution and found two key research areas:
- Research and development of a Through the earth (TTE) communication method;
- Research and development of a sensor system that would make physical measurements of the spoil pile or tailings dam.

For the TTE communication method it was found that very limited amount of solutions are available on the market for through the ground communications. Two main solution for TTE communication have been found with further investigations into RFID based communications methods and magnetic induction communications to be investigated further in stage 2.

Research into physical measurement sensors on the other hand found a great deal of different types of sensors available on the market for making measurements of the ground conditions. However, it was found that these sensors come with a cost and a certain amount of unreliability. Further collaboration with the University of Queensland Geotechnical Department to develop sensors for making physical measurements has been established and will continue over the course of the project.

A stage 1 report and presentation has been submitted to the industry monitors and was well received. The project team will now concentrate their efforts in developing a TTE communication method and physical measurement sensors to start to develop a platform which the autonomous sensors project can be based upon.

C26033
Geotechnical Hazard Awareness Video for Open Cut Coal Mines

University of New South Wales
Ismet Canbulat

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

The main objective of this project is to update a 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, a series of topics that will be included in the video(s) have been developed. A workshop with the industry monitors has been held. The industry monitors have decided to produce three different videos; one for operational personnel; one for supervisors and one for geologists. The preliminary topics for those three videos have been identified and draft scripts have been completed. The next workshop with the industry monitors will be held by the end of August to complete the scripts.

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, Cam Davidson

ACARP Contact: Cam Davidson

This project aims to examine coking properties deterioration in small samples. The projects 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.

One sample is in the lab being tested currently for the client’s original purpose (that includes relevant test work for this project) and a second physical sample and a third borecore are due into the lab for testing within the next three months.
A method has been devised based on the samples to be supplied and circulated to industry monitors for review. Upon confirmation of methods, the document will be circulated to the coal testing laboratories for attaining quotations for price.

Presentation at the recent joint ACARP/Bowen Basin Coal Geologist forum in Mackay was made by MCQR on the rationale, samples available (generically) and proposed methods.

### Maintenance and Equipment

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

Connec  
John Keir

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**ACARP Contact:**  
Keith Smith

This project will 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.

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

CSIRO  
Garry Einicke

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**ACARP Contact:**  
Cam Davidson

This project seeks to develop technology for checking the integrity of mining truck tyres. It is motivated by desires to prevent fatalities arising from explosive zipper failures due to overloading and under inflating of truck tyres. The objectives of the two-year project are:

- Develop a portable subsurface imaging system and software (using x-ray and/or radar) 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; and
- 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 team reports the following progress:

- A manual wheel rotation jig was manufactured at the CSIRO QCAT workshop. This supports acquiring x-rays for analysis of entire tyre walls;
- X-ray images of an entire tyre wall were obtained using a portable, battery-powered, flat-panel x-ray scanner and a portable gamma source. Internal tyre cord damage was successfully identified using the developed analysis software;
- The project team is commencing preparations for mine demonstrations of the developed technology; and
- As usual, the project team would appreciate hearing from mine sites who have surplus truck tyre samples.

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

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

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**ACARP Contact:**  
Cam Davidson

This project follows directly from ACARP 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 will be performed at a sandstone quarry in South East Queensland, with three suitable domains validated via core drilling and mechanical properties testing. Bench sections, with a working face of approximately 3m x 5m, in each of these domains are currently undergoing final preparation for the trials. Joy Global’s DynaCut test machine is being mobilised to the site on Thursday 10th August, with the trial continuing through to early September.

The mine design component remains focused on preliminary economic evaluation and comparison of various mining concepts that have been developed for typical deposit types. The team is currently assessing the concepts based on system capital and operating cost estimates, with consideration of technical and development risks.
C26020  
Preventing Fatigue Cracking Via Proactive Surface Dressing  
Bureau Veritas AIRS  
Simon Krismer  

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

The aim of this project is to test a theoretical method for prolonging asset life, reducing down time, and reducing weld repair costs. Rather than simply monitoring the condition of equipment and structures to identify cracking as it develops, and then having to carry out the repairs, it is 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.

This project is being undertaken with the assistance of Rio Tinto Coal Australia mine sites Hunter Valley Operations and Mount Thorley Warkworth, working on their Komatsu 830E truck fleet. The initial phases of work for the 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. Multiple site visits have been made to inspect trucks, and meet with key mine site personnel to facilitate the project. Target locations on the truck chassis have been confirmed for the trial project. An experimental methodology has been developed in relation to establishing sample cohorts in the truck fleet (based on service hours) for trials, including provision for a control sample population. Data has also been gathered in relation to the current costs of ongoing weld repairs to the truck fleet, so that the benefits of the outcomes of this study can be quantified.

Research has been undertaken to identify suitable practical and cost effective methods for removing a small amount of surface material, and the appropriate equipment has been procured. Laboratory work is currently underway to compare the methods in their effectiveness and ease of use, as well as to establish suitable procedures in order to control and quantify how much steel is removed.

The next phase will be to implement the trial on the trucks, progressively rolling it out to the fleet as part of planned maintenance.

C26021  
Verification of Interoperability - Collision Awareness and Avoidance Systems  
CSIRO  
Jeremy Thompson  

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

This project develops 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 project 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;
- Improve mine industry safety by supporting the take-up and integration of proximity detection systems.

Work is currently underway on the development of the verification tool. This includes the primary verification functionality and user interface as well as support features such as a PDS and machine simulator. The simulation functionality will enable end users to test protocol behaviour against a generic PDS or machine prior to having access to physical hardware. The software is also being updated with any modifications to the specification that occur as it progresses through the standards process.

C26031  
Condition Monitoring and Predictive Maintenance Using AI  
Endellion Technology  

Value: $77,020  
Report Expected: 25/09/2017  
Industry Monitor/s: David Goodale  
ACARP Contact: Cam Davidson

The objective of this project is to demonstrate the value of applying new analytical techniques to derive fresh insights into the root cause of catastrophic equipment failure or low component life, from text and numerical data contained within existing oil sample analysis from laboratories.
We aim to demonstrate that there is not only a significant labour efficiency improvement by using these techniques to review oil sample reports and allocate the required actions semi-automatically, but additionally by improving the efficiency and effectiveness of analysis there is a much greater cost reduction to be achieved by maximising component life and improving equipment reliability.

The project commenced in February and will be completed in early September. Data analytics activities for the project have now been completed. A presentation of the results and conclusions was made to project sponsors and contributors in July 2017. Work has commenced on the final report, it is approximately 30% complete.

**Mining and the Community**

**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:

- To identify the key factors that are likely to be relevant to future landholders, local communities, Aboriginal traditional owners (where relevant) and other stakeholders when negotiating closure of a mining operation;
- To model the economic returns and flows from transitioning mining leases to agricultural and other land functions;
- To test the use of different local expert/stakeholder panel models to select and negotiate preferred scenarios for mine closure and subsequent land use(s); and
- To 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 project is now almost through the workshops, while work on key research papers is continuing. Three workshops have been held in Blackwater to date, workshop 1 on 23rd February, workshop 2 on 27th April and workshop 3 on 1st June.

Workshop 2 was focused on the issues more relevant to landholders for taking on post-mining land, and involved an exercise with a ‘mock-up’ of a mine-site being closed. It had 13 participants, largely selected on the basis of individuals who were interested in the issues, including 8 landholders.

Workshop 3 was focused on how small panels of stakeholders might make planning decisions about post-mining land, as well as the provision of more technical information back to participants. There were 20 participants at the workshop, drawn largely from attendees in the first and second workshops, who were split into four groups of five for the mock-mine planning exercise.

There is one more workshop to be conducted, together with some additional surveys to identify how participant’s views have come closer together as an outcome of the workshop process. This is workshop 4 to be held on 10th August (Blackwater). All participants from the previous workshops have been invited to participate in the final workshop. This 4th workshop will have 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 will also involve some presentation of mapping results of the previous workshops back to participants.

The project team are continuing to work on several reports, including:

- Report 2: An evidence based proposal for stakeholder engagement in planning post-mining land uses;
- Report 3: Options for designing stakeholder panels on post-mining land uses in Queensland; and

**Occupational Health and Equipment Safety**

**C24028**  
**Interface Design for Haul Truck Proximity Detections Systems**

University of Queensland  
Robin Burgess-Limerick

*Value:* $235,620  
*Report Expected:* 25/08/2017  
*Industry Monitor(s):* Gavin White, Kane Usher, Tony Egan  
*ACARP Contact:* Cam Davidson

A draft report is with the industry monitor(s) for review.
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 Australian coal mining environments. It also aims to develop a practical intervention for Australian 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.

