

Mr. Paul Revell
CRC ORE
General Manager
- Research & Innovation



CRC ORE Research Pipeline Overview

CRC ORE Annual Assembly 2017



Australian Government
Department of Industry,
Innovation and Science

Business
Cooperative Research
Centres Programme

CRCORE
Optimising Resource Extraction

Invent



Integrate

Implement



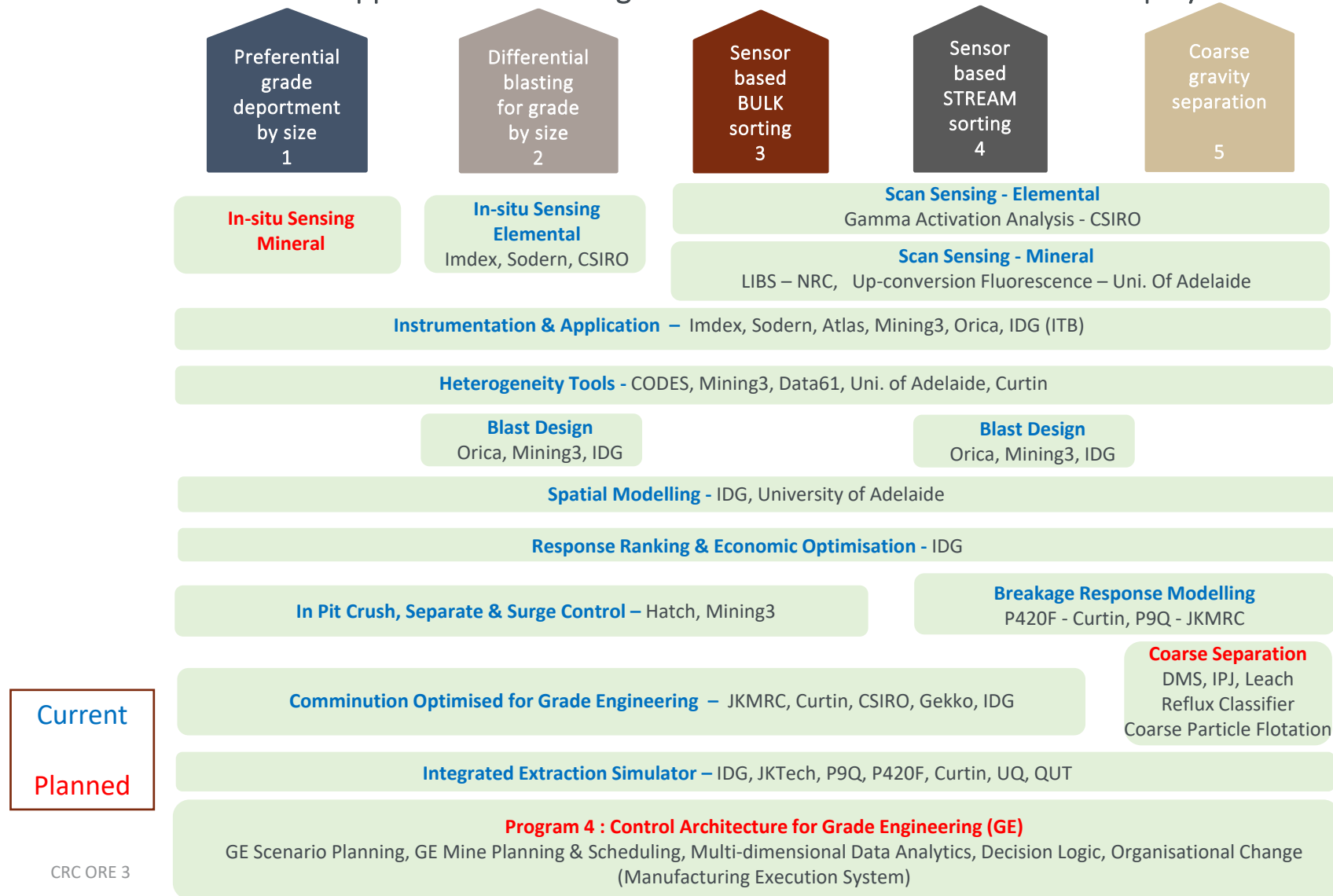
Introduce



CRC ORE Research Pipeline Overview

CRC ORE Annual Assembly 2017

CRC ORE Applied Research Program Overview – Based on End Point Deployment



Future Research themes

Geo-sensing

- Multi-sensor integration.
- Rapid hole drilling & in-situ sensor applications.
- Direct sensing of mineralisation & blast optimisation parameters.

Resource Interpretation

- Geo-spatial modelling.
- Enhanced orebody characterisation within Grade Engineering context.
- Integrating Grade Engineering attributes into mine planning tools.