We have finished collating the data from Survey 1 and correcting coding errors. After removing participants who did not complete the survey, there were a total of 986 participants. The majority participants reported that they had never intentionally taken a major safety risk in the past two months. However, a sizeable minority of participants indicated that they had taken such a risk, at least to some extent.

We are continuing with recruitment of participants for Survey 2. The data from this second survey will help to establish the factors that predict risk-taking. We have now secured approval from the University of Newcastle’s Human Research Ethics Committee to conduct this next stage of the research. We have developed online and paper copies of Survey 2. The survey weblink has been provided to all participating mines and mines rescue stations for distribution and promotional materials have been displayed on-site. A copy of the recruitment poster is presented below.

We are in the process of developing an individualised plan for recruitment at each participating mine site in order to facilitate the best possible response. Recruitment strategies will involve:
- Display of promotional posters;
- Distribution of promotional flyers;
- Email distribution of the survey weblink;
- Inclusion of the survey at scheduled training events and in the roster of activities scheduled for wet weather;
- Promotion of the survey at pre-shift/staff briefings; and
- Specific sessions for survey completion (facilitated on-site by the project research assistant).

C25033
Automated Musculoskeletal Disorder Risk Assessment
JointAction Group
Michael Lawrence
Steve Cowley

Value: $293,232
Report Expected: 25/08/2017
Industry Monitor/s : Mathew Hyde
Simon Worland
ACARP Contact: Cam Davidson

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

C25036
Risk Control Knowledge: Two Case Studies
University of Queensland
Jim Joy
Maureen Hassall

Value: $259,500
Report Expected: 25/08/2017
Industry Monitor/s : Doug Kennedy
Mike Oswell
Occupational Health and Safety Task Group
Tony Egan
Troy O'Reilly
ACARP Contact: Roger Wischusen

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

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

Health-e Mines: The development and implementation of a virtual health system to improve mental health, reduce
alcohol/other drug use, and fatigue-related problems in underground and open cut mines.

This project has 3 key objectives:
1. 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;
2. To evaluate the use of Health-e Mines and associated online treatment programs in pilot mine sites in NSW and QLD in terms of feasibility, acceptability, reach, and effectiveness; and
3. To develop a clear plan for dissemination and sustainability of Health-e Mines beyond the current grant.

Progress - 625 coal miners have completed a needs analysis survey to help inform development of the Health-e Mines portal. 19.4% reported high to very high psychological distress, with a further 22.6% of the sample reporting moderate distress, similar to data found in the Working Well: Mental Health and Mining study.

Most participants indicated that they primarily access the internet through their phone (69%), with the iPhone the most common smartphone used (62.1%) followed by android (36.7%). More than 90% of miners indicated that they have access to the internet at home, and spend on average 8.5hrs per week online (range 0-70hrs).

This information has been used to inform development/refinement of the Health-e Mines website prototype. Based on participant feedback, we have also been developing new content areas. The site will now provide information for supervisors on how to manage staff who are experiencing mental health problems, with advice on potential signals, tips on how to initiate a conversation, and recommended avenues for support. The website will also contain support for miners looking for information on how they can provide support for others (e.g. colleagues, family).

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 Corletto
Shane Apps
Troy O'Reilly

ACARP Contact:
Keith Smith

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

A prototype iOS application has been written by Dr 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. Tony Brown from Seat Shop Australia has prepared a mounting system ready for trial. A visit to Millennium mine to trial connection of the iphone to the truck in vehicle monitoring system is scheduled for August 17.

C26028
Proximity Detection System Performance Testing Framework

University of Queensland
Joj Quidim
Susan Grandone

Value: $268,000
Report Expected: 25/08/2018
Industry Monitor/s :
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 standardized 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.

Several revisions were made to the original scope in order to better align the project deliverables with recent developments within EMESRT. A final plan was approved by all stakeholders in May. The project team commenced work in June while maintaining close consultation with industry monitors.

Due to a change of project monitors, a workshop was held on 26 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 on the 26 July. The latest updated plan will be circulated as Revision 1.8.

Next workshop engagement with ACARP monitors / EMESRT stakeholders is expected to be between mid-late September. A shortlist of workshop participants (an appropriate mix of PDS vendors and mine operators) is expected to be finalised in August. Progress against milestones will be presented and discussed during this upcoming workshop.
Overburden Removal

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

University of Queensland
Ross McAree

Value: $341,400
Report Expected: 25/09/2017
Industry Monitors: Andrew Denman, Hans Hayes, Tony Egan
ACARP Contact: Cam Davidson

The aim of this project is to improve the execution of pivot push dozing by semi-automating the process. The project is a collaboration between University of Queensland, Caterpillar, and Peabody Energy. The primary research questions are to determine:

- How to choreograph the operation to be performed by an autonomous dozer to achieve the most efficient (fastest, lowest unit cost) dozer operation, and ensure the material moved by the dozer is cheaper than the next best option (truck and shovel).
- How to best execute manual and automated Cast Doze Excavate dozer operations.

The project has built from the Caterpillar Semi-Autonomous Tractor System, also known as SATS, extending it to be capable of semi-autonomous pivot push dozing.

This system has been deployed at Wilpinjong mine. A methodology for understanding dozer productivity has been developed and data collected from the SATS tractor while operated in manual mode has enabled analysis of three alternate pivot push strategies.

The SATS system has been extended to implement pivot push dozing and the technology has been implemented at Wilpinjong mine. The project has undertaken a comparison of manual verses semi-autonomous operation. The final project report is currently being reviewed for feedback.

C25038
Dragline Excavation Sequencing: Phase 2

University of Queensland
Andrew Jessett, Ross McAree

Value: $1,129,000
Report Expected: 25/04/2018
Industry Monitors: Andrew Denman, Win Klass
ACARP Contact: Cam Davidson

This project aims to develop and test an operator assist that determines how to sequence dragline excavation and provides guidance to the operator to help prove their execution. 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 aims to deliver:

- More consistent production;
- Faster lineal advance rates down the strip; and
- Continuous assurance of ability to fit the spoil in the forward operation.

The methodology for sequencing is to find excavation sequences subject to constraints that impose structure on the problem. 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 trialled at Caval Ridge to evaluate the benefits of the technology.

In the last quarter the project has:

- Engaged with Caval Ridge to discuss activities and schedule for site trials;
- Tested data interfaces onboard the DRE35 machine; and
- Applied the decision tree framework to current operation scenarios; and
- Progressed the design and implementation of Pegasys GUI interface.

It is anticipated to have a partially functioning system running at Caval Ridge Mine in the upcoming quarter.
The remaining material.

The facility works very well, generating high quality gravity separation and desliming.

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 best strategy suitable for each plant will be identified. 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 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.
C24047  
Steam Pressure Filtration Targeting Step Change Reductions in Filtercake Product Moistures  

QCC Resources  
Andrew Swanson  
Bob Drummond  

Value: $347,049  
Report Expected: 25/08/2017  
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: 25/09/2017  
Industry Monitor(s): Ryan Flanagan, Tom Wilson  
ACARP Contact: Nerrida Scott  

This project is based on identifying feed particle characteristics that lead to changes in the performance of a Solid Bowl Centrifuge (ie cake moisture content) during tailings dewatering. The project was initially based on the installed SBC units at a Hunter Valley Coal Preparation plant, but has been extended to include samples from a pilot SBC at another Hunter Valley mine. Six sample suites (feed, cake, centrate) have been obtained and are being analysed for laser particle sizing, moisture content, XRD and SEM-EDS. A further 1-2 samples are expected to be obtained. This project is expected to be completed in September 2017.

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

University of Queensland  
Anh Nguyen  

Value: $220,000  
Report Expected: 25/03/2018  
Industry Monitor(s): Naomi Pritchard, Penny Walker, Rahul Patel  
ACARP Contact: Nerrida Scott  

The objectives of the project are:  
- 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 May, June and July  
The initial pilot-scale trials on coal and tailings were successfully completed. The effect of flocculants, surfactants, feed rates, particle residence time and g-force were investigated. The optimised operation conditions and the results for moistures and solids recoveries are as follows:  
- Operation condition for coal test work: 10% solids for feed, 0.28 m³/h for feed rate, 1,434 g for centrifugation, 22 for differential rate. No chemical treatment was applied. Final moisture: 26% and solid recovery: 97%;  
- Operation condition for tailings test work: 3% solids for feed, 0.86 m³/h for feed rate, 1045 g centrifugation, 10 for differential rate. No chemical treatment was applied. Final moisture: 29% and solid recovery: 95%.