Separation

- Gravity separation technologies (GE lever 5).
- Enhancing the linkage between comminution & flotation models.
- Developing the control architecture for Grade Engineering implementation.

P1-005:

Upconversion Fluorescence (UF) for real-time mineral identification

Create Upconversion Fluorescence facility and explore UF from minerals to find mineral-specific UF for real-time mineral sensing

Affiliation



Australian Government
Department of Defence
Defence Science and Technology Group

Resources

- 4 academic staff
- 1 PhD students
- Sept 2016 - Sept 2019

Specialisation

- Laser and optics development
- Luminescence studies

Key results to date

- Facility creation on track – key hardware integrated into facility; software integration on track.
- Initial tests of system performance, data collection and processing techniques underway.

What success looks like

- Goal 1: Library of UF wavelengths suitable for real-time identification of specific mineral species.
- Goal 2: Concept demonstration of sensor systems for excitation and detection UF from target minerals.
- Benefits: real-time, mineral species-specific, non-contact; applicable to multiple areas of mining and processing.

P1-006:

Geometallurgical controls on grade by size

Evaluate how mineralogical/textural heterogeneity drives grade by size fractionation for predictive modelling

Affiliation



Resources

- Nathan Fox and Ron Berry
- 2 PhD and 2 MSc students
- October 2016 to June 2021

Specialisation

- Mineral systems
- Ore mineralogy and textures
- Geometallurgy

Key results to date

- Workflow designed to utilise emerging technologies for mineral mapping and feature extraction
- Dedicated study sites (Au) with integration in other CRC ORE study sites (porphyry Cu).

What success looks like

- Geometallurgical framework for predicting grade by size fractionation as a block model attribute.
- Provides a physical understanding of controls on mineral fractionation in mineral systems.

P1-009:

Gamma activation for bulk gold ore sorting

A design study for a pilot bulk sorting plant capable of measuring gold on-belt at $\sim 0.1\text{-}0.2\text{ppm}$

Affiliation



Resources

- 4 researchers
- 1 student
- Apr 2018 - Mar 2018

Specialisation

- Measurement Physics

Key results to date

- Good results for simulated sensitivity and plant shielding.
- Proven success with switching of detectors.
- Sensible sample results.
- No direct measure of gold on-belt contemplated before this research project.

What success looks like

- Direct gold measurement for relevant grades and ore flow rates.
- A pilot demonstration of the technique, preferably at Kalgoorlie Hub.
- Apply in mining situations to reject significant fractions of gangue through bulk ore sorting.

P2-001:

In-Situ Rock Mass Characterisation - Phase 1

Identify superior approaches and systems for characterising in-situ material to enable optimal blast designs for ore upgrading

Affiliation



Resources

- 4 Mining3 staff,
- Technology experts
- Nov 2016 - Dec 2017

Specialisation

- Differential blasting
- Ore body knowledge

Key results to date

- Identified existing and emerging technologies for application to in-situ rock mass characterisation.
- Assessed new approaches to combining these for application and deployment.

What success looks like

- Platforms such as enhanced MWD, drones or rovers with multiple sensors, integrated via data fusion techniques
- Determination of in-situ spatial heterogeneity at the sub-metre scale required for differential blast design

P2-002:

Advanced blast design for maximising value through Grade Engineering levers

Developing optimised designs for GE in a production environment

Affiliation



Resources

- 6 Mining3 staff,
- 1 MEng student
- July 2017 - Feb 2018

Specialisation

- Differential Blasting
- Optimisation

Key results to date

- Fragmentation models and optimisation methods reviewed and selected.
- MVP architecture decided and being coded.

What success looks like

- A module that enables any Drill and Blast Engineer on site to create a GE differential blast design with the optimal value identified via IES
- Moving from a single blastability index for the blast to consider spatial heterogeneity of grade, rock mass and response ranking.

P2-003: Searching for Orebody DNA

Testing methods to identify and learn the recurring patterns in orebody mineralogy and then predict mineral heterogeneity within sparse datasets

Affiliation



Resources

- 6 people, 1.8 fte
- Students etc..
- Mar 2017 - Mar 2018

Specialisation

- Data analytics
- 3D feature and pattern detection

Key results to date

- Results obtained for non-linear analytics, k-means clustering, image and signal processing methods, feature detection, machine learning.

What success looks like

- Demonstration of algorithms that avoid large scale averaging that occurs with conventional (e.g. Kriging) resource modelling methods
- Spatial and volumetric prediction of grades at higher resolution than conventional methods.

P2-004:

Real-time elemental and mineralogical analyser based on combined LIBS and Mid-IR spectroscopy

Proof of concept study to develop a novel new application of combined LIBS - Mid-infrared quantum cascade laser (QCL) spectroscopy for real time on-line mineralogical characterisations.