Flocculants increased solid recovery for both coal and tailings samples. The effluent water quality also was improved by flocculent, but the final moisture was increased in both coal and tailings trials.

C25018  
Improving Solids Recovery and Moisture Reduction in Ultrafine Coal Dewatering  

University of Queensland  
Liguang Wang  

Value: $184,000  
Report Expected: 25/04/2018  
Industry Monitor(s): Justin O'Neill  
ACARP Contact: Nerrida Scott  

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

In the last quarter, a series of bench-top centrifugal dewatering tests was carried out at a lower centrifugal force to understand the operation of the industrial SBC screen section. The effects of the particle size distribution and flocculant dosage on the centrifugal dewatering performance were examined. A comparison was made for the test results obtained at different G-forces.

Attempts have been made to carry out centrifugal sedimentation tests aiming to understand the operation of the industrial SBC bowl section. The combined information on screen section and bowl section will be used to develop new flocculants and methods for the upcoming pilot-scale SBC dewatering tests. Next, a continuous pilot-scale SBC test unit will be installed at The University of Queensland. The test unit is sourced from outside Australia.
The objectives of the project are:

- 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);
- 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
- 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.

The samples requested from a BMA mine in the Bowen Basin, Queensland were recently received, prepared and stored for the project. The samples contained three buckets of dense slurry of fine coal concentrates. They were taken from a flotation circuit. The samples were characterised by sizing and ash analysis. The physicochemical characterisation of the samples was started and will completed by the next research quarter. The imaging of the fine coal samples was started. It was established that high magnification lenses (+20X) would be required to achieve the required image details. The XCT hardware was also serviced and upgraded by the specialists from Zeiss-Xradia, Pleasanton, CA (USA) to achieve the needed centring and stability at high magnification for the project. The development of a specialist software to reconstruct 3D density maps of each of the fine coal particles and maceral constituents was also started. In summary, the project tasks were started, followed and completed as planned.
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. Results to date show that the system produces low ash products at very respectable circuit yields and combustible recoveries. Product ashes well below 10% have been achieved, with combustible recoveries from 38 to 80%, with very high yields in the deslime unit. Runs 10-13 involved very low density cut points which achieved very low product ashes (3-5 wt.%).

Run 12 has now had full size by ash analysis of all 5 streams. This shows that a feed solids rate was 18 t/h at a pulp density of 0.038 mm or higher, and to deslime the product with minimal coal loss.

This year's 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.

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.

The objective of this project 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 2mm. 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 1mm, with gradual drop off to 2mm, with significant recovery at 2mm. 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. These experiments were then repeated at a higher feed pulp density of about 5% solids.

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 wash 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 wash 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 is also close to completion.

The objective of this project is to investigate the performance of the Reflux Flotation Cell at full scale. This will be a two-stage study investigated at a volumetric throughput of up to 1000 m$^3$/h. A key focus of the study is on the physics that underpin the scale-up performance of the technology, in terms of delivering ‘Fast Flotation’, and ‘Desliming Flotation’. The existence of a system of inclined channels increases the segregation rate of the bubbles from the downwards tailing flow. This mechanism produces a significant gas-hold-up, a concentrated bubbly zone, ideal for counter current washing to achieve clean product. A further objective is to assess the potential for process control of the technology, and hence assess the reliability over extended campaigns.

This technology is expected to provide valuable solutions to both energy and metallurgical coal production due to its performance in reducing the flotation footprint and hence capex, and especially its performance in desliming. This is the first quarterly report for this project. The project is a collaboration between an End-User, equipment manufacturer FLSmidth, and the University of Newcastle, and involves some other contributors. There is strong funding support from other sources including the Federal Government to $1M. While numerous meetings have already been held, the project is still currently in a preliminary phase, and will require higher level process design considerations, a construction phase, and commissioning ahead of the main trial. We have been conducting parallel laboratory based assessments of the process to be deployed.

A draft report is with the industry monitor(s) for review.
Following this work, we have upgraded the system to permit using the existing pilot scale device which is already on site. The initial Fast Flotation experiments have been conducted within the downcomer. The novel pilot scale sparger system still needs to be built. It is noted that a new sparger design suitable for the old and new pilot scale systems and future full scale systems has been developed, and has been trialled in our laboratory. This work will require experiments at different gas and feed fluxes, as well as reagent doses.

The Fast Flotation work has now been completed, demonstrating consistent performance across the full range. Applied to a 2.0 m diameter RFC, the range covered is equivalent to about 1000 m3/h, which is 360 m3/m2/h, abut ten times that of a more conventional system. Naturally, the RFC generates a rougher product under these conditions, with a liquid split between 10 and 30% to overflow. Tailings ash levels were typically 69%.

The draft final report has almost been completed.

The objective of this project is to undertake a pilot scale study of Fast Flotation in order to validate the findings from our previous laboratory scale work. The new technology, which operates as a “rougher”, allows the volumetric feed flux to be increased to 10 cm/s, permitting residence times as low as 10 to 20 seconds, depending on the vessel height. This pilot scale study will then form the basis for a full scale study and commercialisation of the technology. The project will commence with a series of modifications to the existing pilot scale Reflux Flotation Cell in order to permit much higher gas and feed fluxes, incorporating a finer gas sparger. This device, which is 0.3mx0.3m in cross-section, and 3.0 m high, is already on location at Bloomfield, and should not be difficult to reconfigure. The objective will be to operate the system at up to 500 L/min, considerably higher than the 50 L/min currently being used. The unit will generate a product at up to 100 L/min, which will be collected, for some runs, and returned to our laboratory for second stage processing. Experiments will be conducted at different volumetric feed rates to assess the throughput limit against what has been achieved at the laboratory scale. This work will require experiments at different gas and feed fluxes, as well as reagent doses.

The primary control parameter was the volumetric overflow rate of the fines lower than the yield of the coarse particles. This is the optimum hence the coarser particles (of low density) are displaced the finer particles of low density. This meant that a low density being the primary variable. Some trial and error was required in the first series of runs to develop an initial appreciation of the conditions required to achieve a satisfactory separation. In one of the runs the medium density was 1735 kg/m3 and in another 1537 kg/m3. When the density was too high it was not possible to achieve a low product density as particles of a relatively high density were sufficiently buoyant to report to the overflow. Here, the overflow rate was lower than the optimum hence the coarser particles (of low density) displaced the finer particles of low density. This meant that a low yield of higher density product was produced, with the yield of the fines lower than the yield of the coarse particles. This is the opposite of what happens in a water-only medium. So, it was necessary to drop the medium density sufficiently to 1537 kg/m3, until a suitable product density could be reached. We then observed a product yield that was largely independent of the particle size, suggesting a high quality dense medium separation. The net result was a feed density of 1481 kg/m3, product density of 1338 kg/m3, and reject density of 1978 kg/m3.

New experiments covering a broader size range from 0.063 mm to 1.0 mm, with operation at significantly higher solids feed rates were undertaken as planned, achieving approximately 20 t/m2/h capacity. This throughput level is considerable given the need to accommodate very high volume fractions of fine magnetite. In fact the magnetite slurry rate and downwards fluidization rate were equivalent to the volumetric feed rate to the system. The primary control parameter was the volumetric overflow rate of...
the product. The data suggests a strong density based separation, where ideally the density cut is nearly independent of the particle size. What we do not know at this stage is the extent to which the fluidization has produced the necessary level of desliming of the product. If the volumetric overflow rate exceeds the fluidization rate then slimes should appear in the overflow.

We have completed the final experiments, and requested additional external analysis to obtain the overall partition curves. The project is thus nearing completion, having provided a strong assessment of the gravity-desliming proposition.

The draft final report has been completed.

**C24045**

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

**QCC Resources**

Andrew Swanson  
Bruce Atkinson

- **Value:** $120,456  
- **Report Expected:** 25/09/2017  
- **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 problem 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 is the first project (see C25019) and it involves 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.

Sampling of the fourth circuit for C24045 (Microcel) has been completed, and samples submitted for CGA. A Project Report for C24045 will be issued following completion of data assessment, and that is anticipated by December 2017.

One site (mechanical cells) has been sampled for the second project, C25019. Four further sites have agreed to participate: 1 x Microcel, 2 x Jameson and 1 x Mechanical. It is anticipated that all of those sites will be sampled prior to the end of 2017.

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**C24049**

**Performance Enhanced Diesel Collector for Coal Flotation**

**CSIRO**

Shenggen Hu

- **Value:** $148,013  
- **Report Expected:** 25/09/2017  
- **Industry Monitor/s:** Alvaro Diaz Lema, Clinton Vanderkruk  
- **ACARP Contact:** Nerrida Scott

In laboratory tests, it has been found that a performance-enhanced diesel collector can achieve greater 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 two 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 float. 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 also 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 has been completed and the final report is being prepared.
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. Prior to the commencement of this project the dewatering had been undertaken in a semi-batch manner following the continuous steady state formation of the agglomerates through a nozzle. The agglomerates were collected in a bucket and then poured over the screen for final separation. But now the goal is to establish a continuous process. 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 trialed several methods of operation. There is also the need to wash the concentrate over a second screen after removing the bulk of the water.

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. This system did not perform to the level required so we constructed a Reflux Flotation Cell. The construction of the system took a couple of months to complete, so we continued on with the basic agglomeration work as well. This work has demonstrated an asymptotic level of performance that permits efficient low binder dosages, low product ashes, and very high feed rates. The agglomeration system appears to be robust. There is very high consistency in the data. 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. We believe the performance can be improved by introducing a stronger bubble hold-up.

Rapid Extraction of Frothers from Process Water

Relatively high concentration of frother in CHPP recirculating process water is known to upset plant operation by causing frothing issues such as inefficient operation of DMCs, thickeners, sumps and pumps. In practice, these operational inefficiencies tend to be compensated by reducing the rate of frother addition to the flotation circuit at the expense of flotation performance, and hence fine coal yield. The objective of this project is to investigate at laboratory scale the rapid extraction and recovery of common frothers, such as MIBC, from process water using innovative Reflux Flotation technology, which permits controlled segregation of bubbles and liquid under “flooding” conditions. The project aims to achieve a significant increase in the throughput rate over existing conventional flotation techniques in facilitating frother extraction. Ultimate success in this project would lead to a new technology to “bolt on” to existing flotation circuits for the propose of rapid frother extraction, thus allowing flotation circuits to operate at optimal frother concentration, while ensuring efficient plant operation.

To maximise frother recovery a low feed flux to gas flux ratio is desirable, while a low entainment of liquid to the frother extract is necessary to achieve a high upgrade. Hence, a key challenge to obtaining a high recovery and upgrade at high feed rates is controlling the liquid flow to product at elevated bubble surface area fluxes. Early experiments demonstrated promising results using desliming cyclone tailings containing around 10 ppm of MIBC, and coarse bubble of nominally 1mm. Theoretical analysis examining the effect of inclined channels on bubble-liquid segregation indicated that for a given recovery and upgrade, both the feed flux and the bubble surface area flux in a Reflux Flotation Cell are maximised when using 100 micron bubbles. Hence, recent experiments have involved using CTAB as frother in a model feed, and very fine bubbles in the order of 100 microns, to examine the formation and propagation of a bubbly bed in the RFC with increasing gas flux at a fixed liquid overflow rate. The experiments illustrated improved throughput capacity for frother extraction compared to a conventional vertical flotation device. Future experiments will examine the separation in the presence of coal and gangue material, multi-stage processing, and the recycling of recovered frother back to a primary coal flotation cell.
C25013
Evaluation of Residual Frother Minimisation Strategies

CSIRO
Philip Ofori

Value: $167,714
Report Expected: 25/10/2017
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 has sourced components for building breathalyser-type systems using the latest advanced alcohol detection systems. The components have been assembled into a frother sensor system.

Frother concentrations in the range of interest (0-20 ppm) in water have been presented to the breathalyser-type sensor system. Measurements have also being 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 is being optimised for detection of low concentrations of alcohol-based frothers. During the optimisation process, measurement drift was observed for blank samples which was believed to be caused by temperature changes in the sensing element. The architecture of the sensing system has now being modified to maintain temperature within a narrow band. The system is being retested for measurement stability, sensitivity and repeatability. Once acceptable measurement repeatability is confirmed, frother partitioning experiments in pilot scale two-stage flotation system will be implemented to examine the impact of different frothers and coal types on frother partitioning.

A pilot scale air stripping column for the removal of organics from aqueous streams has also been set up to study its effectiveness in reducing residual frother concentrations in aqueous streams.

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

CSIRO
Philip Ofori

Value: $165,582
Report Expected: 25/10/2017
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 system were completed. The design of the aerosol generation system and ancillary equipment were also completed. Dosing pumps and atomising nozzles were procured and aerosol generation and delivery systems fabrication were completed. Critical retrofit components 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 ready 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 is near completion. The analysis has identified some gaps in the data so a follow-up site experimental campaign is in the planning stages to resolve this.

In the next quarter a follow-up site experimental campaign will be implemented to be followed by sample and data analyses.

C25017
Leveraging Detailed Maceral Component Information from CGA

QCC Resources
Bruce Atkinson
Karryn Warren

Value: $71,696
Report Expected: 25/08/2017
Industry Monitor/s: Dion Lucke, Justin O'Neill
ACARP Contact: Nerrida Scott

A draft report is with the industry monitor(s) for review.
C25020
Flotation Tailings Online Measurement
A & B Mylec
Alan Bennetts
Todd McDonald

Value: $45,200
Report Expected: 25/08/2017
Industry Monitor/s: Alvaro Diaz Lema
Naomi Pritchard
ACARP Contact: Nerrida Scott

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

C25021
Coarse Particle Flotation for the Plant of the Future
University of Newcastle
Graeme Jameson

Value: $148,169
Report Expected: 25/09/2017
Industry Monitor/s: Clinton Vanderkruk
ACARP Contact: Nerrida Scott

In current coal preparation practice, particles less than 2mm in diameter are usually separated in a two stages. Gravity separation is used for particles in the range 300 µm to 2mm, followed by froth flotation for the fraction below 300 µm.

The aim of this project is to examine the potential of a new type of froth flotation machine, that can achieve the desired separation of coal from ash in a single step, when the feed particles are in the range 0 to 2mm. It uses a new type of flotation cell, which combines the advantages of gravity separation and flotation in a single machine. In the lower part of the cell, a fluidised bed of coarse ash particles is allowed to develop. The bed is supported by a recycle stream taken from the top of the cell. Air is injected into a high-shear device in the recycle line, which makes very fine bubbles that are favourable for the capture of ultrafine coal particles. The fluidised bed is a relatively gentle environment that encourages coarse particles to remain attached to bubbles.

Developed at the University of Newcastle, the new machine is known as the NovaCell. It's distinguishing features are that it gives two concentrate streams – a conventional froth product, which is predominantly in the size range 0 to 500 µm; and a coarse product in the range 500 µm to 2mm. It also has two tailings streams: an overflow containing ultrafine ash particles, and an underflow that has been deslimed at 500 µm. Testwork was conducted using feed material from an operating coal washery, with a small laboratory pilot plant. The cell was operated in batch and continuous modes.

The project has been a complete success. Combustibles recoveries are typically in the range 93 to 96%, and product ashes are typically from 10 to 14%. Due to lack of feed material it was not possible to optimise the product ash, using conventional variables such as froth depth, air rate, and wash water.

Experimental work has concluded and the final report is in preparation.

C26001
Impact of Sub Optimal Operation: Stage 2
BA Firth
Bruce Firth

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.

A first draft of the inverted Health Issue (Sub-Optimal Process)/Symptom (Measurement) matrix has been prepared and requires review/audit/modification by suitable second parties.

Gravity Separation

C20050
Linkage of Dynamic Changes in DMC Circuits to Plant Conditions
CSIRO
Mike O'Brien
Peter Holtham

Value: $492,502
Report Expected: 25/08/2017
Industry Monitor/s: Ryan Flanagan
ACARP Contact: Roger Wischusen

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

C24050
Options for the Addition and Control of Non Magnetic Material in Correct Medium
CSIRO
Mike O'Brien

Value: $205,490
Report Expected: 25/09/2017
Industry Monitor/s: Clinton Vanderkruk
Justin O'Neill
ACARP Contact: Nerrida Scott

The objective of this project is to investigate various options for the addition or maintaining/controlling the level of non-magnetic
material in the correct medium following a period where the concentration of non-magnetics in the medium is low, eg after a shutdown or outage. The most prospective of these options and any operating procedures will be tested at a plant.

Re-Induction at this plant has been completed and the final test at low density is scheduled to be completed this month. A final report is currently being prepared.

C24051

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

CSIRO

Mike O'Brien

Value: $145,255
Report Expected: 25/09/2017
Industry Monitor/s: Alvaro Diaz Lema
ACARP Contact: Nerrida Scott

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. Currently the data is being analysed for the final report preparation.

C25015

Pilot Plant Scale Testing of Modified Downcomer in Jameson Cell

CSIRO

Shenggen Hu

Value: $184,149
Report Expected: 25/10/2017
Industry Monitor/s: none
ACARP Contact: Nerrida Scott

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

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

The pilot scale test rig 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. 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 September.