Affiliation



Resources

- 9 Research Officers
- 3 Technical Officers
- Aug 2017 - July 2019

Specialisation

- Optical sensors for
- Real-time process control

Key results to date

- Review of current LIBS and IR technologies for mineral industry applications nearly completed
- Comparison of XRF, MLA and LIBS measurements on the same tiles in progress.

What success looks like

- Positive outcomes would generate a TRL5 ready application with proof-of-concept at lab scale for mineralogy measurement.
- Ready for field deployment and transfer to METS companies
- Fast, non-nuclear, in-field method for mineral assessment



P3-005: Coarse Particle Liberation & Recovery

Develop an ore characterisation method and subsequent model to evaluate liberation and separation methods for Au ore in the 4.75 – 0.3 mm size range

Affiliation



WASM Gold Technology Group at
Curtin University

Resources

- 5 of 15 staff
- 4 of 10 HDR students
- Feb 2017 – Feb 2020

Specialisation

- Ore characterisation
- Gangue rejection
- Optimisation

Key results to date

- Have developed and are refining ore characterisation method.
- Applying method to multiple ores with multiple crush types to investigate preferential liberation.
- Investigating various separation devices to determine optimal recovery scenarios for each ore and crush type.

What success looks like

- Understand attributes that make an ore amenable to coarse particle liberation by building a database of responses for various ore types, crushing modes and separation devices.
- Standardise the method and build a model in IES to predict responses and optimise recovery.

P3-006: AMIRA P9Q

Translate P9 research outcomes to an integrated process improvement tool (IES)

Affiliation



THE UNIVERSITY
OF QUEENSLAND

SMI JKMRC
Julius Kruttschnitt Mineral
Research Centre



Key results to date

- Delivery of 6 process models in IES P9Q platform.
- Training workshop:
 - *Introduction to IES.*
 - *Introduction to process models.*

Resources

- 6 research institutes
- 11 industry sponsors
- 2017-2020

Specialisation

- Mineral processing
- Modelling

What success looks like

- Integration of comminution and flotation.
- 11 validated multi-component models.
- 2 test circuits for validation of process integration.

P3-008:

Comminution optimised for Grade Engineering

Enhancing coarse gangue liberation through precisely controlled breakage energy using traditional and next generation Vertical Shaft Impactor (VSI) technologies

Affiliation



**THE UNIVERSITY
OF QUEENSLAND**



SMI JKMRC
Julius Kruttschnitt Mineral
Research Centre

Resources

- RM, VJ, CA, PW
- 3 MPhil students
- Nov 2017 - Oct 2019

Specialisation

- Ore characterisation
- Selective ore breakage

Key results to date

- Project is in the early stages.
- One student has started.
- Some preliminary testing has been carried and the results have been reported to CRC ORE.

What success looks like

- Rejection of coarse clean gangue from a wider range of ore types.
- Use precisely controlled breakage to enhance the current GE approach.
- Laboratory testing protocols to identify ores suitable for coarse liberation.
- Significant reduction in unite energy consumption

CRC ORE
Optimising Resource Extraction

P4-003: Data-driven models

Develop robust and effective data analytics approaches to extract value from data typically collected in the ore mining industry

Affiliation

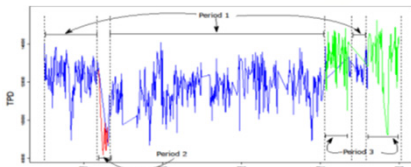


Resources

- 5 academics
- Jan 2017 – Dec 2018

Specialisation

- Data analytics
- Mathematical modelling
- Data-driven models



Key results to date

- Methodology and scripts to pre-process and analyse disparate data sets with visualisation in Power BI.
- Paper: Computational Modelling 2017
- Implementation of *uncertainty quantification* approaches to calibrate a crusher process model
- Initial approach to create *machine learning models* using process data and ore data

What success looks like

- New data-driven approach to calibrate process models using online process data, based on uncertainty quantification.
- Collection of methods and scripts to generate machine-learning based process models.
- Methods and scripts to clean, pre-process, and extract useful information from data (e.g. processing recipes).

P4-004: Implementation Accelerator

Embed a process to fast track the implementation of CRC ORE's technologies, based on Clareo's proven FastPath methodology, incorporating principles of LEAN start-up and learning

Affiliation



Resources

- 4 person Clareo team
- CRC ORE members
- Pilot project

Specialisation

- Rapid and lean approach to innovation implementation

Key results to date

- Kicked off engagement in November after alignment on scope and approach.

What success looks like

- Develop and deliver an Accelerator program designed for CRC ORE.
- Deploy on one demonstration project initially.
- Once proven, wider deployment of the Accelerator program across CRC ORE.

Proven approach





Contact Us

Paul Revell

0429 701 158

p.revell@crcore.org.au

crcore.org.au



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