C25016

G Force Reduction and Failure Monitoring of Multi Sloped Screens

CSIRO

Mike O'Brien

Value: $190,282
Report Expected: 25/09/2017
Industry Monitor/s: Clinton Vanderkruk
ACARP Contact: Nerrida Scott

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

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

All site inductions are now complete and the team has visited the site to plan the next phase of the project with site maintenance personnel. The screen monitoring equipment is being mounted in a stainless steel box for installation at Dawson. This system has been tested and is wirelessly connected back to CSIRO for monitoring a display onsite will provide an indication of any screen issues locally. The test work will commence on the week starting the 14th August. Sampling will take place on Wednesday 16th August prior to the shutdown on Thursday the 17th August. With the sites assistance weights will be removed from a desliming screen and a drain and rinse screen to give approximately 1 g reduction in g force. The screen health monitoring system will also be installed and tested on the desliming screen. Samples will again be taken on Friday 18th to compare the before and after screen operation.

Process Control

C22033

Advanced Control and Optimisation of DMC Operation

CSIRO

Shenggen Hu

Value: $246,685
Report Expected: 25/09/2017
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: 25/09/2017
Industry Monitor(s): Rebecca Fleming
ACARP Contact: Nerrida Scott

The use of recycled water in mining and mineral processing is driven by stricter government regulations. Recycled water contains a higher quantity of inorganic compounds and dissolved minerals. A loss in the plasticity of high rank coals has been observed as a result of using recycled water. The aims of this project are to find evidence of the link between the use of recycled water and the loss of coal fluidity.

High grade large coals were crushed and classified. A coal sample was placed in solutions of 0.01 M of inorganic electrolyte in a 1:6 (coal:water) weight basis for one hour. Samples were subsequently dewatered (approx. 30% water) and stored for 7 days in an air tight container. The samples were then dried in air. A series of inorganic electrolytes has been tested including CaCO3, CaCl2, MgCl2, KCl, K2SO4, Na2SO4, NaOH, Na2CO3 and HCl. All coals treated with solutions of inorganic electrolytes had maximum fluidity results statistically different (ANOVA test) from the sample placed in Milli-Q water (in the absence of inorganic electrolyte). Thus inorganic electrolytes may be said to affect the maximum fluidity. It appears that the relative effect of the cation is not significant except in the case of hydrogen. For the anion, the chloride was different from the carbonate, which may be caused by the HCl. More tests are being conducted to evaluate the maximum mass of process water in the coal acceptable without affecting the thermoplastic properties of the coals.

Logarithm of maximum fluidity of coal samples treated in electrolyte solution classified according to their anion and cation

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

This project has just commenced. No work was undertaken this quarter.

General

C25007
Derrick Stack Sizer In Plant Evaluation

WPE Process Equipment
Brian Packer
Darren Mathewson

Value: $150,800
Report Expected: 25/09/2017
Industry Monitor(s): Naomi Pritchard
ACARP Contact: Nerrida Scott

In many plants, both thermal and coking, millions of tonnes of saleable quality ultrafine coal are ultimately discarded into tailings dams along with the high ash slimes material. Based
purely on the principle of size classification, the Derrick Stack Sizer is a small footprint, high capacity technology capable of recovering coal from fine waste streams and reducing the ash value of existing fine product streams. The Stack Sizer can be used as a replacement for classifying cyclones, to recover coal from thickeners underflow, to scavenge flotation tailings or even to replace flotation. It therefore has the potential to be a ‘gamechanger’ and revolutionise the industry for both thermal and coking coal mines.

The Derrick Stack Sizer test work has been completed at three sites and the final report is being prepared.

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.

One site (mechanical cells) has been sampled for the project. Four further sites have agreed to participate: 1 x Microcel, 2 x Jameson and 1 x Mechanical. It is anticipated that all of those sites will be sampled prior to the end of 2017.

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 – C23054), 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.

The project start meeting was held in late March and three coal samples were received in May. An additional 3 samples have been received in July.

Progress  
Coal A, B and C have been homogenised and are ready for further screening, preparation and testing.

Extensive preparation assessment and testing will be performed on Coal A and Coal C only.

Coal A: dustiness testing according to AS4156.6 has been evaluated for one air drying scheme (AD1) of 3 days duration. Air drying has been completed in accordance with AS4264.1 Section 3.3.3 (drying floor). Testing has been completed with two Moisture Content (MC1 and MC2) reduction schemes (3 repeat tests each). MC1 involves drying test sample in controlled room conditions and MC2 involves drying test sample in a 40°C oven (both as stipulated in AS4156.6). Particle Size Distribution (PSD) has been assessed on the F/S fraction as supplied (AS) and following AD1. Total moisture content (MC) has been evaluated in the F/S and -6.3mm size fractions. Free draining saturation moisture content (SAT MC) has been evaluated in the F/S and -6.3mm size fraction.

Coal C is currently being evaluated for AD1 (3 days air drying duration prior to screening and preparation for the dustiness test method) with MC1 and MC2 moisture reduction schemes. The sample has been air dried and is awaiting screening to -6.3mm size fraction for dustiness testing and analysis.

Coal D, E and F are currently being homogenised.

Project Risk - At present there is a technical issue with the relative humidity sensor in the controlled condition laboratory used for the dustiness testing. It is being attended to, however, has resulted in a pause in the dustiness testing.

At present there is a technical issue with use of Nitrogen in ovens for MC determination. This is expected to be resolved promptly.

Preliminary Observations/Comments - AS4156.6 cites standards that have been withdrawn. This needs to be updated appropriately.

There appears some ambiguity and inconsistency in the specification of the MC determination method stipulated. AS4156.6 cites AS1038.1 (withdrawn), Method B (drying in Nitrogen) as the method for MC determination. AS1038.1 - Method B stipulates sample quantity in the order of 10g. AS4156.6 stipulates a mass of 1.2kg be allowed for MC analysis + characterisation test work. It is unclear as to the effect of Nitrogen on the accuracy of total MC determination. This will be investigated.

Fluctuation in paper collector bag weight has been observed in the controlled environment conditions. This fluctuation has been observed to be in the order of 0.05g (equates to a dust number of 5). Dust Number of 10 is used to determine the TEM. The influence of this fluctuation is much more pronounced at higher moistures (where very little dust is collected) however, this is the zone of measurement/test method that is in closest proximity to the value of dustiness or DEM specified for the coal evaluated. This is being further assessed at the moment due to technical issues with the use of Nitrogen.

For each sample, AS4156.6 stipulates that two pre-moisture checks are conducted prior to the dustiness testing. Here, the standard does not explicitly specify the method to use, the quantity of sample or sampling method. A variation in the order of ±0.2 to 0.3% in actual MC of the coal sample tested has been observed. This preparation step is important as the moisture determined here is plotted (for up to 8 different MC data points) and used to define the reported DEM for the coal tested.
Moisture adjustment: AS4156.6 stipulates adjusting MC of coal samples in 1% intervals. This is coal type dependent and could benefit from rewording.

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 the previous project C23039, through plant tests and technology transfer. The objectives of this project 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 new reagents identified for floating oxidised coals from C23039 in the plant to improve flotation of oxidised coals.

Two oxidation measurement tools developed in C23039 have been redesigned for direct plant use. The first method is alkaline extraction-UV/Vis test. A portable system which can be easily set up in the plant has been fabricated. The second method is dissolved oxygen demand test, and an easy-to-use system has been developed and ready to set up in the plant.

Now we are visiting two coal preparation plants which process oxidized coals. Oxidation monitoring tools, UV-Vis and DO-demand, will be implemented on the two coal sites. The site process engineers will be trained to use these tools to measure the degree of coal oxidation. During this trip, coal samples with different degrees of oxidation will be collected from plants for the lab tests.

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 ACARP priority of ‘optimising maintenance practices and equipment designs to deliver improved process efficiency at lower costs.

This project commenced on July 1. The pilot plant banana screen is undergoing testing and re-commissioning in preparation for this test work.

C26011
CSIRO Instruments at Multiple Plants

CSIRO
Mike O'Brien

Value: $427,798
Report Expected: 25/01/2019
Industry Monitor/s : Naomi Pritchard
Rebecca Fleming
ACARP Contact: Nerrida Scott

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

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

Work is underway to construct a compact electrical impedance monitor (EIM) capable of measuring the density of the slurry. Initial investigations have been carried out at the first plant at which these instruments will deployed and measurements taken for the installation of electrodes. A second plant in NSW has agreed to also hold a trial. These will be the first plants for deployment.
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

This project has just commenced. No work was undertaken this quarter.

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

This project will find how useful the rheology measurements generated by the Thickener Underflow Monitor (TUM) are. The TUM was developed by Clean Process Technologies (CPT) with ACARP assistance (project C24048).

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

This project will 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;
- Provide a means for maintaining more consistent operation of all the above systems.

Progress
21/3/2017 - Visited site (Bulga CHPP) to perform an inspection on possible installation locations.

Met with Michael Carnell, process engineer for Bulga CHPP. Discussed and investigated multiple installation locations and potential streams to be analysed by the TUM. There is thickener #1, thickener #2 and also the paste thickener which could be potential locations for installation.

TUM unit is being constructed and commissioned at CPT facilities, awaiting samples from Bulga CHPP.

Bulga flotation circuit is not yet operational due to a delay in commissioning. Scheduled to be commissioned by the end of May 2017. We will then endeavour to perform a site visit and collect samples to be tested in the CPT facilities.

Q2, 2017
Thickener Underflow Monitor has been constructed at CPT facilities and water commissioned. Improvements being made to automatic flowrate control and backflush sequence to allow greater reliability when operating on site without operator intervention. Design of underflow valve changed to conserve water usage and to reduce wear on components.

Unit has been commissioned on slurry previously collected from CHPPs which were already on site at CPT. This has enabled a baseline calibration data set to be developed for the TUM. As above, some extended wear testing was performed while the TUM was in a controlled environment which enabled more effective materials and flow designs to be chosen.

Q3, 2017
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 still targeted to have the TUM onsite in the 3rd 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 the end of 2017.

C26038
CGA Workshop Series - Driving Implementation
CSIRO
Basacon Services
Bruce Atkinson
Graham O'Brien

Value: $44,910
Report Expected: 25/12/2017
Industry Monitor/s: Angus McIntyre, Chris Urzaa
ACARP Contact: Nerrida Scott

Three workshops have been presented, at Brisbane, Newcastle and Emerald, with a total of 75 participants overall, mainly from mining companies.

Feedback from each workshop has been very positive, with the evidence being that number of industry personnel are now including CGA in their analysis programs, whether that be related to exploration or coal preparation.

Participant interaction has been excellent, and each workshop has been subsequently tuned to take advantage of suggestions and comments derived from the previous workshops. A CGA Forum has been established on Linkedin to assist technical interaction.

The final workshop is scheduled to be undertaken in Sydney on Wednesday 23 August 2017. Following completion of the workshops, a webinar series incorporating the CGA workshop presentations will be published via ACARP.
TECHNICAL MARKET SUPPORT

Metallurgical Coal

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

University of Wollongong
Brian Monaghan

Value: $489,208
Report Expected: 25/09/2017
Industry Monitor/s: Kim Hockings, Oliver Scholes, Tim Manton

ACARP Contact: Dave Osborne

The overarching 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. Key outcomes of the project will be:

- Development of a validated index used in predicting coke reactivity from its mineralogy;
- 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);
- Experimental analogue work for model validation and data (report section in draft);
- Sole oven pilot cokes to test the effects of Fe and Ca on reactivity (currently being produced for testing).

The majority of the work is complete and the final report is in draft form. The sole oven coke data have been measured and are in the final stages of analysis. This work was presented at the Workshop of Australian Coal Research on Metallurgical Coal at UNSW on 28th July. There were some delays in the washing of the coals for the sole oven pilot cokes that have delayed the final report; these have been overcome and a final submission is in progress.

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: Kim Hockings, 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 can simulate the heat transfer of large scale coke ovens and allows in-situ measurements and direct sampling of the plastic layer during coking process.

A series of experiments have been carried out using coal samples supplied by the industry monitors. Good quality coke samples have been produced at a heating rate of 10°C/min. The temperature profile and Internal Gas Pressure (IGP) 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. The project has been extended in order to do some preliminary investigations on coal blending and coke oven validation. CSR/CRI tests are being carried out on coke samples made from single coals. The coke oven rig has been 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. Further experimental work will be focused on coal blends. The effects of heating conditions on temperature profile, internal gas pressure (IGP), plastic layer characteristics and coke quality will be systematically investigated.

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: 25/09/2017
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.

All of the analyses are complete and a draft report has been commenced. The extension project to analyse a further two coals has commenced. In the next quarter we plan submit the draft report.
C24058
Microscopic Properties of Coal and Coke: Comparing Coal Grains with the Optical Properties of Coke and Determining their Relationship

ALS Coal
Bill Cash
Philip Bennett

Value: $42,600
Report Expected: 25/08/2017
Industry Monitor/s: Ashley Conroy
Kim Hockings
Oliver Scholes
Stephen Brant

ACARP Contact: Dave Osborne

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

C25042
Mechanistic Model for the Understanding of the Sole Heated Oven

CSIRO
Joan Boulanger
Merrick Mahoney
Richard Sakurovs

Value: $159,105
Report Expected: 25/11/2017
Industry Monitor/s: Graeme Harris
Kim Hockings
Oliver Scholes

ACARP Contact: Dave Osborne

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.

A first draft CFD model has been prepared that incorporates the previous models and it is being tested against experimental data. It is expected that the draft report will be ready by November.

C25043
Strength of Interfaces in Coke and its Influence on Coke Abrasion

University of Newcastle
Hannah Lomas
Richard Sakurovs

Value: $120,410
Report Expected: 25/08/2017
Industry Monitor/s: Kim Hockings
Stephen Brant

ACARP Contact: Dave Osborne

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

C25045
In-Situ High Temperature Strength of Low CSR Cokes

University of New South Wales
Pramod Koshy

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

ACARP Contact: Dave Osborne

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

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: 25/09/2017
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 and Ionisation time of flight mass spectrometry (LDI-TOF-MS) which is capable of semi-quantifying the molecular weight distribution to ~7000 Da in size. Four coals have been evaluated with a fifth coal in transit. 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. 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). Solid state analysis has shown that peak molecular weight in raw coal is related to coal rank, while peak intensity of semi-cokes is related to coal fluidity. The project is expected to finish in September.

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 characterization which will include the identification of different types of IMDC and RMDC;

Develop novel automated image analysis methods for coke texture characterisation; and to

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.

Work on project is at the following stage:

- Task1 - Coke selection, data collection and polished blocks preparation;
- Task2 - Development of Software for controlling the Motorized Rotating Polarizer, collecting images and producing and analysing Maximum/Minimum reflectance and Bireflectance maps; and
- Task3 - Porosity measurements and proper data processing have been completed and corresponding analysis performed.

Optimisation of bireflectance measurements on ZEISS microscope with automated rotating polarizer and Smith reflector from Leica microscope was performed. Calibration procedure (to standardize image collection) has been developed. It was also realized that previously developed Mozaix imaging (when a complete Mozaix image is collected for one polarizer angle) creates relative shifts between Mozaix images corresponding to different polarizer angles. An alternative image collection procedure is now under development. In this procedure a whole stack of elementary images corresponding to all polarizer angles will be collected in each moving stage position, and after that Mozaix images corresponding to different polarizer angles will be produced. After the errors of both procedures will be estimated and minimized the imaging procedure will be finalized. Currently the database of different carbon types is also being collected. When both these jobs are finished, Task 4 - the imaging of coke samples will start.

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: Stephen Brant, Susan Ellis
ACARP Contact: Dave Osborne

The 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; and
- 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 already sent to Pearson’s for coke imaging by the collaborators;
- Optical reflected light imaging were completed for all the coal halves received from the collaborator at CSIRO;
- In parallel CGA analysis of coke oven feed size fractions for each of the six single coals and three blends. All size fractions (+2mm, -2+1mm, -1+0.5mm and -0.5mm) of coke oven feed (24) and three blends (12 samples) imaged and processed using CGA;
- Modify CGA software to characterise coal blends for Task 6;
- SEM and optical imaging of coke halves already started for Task 7.

In the next quarter:

- Pearson Coal Petrographic for automated coke textural analysis (MTA) on the flat surface of the coke (Task 5(d)) will be completed;
- MTA analysis of the cokes produced for these 9 samples (collaborators, Newcastle University);
- Use the characterized images (Task 3) from the matched coal and coke halves to determine the fusible reflectance range for each coal (Task 4) planning to start once sample received from Pearson’s Coal Petrographic; and
- Establish work for SEM assessment of coal and coke halves to provide detail on mineral size and chemical transformation during coking (Task 7), ongoing.

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: 25/10/2017
Industry Monitor/s: Nick Andriopoulos, Oliver Scholes
ACARP Contact: Dave Osborne

The project is an extension to C23048, Investigation of the links between microstructure development in softening coal and the characteristics controlling coke quality. This project will extend the successful outcomes of the previous project. It 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:

- Further develop understanding of the relationships between key microstructural features of coke and coke failure mechanisms and strength indices;
CT images were collected in July for the samples at the Australian Synchrotron. Analysis of the images is nearly complete and interpretation of the results is about to commence. It is expected that the submission of the draft report will be delayed until October 2017.

**C25052**

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

University of Newcastle  
Wei Xie  

- **Value:** $91,690  
- **Report Expected:** 25/09/2017  
- **Industry Monitor/s:** 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 6 months because one of our colleagues had used the reflux classifier for concentrating small size macerals (<40 µm) for their ACARP projects. In last quarterly report, we mentioned that we had poor reproducibility for the blends composed of 1.6-2.0 mm inertinite concentrates and 0-2.0 mm standard strong coking coal because the limit of the amount of 15.0 grams with this experimental set-up is not enough to represent the large size sample. We now have decreased the particles size of the standard strong coking coal to 1.0 mm and found that the blends composed of 1.6-2.0 mm inertinite and 0-1.0 mm standard strong coking coal showed good reproducibility in swelling. We are seeking permission from the monitors to decrease top particle size to 1.0 mm for the standard coking coal in the blends. Also, we have permission to extend this project to December of this year for the submission of the draft report. Over the next quarter, we expect to complete all experimental work, and we expect to submit the draft report in December.

**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 cokrake structure and strength and improve our ability to explain/predict anomalous strength results;  
- 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.

This project commenced in July. Coal samples to be used have been located and preparation for CGA has commenced and the coke samples are currently being obtained from reserves.  

Next quarter we will be undertake CGA of one of the coals. A proposal for access to the Australian Synchrotron medical imaging beam line (for 3D CT image collection) will be submitted.

**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 is burnout calculation over the entire raceway surface vs burnout calculation along the tuyere centrel ine only.
This quarter:

- Dr FY Meng and Mr JH Liao recruited to work on the project;
- Significant effort has been made to improve the PCI model by including more details, for example, in the last quarter, we included binnest into the model. This quarter, we developed a CFD-DEM model to simulate the raceway shape and size;
- The typical in-furnace phenomena of PCI operation using BSL conditions is simulated;
- The key results have been reported in an ACARP workshop on 28 July 2017;
- Some coal data has been received from Peabody and CSIRO, they will be simulated by the modified PCI model.

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 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.

The experimental apparatus is being developed, with current assessment of a screw feeder and development of a control system. 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 settle or travel on the tube wall, heating by conduction and swelling during devolatilisation may be occurring.

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
ACARP Contact: Dave Osborne

The main objective of the project is to develop an 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:

- M1 - M4 were completed in the period from February to May;
- M5 - Interim workshop was completed on 28 July 2017. 36 delegates attended the workshop, 9 presentations were made for the audience of researchers and technical marketers;
- M6 - Tensile strength, crystallinity and microstrength of six cokes treated under the simulated blast furnace conditions have been determined using tensile testing, XRD and ultra-micro indentation. Microstructure of three cokes has been characterised using Raman spectroscopy;
- M7 - I-drum tumbling test for two cokes gasified and annealed under the more aggressive conditions were completed.

The results of XRD and ultra-micro indentation tests indicated that the coke made from coal with higher rank showed greater development in its graphitisation degree and more significant strength degradation in its RMDC microstructure under the simulated blast furnace gasification and annealing conditions.

Tensile test results indicated that all the cokes experienced significant degradation in their tensile strength after gasification with subsequent annealing at 2000°C. It should be noted that, although five of the cokes had similar CSR, their relative performance under annealing at 2000°C was significantly different. For example, for Cokes J and N, which had exactly the same CSR (ie CO2 gasification at 1100°C), Coke N was 33% weaker than Coke J after annealing at 2000°C. Also, for Coke D, which had a much lower CSR than the other five cokes, its strength decreased less after annealing at 2000°C. At the high temperatures (up to 2000°C) in the blast furnace, annealing appears to have a much stronger effect on coke strength degradation than gasification. The operating temperature of CSR test is not high enough to reveal this difference amongst cokes.
techniques of rheometry, DETA and TGA, however, the TGA macerals from large chunks. We are using the same analytical produce maceral concentrates we are attempting to handpick the inertinite from one coal with the vitrinite from another. To particular, we are doing cross-fertilisation studies where we mix a variety of impacts on behaviour in the coke oven. In this behaviour, and consequently liquid phase behaviour, which has proposed that inertinite plays an important role in volatile release.

In project C24055 we observed interactions occurring and initiated (M7). and annealed under the more aggressive conditions will be XRD analysis at UNSW. The characterisation of coke gasified simulated blast furnace conditions will be characterised using Bireflectance analysis; minerals of cokes treated under the microtexture analysis will be prepared and subjected to Pearson will be determined using image analysis at UNSW; samples for BET analysis at UNSW; pore structure of cokes gasified blast furnace conditions will be completed by October (M6). The characterisation of the coke 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

Next quarter work
The characterisation of the coke treated under the simulated blast furnace conditions will be completed by October (M6). Microstructure of cokes will be determined using Raman spectroscopy; I-drum tumbling strength of the original cokes and cokes after treatment will be characterised using I-drum tumbler at BlueScope Steel; specific surface areas of original cokes will be tested using BET analysis at UNSW; pore structure of cokes will be determined using image analysis at UNSW; samples for microtexture analysis will be prepared and subjected to Pearson Bireflectance analysis; minerals of cokes treated under the simulated blast furnace conditions will be characterised using XRD analysis at UNSW. The characterisation of coke gasified and annealed under the more aggressive conditions will be initiated (M7).

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
ACARP Contact: Dave Osborne

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.

So far we have developed a procedure for producing maceral concentrates. We were trained by geologists in the School of Earth Sciences on how to identify the vitrinite-rich and inertinite-rich regions. We developed a method of separating the vit-rich regions from inert-rich regions using small chisels and carrying out the work within a glove box flushed with N2 and fitted with an O2 sensor to confirm 0.0% O2, and therefore avoid oxidation occurring to the small particles that we produce. Petrographic analysis on the 1st coal confirmed that we had 85.8% vitrinite and 12.0% inertinite in the vit-rich sample and 29.0% vitrinite and 56.6% inertinite in the inert-rich sample. This is a good split and should allow us to study interactions. We prepared 2 batches (approx. 40 g, 100-300 micron) of inert-rich and vit-rich to allow us to carry out all the testwork needed for this 1st coal. We have carried out rheometry testwork on these batches and confirmed substantial fluidity development in the vit-rich sample and no fluidity (or expansion) in the inert-rich sample. From these confirmations we are now splitting out subsamples in our N2 filled glove box from the batches that will be sent to Newcastle for DETA testwork and we will be commissioning our high mass TGA. We plan to move on to preparing concentrates from the 2nd coal received over the next month in addition to completing the DETA, rheometry and TGA testwork.

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;
- A validated and extensive 3D data set of coke reactivity data with time and temperature that can be used to inform extant CSR/CRI data and its application.

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

Developed methodology on synchrotron measurements for base coke analogue and coke analogue with Fe. This work was presented at the Workshop of Australian Coal Research on Metallurgical Coal at UNSW in July:
- Validation and guidance approaches using 2 D data on the analogue;
- Porosity and mineral dispersion data obtained.
Discussed and confirmed microCT measurement approaches with Dr Belinda Godel of CSIRO at a meeting in Perth.

Obtained access to CSIRO’s GeoDict software and using to 3D asses synchrotron data. This is ongoing. The plan is to publish this 3D assessment.

Review of 3D measurement:
- A draft review has been prepared and is currently being reviewed by the project leader. As soon as practical this will be shared with the rest of the project team.

Ms Jayasekara primary focus will be on the experimental work. Two industrial cokes have been identified for study. One has been fully characterised with respect to microscopy, XRD, TGA analysis and porosity. It has also been ashed and an analogue prepared. This has also been fully characterised and reacted and is ready for microCT measurement. A second coke arrived and is in the process of being characterised and ashed.

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
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.

To date, we have selected 3 coals with varying ranks, 1.0, 1.3 and 1.5% reflectance. We have contacted our monitors about the coal selection and they suggested that these coals should be supplied from the ACARP coal bank. We have also contacted CSIRO for CGA and modified our work flow sheet for this analysis. Over next research quarter, we plan to complete CGA for the raw coals and get maceral separated by reflux classifier for the first coal.

### General

<table>
<thead>
<tr>
<th>Project Code</th>
<th>Title</th>
<th>Value</th>
<th>Report Expected</th>
<th>Industry Monitor/s</th>
<th>ACARP Contact</th>
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<tr>
<td>C25044</td>
<td>Trace Elements in Coal: Status of Test Methods in use and Applicability to Industry Needs</td>
<td>$235,227</td>
<td>25/01/2018</td>
<td>Graeme Harris, Greg Wickman, Kahlee Saunders, Kay Palmer, Kristene Rhodes</td>
<td>Dave Osborne</td>
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<tr>
<td>C25047</td>
<td>International Carbonisation and Coke Testing Round Robin</td>
<td>$86,500</td>
<td>25/08/2017</td>
<td>Ashley Conroy, Oliver Scholes</td>
<td>Dave Osborne</td>
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A draft report is with the industry monitor(s) for review.
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.

At this stage over half of the reports have been examined in detail and their assessments are continuing. The expected date for submission of the draft report has been delayed to April 2018.

The main objective of this project is to operate the ACARP coal sample bank 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. At this stage all necessary forms (coal order, despatch and quality) have been developed and modified to suite the need of coal producers and testing facilities. Created confidential database is stored within the directory with limited access. Up to date, 16 coal samples were delivered and stored at -18°C and their details updated to the database. However, only 7 coals were fully analysed and analysis results provided.

To further minimise the chance of coal oxidisation which would negatively impact the coal properties coal storage under vacuum at -18°C was proposed by CSIRO. The vacuum sealer and vacuum sealing bags for this purpose were purchased and coal samples will be subdivided and vacuum sealed within next months.

Since the ACARP Coal Sample Bank project seems to be successful, CSIRO was asked to prepare the long proposal and extend the ACARP Coal Bank services for another 3 to 5 years. The long proposal will be submitted by CSIRO by the end of August.

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.

Planning for the meeting of ISO TC27 Solid Mineral Fuels, to be held in Brisbane in October 2017 is well advanced. Delegate registrations are healthy. A technical visit, in conjunction with the meeting is being organised to visit CSIRO QCAT and to inspect the coal gasification facilities and to discuss a possible roadmap for the development of ISO coal gasification Standards. The Chinese already have their own Standards, wanting to introduce these into ISO, but it is necessary to understand the types of gasification equipment being used worldwide and which quality parameters are relevant to each.

SA Committee MN/1/1 (Coal Analysis) held a meeting in Brisbane in July and the work preparation for the upcoming ISO TC27 meeting was discussed. A presentation was made by Dr Richard Sakurovs, CSIRO on the robustness of the ISO CSR/CRI Coke test, with regard to coke size used in the test. It is understood that this may be put forward as a future ACARP proposal, with a view to using the findings to revise the ISO Standard.

SA Committee MN/1/2 (Coal Preparation) has a rather extensive list of current projects, a number of which may eventually be made into ISO Standards. Work is progressing on a draft ISO Standard, Guidance on the Inspection of Mechanical Sampling Systems.

SA Committee MN/1 (Coal and Coke) held its annual meeting in Brisbane in July and reviewed work programs (both AS and ISO) of its subcommittees. It also endorsed a number of committee and subcommittee members to attend the ISO meetings as observers.

Current small scale laboratory tests, such as the UN test N4, have a limited test volume size (100mm sided cube). This may limit their utility for Australian coal due to prevalence of large coal particle sizes (up to nominal 50mm). It is possible to improve its use for coal self-heating assessment by increasing
the size of the test chamber that is used for the N4 test. Other self-heating test methods such as the R70 / RIT test may be more applicable to Australian coal assessments. The aim of this project is to determine the optimum testing protocol for spontaneous combustion potential of Australian coal. The specific objectives of the research will be:

- Test the suitability of UN test N4 for measuring the self-heating potential of Australian coal;
- Investigate larger test cells for incorporating larger coal particle sizes using the N4 procedure;
- Review alternative tests for spontaneous combustion potential of coal;
- Recommend an appropriate approach for measuring the spontaneous combustion potential of Australian coal applicable to coal storage and transport systems; and
- Report on the range of results for Australian coals.

The project commenced in September 2016, the following progress has been made this quarter:

- Testing on sample preparation methods;
- Continued testing of sensitivity of UN.N4 test on -
  - upper particle size
  - sample preparation methods
  - compaction type
  - oven airflow circulation
  - oven air exchange values
  - basket configurations
- A new parameter has been identified as requiring further investigation on test results, namely oven temperature uniformity. It has been found that the temperature variation in the oven with an without samples within the oven volume can be significant. This variation in temperature uniformity around the sample may lead to significant variations between different oven configurations and also change the temperature profile around the sample;
- Other work completed is -
  - the 1st ship cargo based thermocouple data collection for a ship journey has been completed,
  - initial test work for stockpile measurement has commenced.

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
Daniel Chidgey

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

ACARP Contact:
Dave Osborne

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<tr>
<th>Item</th>
<th>Description</th>
<th>Meeting year [2017]</th>
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<tr>
<td>3</td>
<td>National Mirror Committee Support</td>
<td>See Item 1.1.</td>
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<tr>
<td>4</td>
<td>Travel Support for delegates TC27 (X1), SC5 (X2), SC1 (X1), and SC4 (X1) - SA and MN-003 Committee will nominate/close the ISO TC27 meeting (Oct 2017).</td>
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<tr>
<td>5</td>
<td>Travel Support for SA PM - SA Project Manager will attend the ISO TC27 Meeting (Oct 2017).</td>
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<tr>
<td>6</td>
<td>Host meeting costs - Brisbane</td>
<td>See Item 1.2.</td>
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</table>
The current project is Phase-IV of a multi-phase project that is concerned with the development and demonstration of the Stone Dust Looping (SDL) process for abatement of the ventilation air methane (VAM). Previous ACARP funded projects on this topic designated as Phase-I to Phase-III primarily focused on prototype development and pilot-scale demonstration of the SDL process without the option for regeneration of stone dust particles. However, the vision in Phase-IV is to furnish the SDL process with the necessary means for in-situ regeneration of these particles. This is driven by the fact that additional heat is released when the CO2 formed by the oxidation of VAM reacts with the calcium oxide particles undergoing the in-situ regeneration. This in turn, enables the SDL process to reach the state of auto-thermal operation (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). The Phase-IV project aims at pilot-scale demonstration of the above configuration as well as determining its scaling principles and techno-economic merits.

Phase-IV has been defined as a two-year project with the primary aims of:

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

The focus of the first year of the project is on objective (i). The design of the SDL unit is ongoing and the project is on target to achieve commissioning of the system within the first twelve months. The following progress has been achieved against the relevant milestone tasks.

The main objective of the project is to evaluate the feasibility of photocatalytic oxidation of ventilation air methane (VAM) for coal mining fugitive emissions abatement. This proof-of-concept study is based on laboratory tests of photocatalytic oxidation of the simulated VAM.

Over the last three months, all the laboratory tests of VAM photocatalytic oxidation with a continuous flow reactor have been completed. Two top-performed photocatalysts which were identified based on the batch-mode experiments have been tested with the continuous flow reactor under various conditions of VAM flow rates, reaction temperature and humidity. A LED lamp with a single wavelength UV output has been used for testing photocatalytic reaction to evaluate the quantum efficiency and energy consumption of VAM photocatalytic oxidation. The draft final report is being prepared and will be submitted to the Industry Monitors for review in August 2017.

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.

The project is on time and budget. Of particular importance is the progress made against developing the 2-D and 3-D CFD models to predict the key parameters such as explosion pressure rise, pressure wave velocity and flame propagation velocity associated with fire and explosion caused by methane-air mixture. All tasks and milestones associated with the development and validation of the basic explosion model have been completed. Additionally, the CFD modelling data have been validated against the experimental results obtained from the detonation tube facility at the University of Newcastle.

Predicted results from the CFD model for the pressure rise show a comparable pattern and trend with the experimental data acquired from the detonation tube (see Figure 1).

As observed in Figure 1 there is a small time step variation between the predicted and experimental data. Research team initial speculation for this variation was focused on the initial ignition energy. However, further investigation and discussion between the University team and CFD consultants (in Australia and India) indicated that the discrepancy between the two sets of data can be due to the delay in ignition time and signals reading by the pressure transducers fitted to the detonation tube.

Reviewing the delay time between the ignition time and start-up of pressure signal reading determined a delay of 50 to 75 millisecond. Therefore, incorporating this reading lag into the model should resolve the time variation and precisely match up the results.

The draft CFD model is mesh and geometry independent. Therefore the final package can be applied to different geometries, such as RTO units, to simulate their properties as well as their performance. The report associated with this part of the project is being prepared and will be presented in the next quarterly report.